Are caesarean section rates higher among family physicians than obstetricians?: A population-based cohort study using instrumental variable methods.

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Abstract:	Background: Previous research suggests that family physicians have lower or equivalent rates of caesarean section compared to obstetricians. However, family physicians are often thought to serve lower-risk patients than obstetricians, and adjustments for risk differences in previous analyses may have been inadequate. This study uses instrumental variable adjusted regression to estimate the relative risk of caesarean section in family physicians vs. obstetricians while adjusting for unmeasured confounders. Methods: This retrospective population-based cohort study included all Canadian (except Quebec) hospital deliveries between April 1st, 2006 and March 31st, 2009. Patients delivered by family physicians or obstetricians were included, except those with multiple gestations, birth weights less than 500 grams, or gestational ages less than 20 weeks at delivery. Results: 776,299 patients were included. The relative risk (RR) of caesarean delivery for patients of family physicians vs. those of obstetricians was 0.48, 95% confidence interval (CI) 0.41-0.56, ($p<0.0001$) using logistic regression, and 1.27 95% CI 1.02-1.57

	(p=0.030) using instrumental variable adjusted regression. Interpretation: This suggests that patients of family physicians may have a higher risk of caesarean section when compared to patients of obstetricians. This application of the instrumental variable technique is relatively new in clinical research and should be interpreted cautiously. Further study is needed to assess whether family physicians across Canada serve a higher-risk demographic of patient than has previously been thought, and what additional factors may explain the above findings.

Are caesarean section rates higher among family physicians than obstetricians?: A population-based cohort study using instrumental variable methods.

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ABSTRACT

Background: Previous research suggests that family physicians have lower or equivalent rates of caesarean section compared to obstetricians. However, family physicians are often thought to serve lower-risk patients than obstetricians, and adjustments for risk differences in previous analyses may have been inadequate. This study uses instrumental variable adjusted regression to estimate the relative risk of caesarean section in family physicians vs. obstetricians while adjusting for unmeasured confounders.

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Interpretation: This suggests that patients of family physicians may have a higher risk of caesarean section when compared to patients of obstetricians. This application of the instrumental variable technique is relatively new in clinical research and should be interpreted cautiously. Further study is needed to assess whether family physicians across Canada serve a higher-risk demographic of patient

than has previously been thought, and what additional factors may explain the above findings.

INTRODUCTION

Caesarean section is a valuable and often life-saving intervention.(1) However, the widespread and rapid increase in its use has not been associated with improved health outcomes, and there are risks associated with the procedure.(1-4) The World Health Organization (WHO) has suggested a target caesarean section rate of </= 10 – 15% for a population (World Health Organization, Lancet, 1985),(5) which is exceeded by many countries, including Canada (27%).(6) Therefore, investigation into the factors that contribute to lower caesarean section rates are increasingly of interest.(7)

Some authors have found family physician (FP) maternity care to have equivalent(8) or higher(9) caesarean section rates compared to midwives; and lower(8-10) or equivalent(11) rates compared to obstetricians (OBs). FP and midwife rates of caesarean section may be lower than OBs due to their low-risk patient demographic.(11) However, others suggest FPs' and midwives' accessibility to underserved populations may give them high-risk patients also.(7,11,12) It is also possible that some types of provider are more diligent in coding the risk factors of their patients, confounding research which depends upon such documentation.

Some authors have assessed caesarean section rates by limiting the population studied to low risk patients.(9,13,14) This creates a more homogeneous cohort, which is more easily studied but less representative of the wider population. There is a need, therefore, for a method of analysis that can accommodate the whole population served, and this is what the instrumental variable (IV) approach

provides. IV adjustment acts like "a natural randomization of patients"(15) into cohorts with a different probability of receiving the treatment of interest, and thus leverages the benefits of randomization by decreasing heterogeneity across the treatment groups. This high-powered nation-wide study is the first to use instrumental variable (IV) methods to compare caesarean rates between FPs and OBs.

METHOD

Study Design, Data Sources and Population

We accessed maternal and neonatal Discharge Abstracts Database (DAD) records from the Canadian Institute for Health Information (CIHI) for all deliveries between April 1st, 2006 and March 31st, 2009. The DAD captures clinically significant diagnoses with high sensitivity and specificity,(16,17) and has been used for numerous studies and reports of obstetrical outcomes.(4,18-26)

Records were linked to Statistics Canada Census socioeconomic information using the maternal residential postal code and the Postal Code Conversion File.(27) Multiple gestations, and infants with birth weights less than 500 grams or gestational ages less than 20 weeks at delivery were excluded.(28,29) This research was approved by our provincial Health Research Ethics Board. We followed STROBE guidelines for reporting the results of observational studies.(30)

Record Linkage and Group Assignment

Neonatal records were linked to the corresponding maternal record in order to adjust for perinatal factors that may have affected the choice to deliver by caesarean section. Linkage was conducted using a variable provided by CIHI, or probabilistic linkage using additional variables. Infant records that could not be matched to a single mother were excluded. The DAD includes 10 variables to record the types of providers involved in the care of patients and the role they played. Records were assigned to the FP group if a FP was coded at any point as the most responsible provider (MRP). Midwife deliveries were designated in a similar fashion but were excluded from the analysis because the sample size was insufficient to obtain precise results using the primary statistical method. This classification appropriately assigns patients for whom a FP delivery was planned but who developed intrapartum complications requiring transfer to an OB or other provider (e.g. for caesarean section). However, the approach may bias against family physicians in some hospitals where care is shared between family physicians and obstetricians. In these models, high risk patients (and the higher caesarean rate) for whom an obstetrician delivery is planned are often admitted under the family physician. Remaining patients were categorized into the obstetrics group if the delivery provider was an obstetrician, and all remaining records were excluded. We conducted sensitivity analyses testing different methods of group assignment including assigning patients solely to the practitioner coded as the MRP, or to the practitioner coded as the delivery provider.

Instrumental Variable

Instrumental variable adjusted regression is a technique from the field of econometrics that adjusts for unmeasured confounding in observational studies. An instrumental variable predicts the receipt of treatment (e.g., delivery by FP) but is not directly associated with outcomes (e.g., caesarean section), except through its effect on treatment. For this study we looked at the women living within the catchment area of each local women's hospital and took the instrumental variable to be the proportion of those women who were delivered by a FP. Thus we assume that living in an area with a relatively high frequency of delivery by FP increases the likelihood of being delivered by an FP (treatment) without directly acting as a risk factor for caesarean section (outcome) itself.

The IV also must not directly affect the unmeasured variables in order to adjust for these. The unmeasured variables themselves may affect the receipt of treatment and/or the outcomes directly. For example, in the current study the presence of diabetes mellitus (DM) is an observed (i.e. measured) variable, but the severity of that DM is unmeasured, even though severely uncontrolled DM may increase the likelihood of delivery by an OB. Therefore, when we group our patients into quintiles of the IV (Table 1), it is expected that these unmeasured variables will be evenly distributed among the quintiles, since the IV is not directly associated with the unmeasured variables themselves. For additional discussion regarding instrumental variable techniques, please see the Appendix.

Hospital Catchment Areas

Hospital catchment areas were defined using small area analysis methods, except that catchment areas were not adjusted for geographic contiguity.(31) Postal codes were assigned to a hospital if a plurality of patients living within the postal code were admitted to that hospital for their acute inpatient care. All (not just obstetrical) visits to acute care hospitals for the study period were used to assign patient postal codes to a hospital in this fashion.

Study Outcome and Statistical Analysis

The study outcome is the relative risk of caesarean section between deliveries managed primarily by family physicians compared to those managed by obstetricians. Caesarean deliveries were identified if any of the procedure variables included the International Statistical Classification of Disease and Related Health Problems - 10th revision – Canada (ICD 10-CA)(32) code 5MD60. We hypothesized that family physicians might be less comfortable performing procedural vaginal deliveries than obstetricians, and that this might increase their likelihood of choosing caesarean section. We therefore analyzed the rate of all procedural delivery (caesarean, vacuum and forceps delivery) as a secondary outcome. The additional ICD 10-CA codes included in this outcome were 5MD53-55. For information about how hospital service level and other covariates were determined, please see the Appendix.

The primary statistical approach used the generalized method of moments to estimate multiplicative structural mean models with published Stata syntax.(33) This method is thought to be the most robust method of estimation for instrumental

variable models with a dichotomous outcome and continuous instrumental variable.(33,34) We also used logistic regression in order to compare our results with previous literature.(35-37) Risk ratios rather than odds ratios were estimated from our logistic models as described previously, and all models were adjusted for clustering at the hospital level.(38) All analyses were conducted using Stata v. 13.1.

RESULTS

The study cohort and exclusions are outlined in Figure 1. The final cohort included 776,299 mothers who delivered in 390 hospitals. Table 1 presents selected characteristics of the study population, delivery providers, and hospitals across FP delivery quintiles. The main study findings are presented in Table 2.

Strength of Instrumental Variable

Our instrumental variable predicted a wide range in the mean percentage of deliveries by a family physician (4.1% to 64.5% across quintiles). While there are some differences in measured covariates across these quintiles (Table 1), there was essentially no correlation between catchment area caesarean section rate and the IV ($r^2=6.6x10^{-4}$), a required characteristic to ensure unbiased results. The F-statistic for our instrumental variable (F=1165.94) far exceeded the Stock-Yogo "critical value" necessary to define a strong instrument.(39) The partial correlation coefficient between the delivery provider and instrumental variable was 0.55, indicating that 30% of the variation in the rate of delivery by family physicians was explained by the instrumental variable, also a marker of a strong instrument.

Sensitivity analyses

We compared multivariate models that both included and excluded variables for the service level of the delivery hospital. We also compared models with different definitions of delivery provider as described in Methods. Neither of these adjustments changed the direction of the estimated effects (risk ratio greater or less than 1.0) or the statistical significance of the association (data not shown).

INTERPRETATION

This study's findings of increased risk of caesarean section for patients of FPs vs. OBs (RR = 1.27, Table 2) is surprising, given that previous studies suggest that caesarean rates are equivalent or lower for FPs than for OBs. In contrast, when the current data set was re-analysed using standard logistic regression, FP patients have a 52% lower risk of caesarean section than their obstetrician counterparts. Although this is among the most highly powered studies on this subject to date, and previous studies lacked the benefit of the instrumental variable, because of the novelty and magnitude of our finding and because of the methodological limitations outlined below, we believe our findings require confirmation before a widespread clinical and/or policy response should be considered. However, in light of this new information, it would be prudent for FPs providing intrapartum services to reflect carefully on decision-making pathways that culminate in caesarean section.

Several clinical studies have compared the results from different methods of observational analysis to those from randomized controlled trials. In a study of cardiac catheterization after myocardial infarction using hospital administrative

data, results from traditional observational methods suggest that catheterization results in an almost 50% reduction in mortality, whereas RCTs quantify the benefit at approximately 14%. Using the same observational data, these authors used IV analyses to obtain results that were essentially identical to those from RCTs.(15) Similarly, in a study of the effectiveness of long term control therapy on asthma outcomes, IV analyses showed a protective effect comparable to what was observed in RCTs, whereas traditional observational statistical methods suggested that the medications exert no benefit.(40) In both of these studies, unmeasured factors affected the treatment decision, thereby biasing the estimates from traditional statistical methods. Because IV techniques account for these unobserved factors, the results from these analyses are much closer to those from RCTs.

Several factors may be responsible for our findings. First, FPs may emphasize a patient centered approach to the point of deferring other interventions, such as induction of labour, as the patient prefers. In some instances, such interventions may have facilitated a vaginal delivery prior to complications that may be more likely to occur after 41 weeks gestational age and ultimately lead to an urgent caesarean section. Additionally, some FPs may be less skilled at identifying an intrapartum malposition and rectifying the same (e.g., via manual rotation of an occiput-posterior baby when the head is still high enough). Furthermore, in centers where FPs do not have specialist OB support, FPs may be less comfortable with instrumental vaginal delivery and may therefore be more likely to choose a caesarean section when an instrumental vaginal delivery would be adequate. In support of this hypothesis, when we analyzed the difference between FPs and OBs

for all procedural deliveries (caesarean, forceps and vacuum delivery), we found a relationship that was attenuated and non-significant in comparison to the caesarean-alone analysis (Table 2). These or other factors not discussed may interpret the study findings, but as a nationwide study capturing a variety of circumstances, caution must be exercised in applying these results to any one context.

Caesarean sections have been associated with increased morbidity and mortality in several studies,(1-4) and our findings raise the possibility that morbidity and mortality may be increased in family medicine obstetrical patients as a result of their higher adjusted caesarean rate. However, in a previous study, Aubrey-Bassler, et al. found no difference between FP and OB cases in both maternal and newborn morbidity and mortality using the same cohort used here.(41)

Limitations

There are limitations to the instrumental variable approach. Although this type of analysis has been used in the econometrics literature for almost 90 years, it is relatively new to epidemiologists and clinical applications may require further testing and refinement. As a new tool, it is not as well understood and may not be as readily accepted as more traditional methods, especially when the results differ in a potentially controversial manner, as in this case. Nevertheless, this also highlights the need for this tool and its potential to address the limitations of traditional approaches.

A further limitation, in our case, is the incomplete randomizing effect of the instrumental variable upon our patients. Under ideal conditions, the instrumental variable works by equalizing the unobserved variables across different levels (quintiles) of the instrumental variable. We checked the degree to which this was successful by measuring covariates across categories of the instrumental variable (Table 1). Where the observed variables are equal across quintiles, we assume the unobserved variables have been likewise equalized. Among the most important factors affecting the decision to pursue a caesarean section is a prior caesarean, and these rates were quite similar across different levels of the IV (Table 1). However, we found several variables that did differ across IV quintiles, and this variation raises the possibility that unobserved variables also differ between levels of the IV. For example, the Aboriginal representation across quintiles ranged from 2.4 – 10.9 %. Our data (not shown) indicate that caesarean section rates are lower in populations with higher proportions of aboriginals, but we adjusted for this factor in our multivariate analyses. This observation is only important if unobserved factors also vary across levels of the instrumental variable, and by a sufficient magnitude to explain our findings. Because aboriginal populations tend to be higher in regions with a higher proportion of family physicians, and their caesarean rates tend to be lower, unobserved variables varying in a similar pattern would tend to lessen the effect we observed. Thus, we feel that fully adjusted Caesarean section rates are likely higher in FP patients than in OB patients in Canada, but because of the limitations we outlined, the magnitude of the effect we observed should be interpreted cautiously.

Conclusion

OBs appear to have lower caesarean section rates compared to FPs when the instrumental variable method of analysis is used to adjust for unobserved variables. This is a relatively new application of the instrumental variable method and its findings differ from those of a standard logistic regression analysis, so they should be interpreted with caution. Further study of the wider population, not just low risk patients, is needed to verify these preliminary findings.

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Table 1: Selected Characteristics of the Study Cohort (data are percentages unless otherwise indicated)

	Quintile of Catchment FP Delivery Rate					All
	1	2	3	4	5	
FP Deliveries	4.3	9.2	16.9	40.2	69.1	28.1
Missing data*	1.1	1.3	1.4	2.9	1.8	1.7
Sample (no. mothers)	148059	158593	160518	151206	157923	776299
Predicted CS Rate[τ]	28.4	28.9	27.8	27.8	27.1	28.0
Demographics						
Income (mean $)	27222	28601	28408	26604	26632	27 509
Some High School	83.0	86.5	83.4	83.5	80.2	83.3
Aboriginal	3.6	2.4	5.8	5.9	10.9	5.8
Urban (CMA or CA)	86.8	93.1	84.9	78.5	60.1	80.7
Delivery Hospital						
Level 3	9.4	24.9	37.4	35.7	23.2	26.3
Annual Vol (mean)	2626	3579	2936	3462	2016	2923
Delivery Provider						
Annual Vol (mean)	269	260	252	176	96	210
Obstetrician	95.7	90.8	83.2	59.8	30.9	71.9
Midwife*	3.8	4.5	4.3	3.5	2.8	3.8
Maternal						
Age (mean yrs.)	29.3	30.5	29.0	29.3	28.2	29.2
Caesarean	28.4	28.5	27.2	27.9	28.0	28.0
Prior Caesarean	13.1	13.3	12.5	12.9	13.0	13.0
Type 1 DM	0.3	0.3	0.3	0.3	0.2	0.3
Type 2 DM	0.3	0.3	0.4	0.3	0.3	0.3

GDM	4.5	5.1	4.1	5.8	4.0	4.7
Eclampsia	0.08	0.06	0.06	0.04	0.06	0.06
PIH	5.7	5.4	6.5	6.2	6.4	6.0
HIV	0.05	0.05	0.06	0.08	0.04	0.06
Neonatal						
Male	51.2	51.3	51.2	51.5	51.2	51.3
GA (mean weeks)	38.9	38.9	38.9	38.9	39.1	38.9
Weight (mean g)	3382	3360	3417	3393	3443	3399
Congenital anomaly	3.0	2.8	3.3	3.2	2.8	3.0
Abruptio placenta	0.1	0.1	0.3	0.2	0.1	0.2
PROM	0.3	0.2	1.3	0.6	0.3	0.6
Perinatal Mortality	0.46	0.44	0.37	0.42	0.38	0.41

Abbreviations: CA, census agglomeration; CMA, census metropolitan area; CS, Caesarean Section; Deliv Vol, delivery volume; DM, diabetes mellitus; GA, gestational age; GDM, gestational DM; PIH, pregnancy induced hypertension; PROM, premature rupture of membranes; Vol, volume; Weight, foetal weight;

*Records with data missing and deliveries by midwives were excluded from the final analysis.

$^{\tau}$ Mean predicted caesarean section rate was calculated from a logistic regression model including all covariates except for delivery provider.

Table 2: Ratio of Caesarean delivery risk for family physicians vs obstetricians using logistic and IV adjusted regression.

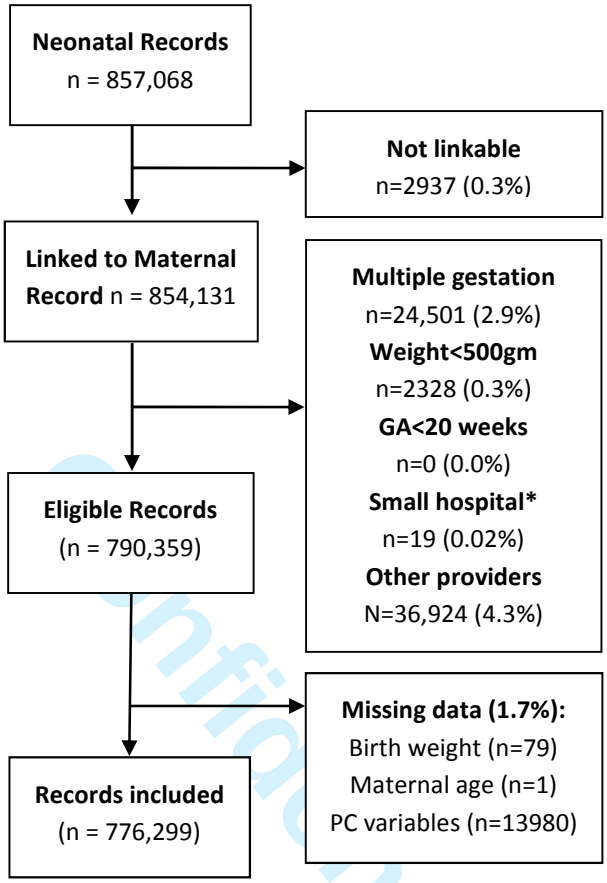
Method	**Caesarean Delivery**		**Procedural Delivery†**	
	RR (95% CI)	p	RR (95% CI)	p
Logistic Regression				
Unadjusted	0.33 (0.27-0.40)	<0.0001	0.50 (0.45-0.54)	<0.0001
Multivariate adjusted*	0.48 (0.41-0.56)	<0.0001	0.61 (0.56-0.67)	<0.0001
GMM (IV adjusted)				
Unadjusted	0.96 (0.79-1.17)	0.694	0.94 (0.82-1.09)	0.414
Multivariate adjusted*	1.27 (1.02-1.57)	0.030	1.16 (0.99-1.35)	0.065

Abbreviations: CI, confidence interval; GMM, generalized method of moments; IV, instrumental variable; RR, rate ratio

*Multivariate adjusted models controlled for all comorbidities listed in supplementary material

†Procedural delivery includes caesarean section, and vacuum and forceps assisted vaginal deliveries.

Figure 1: Cohort exclusions flow diagram.



Abbreviations: GA, gestational age; PC, postal code

*Hospitals with less than 20 caesarean sections performed on women living within their catchment areas were excluded.

Caesarean Section Study Appendix

METHODS

Instrumental Variable

The *local* rather than delivery hospital (in many cases the same hospital) was used because high risk women are selectively referred to more specialized hospitals (where a higher percentage of deliveries may be by obstetricians). We believe that using the local rather than delivery hospital in this fashion was critical to minimize the possibility that the instrumental variable was associated with unobserved confounders. Living in regions with different proportions of deliveries by family physicians should affect the probability of being delivered by a family physician, but should not directly affect the risk of having a caesarean section, after adjustment for additional covariates such as obstetrical comorbidity. Thus, this variable meets the requirement that an IV is not directly associated with the dependent (outcome) variable. An additional requirement is that the IV is not directly related to the error term in a regression equation. In the case of the current study, this would require that unmeasured risk factors are evenly distributed across the catchment areas of different hospitals. While this cannot be proven, it is commonly assumed that this is the case if *measured* covariates are similar across regions with different levels of the IV, and if the correlation between the IV and the predicted risk of outcome is negligible. We therefore divided home hospital delivery volume into quintiles and compared comorbidities across these quintiles as a check of the suitability of our IV. We also used the Kleibergen-Paap rk first-stage F-statistic reported in the Stata IVREG2 output as a measure of instrumental variable strength. [17]

Hospital Service Level and Delivery Volume

Each hospital in our dataset was assigned a service level according to guidelines provided by the Canadian Pediatric Society[19] with modifications for use with administrative data: 1. Tertiary: All hospitals so described by the Canadian Perinatal Network for the time period [20]; 2. Secondary: Those that delivered a minimum of 25% of the 32-34 week gestational age (GA) newborns with a length of hospital stay of at least 5 days from their catchment areas for the study period. Because of uncertainty about the level of care, small volume hospitals with less than 12 deliveries at 32-34 week GA from their catchments during the study period were classified as primary care hospitals regardless of whether they met the percentage criterion above; 3. Primary: Those that delivered a minimum of 10% of the 35 week or greater GA newborns from their catchment areas for the study period. 4. Level 0 hospitals were those not meeting the criteria above. We conducted sensitivity analyses including only a tertiary hospital term and excluding delivery hospital level entirely from our regression analyses. The number of deliveries at the delivery hospital was entered into our models as a continuous variable.

Covariates in regression models

Six digit patient postal codes were mapped to the best match Statistics Canada Census Dissemination Area using the Postal Code Conversion File. [11] Median income, percent of the population with at least high school education, percent aboriginal and the unemployment rate in the maternal residential census dissemination area were entered as continuous covariates. Residential Statistical Area Classifications were dummy coded into urban (census metropolitan area and census agglomerations), strong, moderate, weak and no metropolitan influenced zone rural subheadings, and territories. [10] Analyses were adjusted for the variables described in Table 1. When not recorded, delivery gestational age was

approximated using the admission gestational age and the difference between the dates of admission and delivery.

Table 1: Covariates included in multivariate analyses (Codes are maternal ICD-10-CA codes unless otherwise specified)

Covariate	Definition
Median income*	Median income of all persons 15 years of age or older in a residential household
Education rate*	Proportion of census respondents who graduated high school
Aboriginal population*	Percentage of census respondents that reported identifying with at least one aboriginal group, being a Treaty Indian or Registered Indian, or being a member of an Indian Band or First Nation.
Minority status*	Percentage of census respondents self-identifying as a visible minority (non-aboriginal, non-Caucasian, non-white in colour)
Delivery hospital volume	Average number of deliveries per year at the delivery hospital based on the current dataset, dummy coded into quintiles
Delivery hospital level	The level of obstetrical service offered, dummy coded into Levels 0, 1, 2 or 3 (see Methods)
Provider volume	Volume of deliveries by delivery provider, dummy coded into quintiles
Maternal age	Maternal age in years at delivery, dummy coded (<15, 16-20, 21-25, …, 41-45, >45)
Gestational age	Maternal analysis: Gestational age in weeks at delivery, dummy coded (<27, 27-28, 29-30, … 40-41, >41)
Neonatal gender	Dummy coded into female (reference), male, or other
HIV	Maternal record: B24 or Z21

Type 1 DM	Maternal record: E10.0, 10.2-9, or O24.5
Type 2 DM	Maternal record: E11.0, 11.2-9, or O24.6
Gestational DM	Maternal record: O24.8 or Neonatal record: P70.0
DM, other or unspecified*	Maternal record: E13.0, 13.2-9, 14.0, 14.2-9, H36.0, or O24.7 or neonatal record contains P70.1-2
Cystic fibrosis	Maternal record: E84
Rheumatic heart disease	Maternal record: I05-09
Hypertension	Maternal record: I10.0-1, 15.9, O10.0-1, 10.3-9, 13, 14, or 16 or neonatal record contains P00.0
Ischemic heart disease	Maternal record: I25.2, or 25.5-9
Pulmonary hypertension	Maternal record: I27.0 or 27.8-9
SLE	Maternal record: M32
Chronic renal disease	Maternal record: N01, 03-04, 18, 25, or 26
Birth weight	Weight of fetus, dummy coded (500-999 gm and 500 gm increments up to >4500 gm)
Premature rupture of membranes	Maternal record: O42 Neonatal record: P01.1
Oligohydramnios	Neonatal record: P01.2
Abruptio placentae	Maternal record: O45 Neonatal: P02.1
Prolapsed umbilical cord	Neonatal record: P02.4
Noxious influences	Neonatal record: P04

transmitted via placenta or breast milk	
Congenital anomalies	Neonatal record: D21.5, D82.1, P35.0-1, or P37.1, Q
Hydrops fetalis	Neonatal record: P56.0
Eclampsia	Maternal record: O15
Other maternal conditions	Neonatal record: P00.8
Previous caesarean	Maternal record: O34.20 or 75.7

Abbreviations: DM, Diabetes Mellitus; SLE, Systemic Lupus Erythematosus

* Statistics Canada Census, 2006

*DM, unspecified only coded if other DM variables marked “no”

February 7, 2017

Dear Editor,

Please see the following STROBE statement for cohort studies. Beneath each recommendation (the right-hand column) you will find a reference, in bold font, to which page and/or section of the manuscript addresses each relevant item.

Sincerely,

Russell Dawe
Primary Investigator

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **Addressed in manuscript on Page(P)1, Line(L)2**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **P3-4 (see Abstract)**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **P5-6, L7-9: need to lower caesarean section rates** **P5, L10-12: family physicians previously found to have lower or equivalent caesarean section rates to obstetricians** **P5, L20 – P6, L4: need for instrumental variable method to address this question**
Objectives	3	State specific objectives, including any prespecified hypotheses **P6, L4-6**
Methods		
Study design	4	Present key elements of study design early in the paper **P6 (see Study Design, Data Sources and Population)**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **P6 (see Study Design, Data Sources and Population)** **P8-9 (see Hospital Catchment Areas)**
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up **P6-7 (see Study Design, Data Sources and Population; Record Linkage and Group Assignment)**
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed **N/A**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable. **P7-8 (see Instrumental Variable)**

		P9-10 (see Study Outcome and Statistical Analysis)
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group **P6-7 (see Study Design, Data Sources and Population; Record Linkage and Group Assignment)**
Bias	9	Describe any efforts to address potential sources of bias **P7-8 (see Instrumental Variable)**
Study size	10	Explain how the study size was arrived at **P6 (see Study Design, Data Sources and Population)** **Figure 1**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **P6-7 (see Study Design, Data Sources and Population; Record Linkage and Group Assignment)** **P7-8 (see Instrumental Variable)**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **P7-8 (see Instrumental Variable)** **P9-10 (see Study Outcome and Statistical Analysis)**
		(*b*) Describe any methods used to examine subgroups and interactions **N/A**
		(*c*) Explain how missing data were addressed **P6-7 (see Record Linkage and Group Assignment)**
		(*d*) If applicable, explain how loss to follow-up was addressed **N/A**
		(*e*) Describe any sensitivity analyses **P11 (see Sensitivity Analysis)**
Results		
Participants	13*	(a) Report numbers of individuals at each stage of study—e.g. numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed **P10 (see Results)** **Table 1**
		(b) Give reasons for non-participation at each stage **Figure 1**
		(c) Consider use of a flow diagram **Figure 1**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Table 1**
		(b) Indicate number of participants with missing data for each variable of interest **Table 1**
		(c) Summarise follow-up time (e.g., average and total amount) **N/A**
Outcome data	15*	Report numbers of outcome events or summary measures over time **Table 2**
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (e.g., 95% confidence interval). Make clear which confounders were adjusted for and why they were included

		Table 2 **Table 1** **P7-8 (see Instrumental Variable)** **P9-10 (see Study Outcome and Statistical Analysis)**
		(*b*) Report category boundaries when continuous variables were categorized **Table 1**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **N/A**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **P9-10 (see Study Outcome and Statistical Analysis)** **P11 (see Sensitivity Analysis)**
Discussion		
Key results	18	Summarise key results with reference to study objectives **P11, L8-12 (see Interpretation)**
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias **P13-14 (see Limitations)**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **P11, L12 – P13, L12 (see Interpretation)**
Generalisability	21	Discuss the generalisability (external validity) of the study results **P12, L17- P13, L6 (see Interpretation)**
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based **P1-2 (see Funding)**

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.