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Reproductive patterns, pregnancy outcomes, and parental leave practices of women physicians in Ontario, Canada: the Dr. Mom Cohort Study protocol

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ABSTRACT

Introduction: Surveys and qualitative studies suggest that women physicians may delay childbearing, be at increased risk of adverse peripartum complications when they do become pregnant, and face discrimination and lower earnings as a result of parenthood. Observational studies enrolling large, representative samples of women physicians are needed to accurately evaluate their reproductive patterns, pregnancy outcomes, parental leave practices, and earnings. This protocol provides a detailed research plan for such studies.

Methods & Analysis: All practicing physicians in Ontario, Canada, are registered with the College of Physicians and Surgeons of Ontario (CPSO). By linking a dataset of physicians from the CPSO to existing provincial administrative databases, which hold health data and physician billing records, we will be able to assess the reproductive healthcare utilization, work practices, and pregnancy outcomes of women physicians at the population-level. Specific outcomes of interest include: (1) rates and timing of pregnancy; (2) pregnancy-related care and complications; and (3) duration of parental leave and subsequent earnings.

Ethics & Dissemination: This protocol has been approved by the Research Ethics Board at St. Michael's Hospital in Toronto, Ontario, Canada (#18-248). We will disseminate findings through several peer-reviewed publications, presentations at national and international meetings, and engagement of physicians, residency programs, department heads, and medical societies.

Keywords: Epidemiology; Obstetrics; Maternal Medicine; General Medicine; Medical Education & Training; Surgery

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STRENGTHS & LIMITATIONS OF THIS STUDY

- The observational studies proposed will be the largest to date of women physicians who have experienced pregnancy and childbirth.
- Linkage of the physician cohort to population-based administrative health databases will enable accurate ascertainment of occupational factors such as work intensity that may be associated with pregnancy outcomes.
- Due to the inherent limitations of such databases, we will be unable to account for sociodemographic factors such as relationship status and specific intentions with respect to pregnancy, family planning, and work leave practices. We will also be unable to determine the education level or occupation of non-physician controls.
- This study will be conducted in Ontario, Canada, and may not be generalizable to jurisdictions with major differences in medical training.

INTRODUCTION

Despite a marked increase in the number of women entering medicine over the last 50 years (1, 2), the challenges associated with becoming pregnant and having children during training or clinical practice have been minimally addressed (3). Evidence from qualitative studies and surveys of women physicians raise concerns that pregnancy and motherhood may jeopardize career advancement, reduce job and fellowship opportunities, negatively impact referral patterns, and result in resentment from colleagues who may feel hampered with a greater workload (3-10). Inconsistent institutional support for pregnant women and parents, and the reality that physician mothers usually bear a disproportionate burden of home and parenting obligations compared to physician fathers, may exacerbate these problems (11-16). In part because of these issues, it is thought that women physicians may delay childbearing, have fewer children, or even remain childless more often than men physicians and non-physician women (3, 17-21). However, epidemiologic studies investigating such hypotheses are lacking.

Once pregnant, the demands faced by physicians may predispose them to an increased risk of adverse outcomes. Prolonged hours, shift/night work, and exposure to infectious agents and radiation have been described as potential risk factors for pregnancy complications (22-25). Advanced maternal age, due to delayed childbearing, is associated with subfertility as well as increased risks of pregnancy complications including hypertensive disorders, fetal growth restriction, placental abruption, preterm delivery, and stillbirth, among others (26).

Existing studies comparing pregnancy outcomes in physicians and non-physicians are almost exclusively survey-based and findings vary widely (Table 1). Some studies demonstrate that physicians have increased risks of certain adverse pregnancy outcomes, such as hypertensive disorders and threatened preterm labour (27-32), while others find no such relationship (33, 34).

In the only registry-based study published to date, physician occupation was not associated with preterm labour, low birth weight, or perinatal death compared to women with other white-collar jobs, but differences across specialties, trainee status, or work intensity were not investigated (34). Since an association between the nature of physicians' work and adverse pregnancy outcomes is biologically plausible, additional high-quality studies are needed.

Women physicians face many challenges after pregnancy, and the literature is limited in this area as well. Although many cross-sectional surveys have identified barriers to obtaining adequate maternity leave and managing clinical loads around delivery and return to work (5, 12, 35-37), few studies have systematically described the practice patterns of physician mothers (16). The impact of childbirth and parental leave on the subsequent earnings of women physicians is also unclear. In one survey, over half of physician mothers reported losing $10,000 or more in income due to leave (7). In other fields, a motherhood earnings penalty beyond the gender pay gap has been noted (38, 39). Although qualitative studies and surveys have underscored a possibly similar phenomenon in physicians (5-7), observational research is required.

SPECIFIC AIMS

In the proposed studies, we will harness unique data resources available in Ontario, Canada, to address unanswered questions in this field. We will first develop a representative cohort of Ontario physicians by linking physician registration data to existing provincial health administrative data. We will then conduct analyses within specific subgroups of this larger cohort (Figure 1) to address the following objectives:

1) Compare reproductive patterns between women physicians and non-physicians, and determine if physician work characteristics are associated with rates of pregnancy

2) Compare pregnancy outcomes and processes of obstetrical care between women physicians and non-physicians, and determine if physician work characteristics are associated with adverse pregnancy outcomes
3) Describe the pregnancy and postpartum work practices of women physicians, and determine the impact of childbirth on subsequent practice patterns and earnings

METHODS & ANALYSIS

Cohort development

Rationale & Overview

Existing studies examining issues around pregnancy in physicians are almost entirely self-report surveys with moderate response rates and small sample sizes, susceptible to selection and misclassification bias. We will address this limitation by developing and studying a cohort of practicing physicians registered with the College of Physicians and Surgeons of Ontario (CPSO), linked to existing Ontario population-based administrative databases.

Data Sources

CPSO Database

The CPSO is the body that regulates the practice of medicine in Ontario. Physicians are required to be members of the CPSO to practice medicine in the province. The CPSO also has a legislated mandate to continuously improve the quality of care provided by physicians, by maintaining standards of medical practice through peer assessment and remediation.

To do this, the CPSO maintains a database of all physicians who have registered to practice medicine in Ontario. We obtained a dataset of physicians who registered with the CPSO

from January 1, 1990 to November 26, 2018 (Supplemental Table 1). This dataset has variables on physicians' registration status, medical school, year of graduation, practice location, and specialty, collected at one or two possible time points: (1) the date of physicians' initial registration, and/or (2) the most recent data query.

Physicians of all age and genders in the CPSO dataset were probabilistically linked to existing provincial administrative databases using physicians' given name, surname, gender, and date of birth. Subsets of this larger linked cohort will be used to address each aim (Figure 1). The linkage of the CPSO dataset to existing Ontario administrative databases enables assessment of physicians' health service utilization and health outcomes.

Ontario Administrative Databases

All provincial administrative databases (Supplemental Table 2) required to establish the cohorts, exposures, outcomes, and covariates specific to each aim are held at ICES, a non-profit research institute authorized to collect and use health data on Ontario residents for the purposes of health system evaluation and improvement. Collection and compilation of health records at ICES is possible because Ontario residents have universal access to physician services and hospital-based care through the Ontario Health Insurance Plan (OHIP). ICES databases are linked using unique OHIP numbers that are assigned to each individual.

Demographic data will be identified from several ICES databases. Vital statistics and postal code of residence, used to derive rurality and area-level income quintile from Canadian census data, will be obtained from the Registered Persons Database (RPDB). Immigration status will be obtained from the Ontario portion of Immigration, Refugees, and Citizenship Canada's Permanent Resident Database. Marginalization, another area-level measure of socioeconomic

status based on residential instability, material deprivation, dependency, and ethnic concentration, will be obtained from the Ontario Marginalization Index.

Comorbidities will be ascertained from the Canadian Institute for Health Information (CIHI) Discharge Abstract Database (DAD), which holds diagnostic/procedural information on inpatient hospital stays since 1988; the Same Day Surgery (SDS) database, which holds records for same day procedures since 1991; the National Ambulatory Care Reporting System (NACRS), which holds records on emergency department visits since 2000; and the OHIP database, which holds physician billing claims for health services since 1991. Several Ontario-specific registries and ICES-derived cohorts, including the Ontario Cancer Registry, Ontario Diabetes Dataset, and Ontario Hypertension Dataset, can also be used identify specific medical conditions.

Childbirths and other recognized pregnancies (e.g. spontaneous abortions, ectopic pregnancies) will be identified from the ICES-derived Mother-Baby Dataset (MOMBABY), which links the CIHI records of delivering mothers and their newborns; the Better Outcomes Registry and Network (BORN), Ontario's perinatal registry including data from fertility clinics, specialized antenatal clinics, hospitals, midwifery practice groups, and both prenatal & newborn screening laboratories; as well as the DAD, SDS, OHIP, and NACRS databases (Supplemental Table 2-3). Adverse pregnancy-related and mental health outcomes will be obtained from these same databases and as the Ontario Mental Health Reporting System (OMHRS) database, which holds data on patients in adult designated inpatient mental health beds. Prenatal, antepartum, intrapartum, and postpartum health service utilization, including assisted reproductive technology, will be obtained from the OHIP, DAD/SDS, and BORN databases.

The work practices and earnings of Ontario physicians will be obtained from the OHIP database; 95% of specialists and 50% of primary care physicians receive their income from fee-

for-service (FFS) billings, and all Ontario physicians are required to submit shadow billings for non-FFS services. The frequency and timing of physicians' billing claims for health services and surgical procedures will be used to establish measures of work intensity such as overnight work, and evening and weekend shiftwork, before, during, and after pregnancy. Physician earnings will be derived from total OHIP billings. Practice model for family physicians will be obtained from the Client Agency Program Enrolment (CAPE) database. Specialty, trainee status, and practice location, will be obtained from the CPSO dataset and the ICES-derived Physician Database (IPDB), which contains updated yearly information about physicians in Ontario.

Study Populations & Exposure Assessment

Study populations will depend on the aim (Figure 1). Aim 1 will include Ontario women of reproductive age (15-50 years). Aim 2 will include Ontario women of reproductive age who have had at least one childbirth ≥20 weeks gestational age (GA). In both Aims 1 and 2, physician occupation will be the main exposure of interest; we will compare women physicians (exposed) to non-physicians (comparator). Physicians will be selected from the CPSO dataset. Non-physicians will be selected from the RPDB, and randomly assigned a simulated CPSO registration date based on the distribution of registration dates in physicians.

Aim 3 will include women and men physicians of reproductive age. Childbirth ≥20 weeks GA will be the main exposure of interest; we will compare women physicians who have had at least one childbirth (exposed) to: (1) women physicians who have had no childbirths, and (2) men physicians (comparator). Comparator physicians will be randomly assigned a simulated date of childbirth based on the distribution of childbirth dates in women physicians.

Covariates

We will examine several covariates in physicians and non-physicians. Demographic factors will include age, year of cohort entry, income quintile, and immigration status. Clinical factors will include comorbidities, use of assisted reproductive technology, number of previous livebirths, and number of previous recognized pregnancies. We will group comorbidities into Aggregated Diagnosis Groups (ADGs) on the basis of similarity, chronicity, disability, and likelihood of requiring specialty care using the Johns Hopkins ACG® System (40).

We will also examine several covariates in physicians only. Trainee status, specialty, practice model, practice location, and measures of work intensity (e.g. weekend and overnight shifts, time spent operating) will be ascertained according to methodology described below and in previous work (41-43).

Anticipated Challenges & Mitigation Strategies

Variable Follow-Up

Physicians are a highly mobile population; 34% of Canadian medical graduates move outside of their home province for residency training (44), and 30% of Canadian physicians in independent practice obtained their medical degree internationally (1). We therefore anticipate that some physicians will have lived in Ontario for their entire reproductive lifespans (complete look-back), while others may have left Ontario periodically or arrived for the first time after medical school graduation (incomplete look-back).

Physicians with incomplete look-back prior to their CPSO registration may have insufficient data available to obtain study variables that rely on a historical period, particularly to ascertain previous pregnancies, thus introducing potential for misclassification. For example,

a 32-year-old American physician with one prior childbirth moving to Ontario to practice would have no record of that birth in ICES databases. To mitigate this, we will truncate the look-back of non-physicians to mirror that of matched physicians so that they undergo an identical process of ascertaining covariates. This will facilitate appropriate comparison.

Determining Transition to Independent Practice

The CPSO database contains one variable describing the type of license (e.g. postgraduate education, independent practice, etc.) held by physicians at the time of their initial registration with the CPSO (Supplemental Table 1). Preliminary analyses demonstrate that 90% of reproductive-age physicians first registered as residents/fellows on a postgraduate education license. However, the CPSO database does not hold information on license changes, or when physicians transition from postgraduate education to independent practice.

To mitigate this, we plan to use OHIP data to identify the transition from training to practice. Physicians with a postgraduate education license receive a salary from the provincial Ministry of Health and Long-Term Care, while physicians with an independent practice license receive an income by submitting billings to OHIP. We will use physicians' initiation of billings in OHIP as indicator of their transition from training to practice.

Determining Physician Specialty

The CPSO database contains two variables describing the specialty of physicians (Supplemental Table 1): one is collected at initial registration with the CPSO, and the other is collected at the most recent data query. Specialty is not formally assigned until after physicians finish residency training and are certified for practice by either the Royal College of Physicians

and Surgeons of Canada or the College of Family Physicians of Canada, despite the fact that they have been working in that specialty for several years.

We will therefore assign specialty from the CPSO database based on information available at the time of either initial registration or the most recent data query. For physicians lacking specialty information, we will use linkages to IPDB and OHIP. If specialty information remains missing after searching all three data sources (CPSO, IPDB, OHIP) and the physician was a recent graduate from medical school (≤5 years), then such physicians be deemed active residents with specialty not yet determined.

Aim 1: Compare reproductive patterns in women physicians and non-physicians

Rationale & Overview

Numerous survey-based studies suggest that women physicians frequently delay childbearing and subsequently experience a higher rate of infertility compared to the general population (3, 17-20). This has been quantified in only one retrospective cohort study assessing birth trends among Taiwanese female physicians (21), which demonstrated that maternal age at delivery was up to four years later in physicians than non-physicians. Further studies are needed to characterize the timing and factors impacting pregnancy in physicians.

Analysis Plan

We will evaluate reproductive patterns among Ontario women physicians and non-physicians of reproductive age (15-50 years). We will use MOMBABY to ascertain childbirth, and NACRS, OHIP, and CIHI-DAD to identify other recognized pregnancies. Unmatched time-to-event analyses will be performed to compare rates of childbirth between physicians and the

general population, and matched or adjusted time-to-event analyses will be used to evaluate the independent association of physician occupation with rates of childbirth. We will also examine secondary outcomes such as number of childbirths, number of recognized pregnancies, and maternal age at childbirth, among physicians and non-physicians.

We also aim to determine whether specific work-related factors faced by physicians impact their reproductive patterns and rates of childbirth. Adjusted time-to-event and Poisson regression models will be constructed in women physicians only to evaluate whether variables such as specialty, trainee status, and frequency of overnight work are associated rates of childbirth and other secondary outcomes respectively.

Aim 2: Compare adverse pregnancy outcomes in women physicians and non-physicians

Rationale & Overview

It is unclear how work as a physician and related characteristics such as night shifts and working hours impact obstetrical outcomes. A recent systematic review demonstrated that pregnant women who work shifts or longer hours have increased odds of preterm birth and other adverse outcomes, but all included studies were at substantial risk of bias, and only one pertained specifically to physicians (25). Surveys of residents show an association between increased work intensity and adverse outcomes, but exposures were obtained by recall and defined inconsistently across studies (27, 31, 45). We will be able to reliably establish work characteristics prior to and during pregnancy from OHIP, and thus provide unique insight into the association between physician occupation and adverse pregnancy outcomes.

Outcomes

We will evaluate adverse pregnancy outcomes among Ontario women physicians and non-physicians of reproductive age who have experienced at least one childbirth ≥20 weeks GA. All outcomes of interest were chosen for their clinical relevance and established methodology for ascertainment from ICES databases such as MOMBABY, DAD, and OHIP, using standard diagnostic and procedural codes (46-54) (Supplemental Table 3).

Perinatal outcomes include: preterm birth (delivery at <37 weeks GA); low birthweight; stillbirth; neonatal intensive care unit (NICU) admission; and neonatal death at <28 days of life. Maternal outcomes include: severe maternal morbidity (a composite endpoint of potentially life-threatening complications occurring during the index pregnancy) (48); maternal death (from 20 weeks GA to ≤42 days postpartum); new onset hypertensive disorders in the index pregnancy; other obstetric (e.g. premature rupture of membranes) and non-obstetric complications (e.g. peripartum mood disorders); and processes of obstetrical care (e.g. antenatal care, labour induction, mode of delivery, epidural).

Analysis Plan

Unmatched logistic regression will be performed to compare each adverse pregnancy outcome specified above between physicians and the general population. Matched or adjusted logistic regression analyses, accounting for demographic and clinical covariates as described above, will be performed to isolate the independent association of physician occupation with adverse pregnancy outcomes. We also aim to determine whether specific work-related factors faced by physicians influence their pregnancy outcomes. Adjusted logistic regression models will be constructed in women physicians only to evaluate whether variables such as specialty, trainee status, and overnight work are associated with adverse pregnancy outcomes. For all

analyses described, we will also consider use of log-binomial or modified Poisson regression models to determine risk ratios directly.

Aim 3: Compare practice patterns and earnings of women physicians experiencing childbirth to non-parent physicians

Rationale & Overview

Although the challenges faced by both medical trainees and practicing physicians in taking parental leave have been documented in the literature (5, 12, 35-37), the work and leave practices of physician mothers in Canada are unknown. The financial implications of pregnancy and childbirth on physician earnings are also unclear. Whether a "motherhood earnings penalty" exists for physicians (38, 39) remains unclear but would be of significant concern to physicians practicing in Canada, the majority of whom are self-employed. We aim to describe the parental leave patterns and earnings of Ontario physicians using a rigorous observational design.

Analysis Plan

We will evaluate practice patterns and earnings of men and women physicians in Ontario of reproductive age. We will hard-match women physicians who have had at least one childbirth to women physicians who have had no childbirths, and to men physicians, on their specialty and year of graduation from medical school. Physicians who have delivered will enter the study on their obstetrical delivery date, and physicians who have not delivered will be assigned a corresponding referent date.

In women physicians who have delivered, we will examine: (1) length of leave, defined by the absence of OHIP billings adjacent to the delivery date; and (2) timing of leave, defined in

relation to the delivery date. In all physicians, we will examine: (1) work intensity, defined as mentioned previously through evaluation of measures such as overnight call practices and operating time; (4) earnings, as defined by OHIP billings.

We will compare earnings across three distinct 2-year periods: (1) pre-pregnancy, (2) peripartum; and (3) post-pregnancy. We will first perform a within-patient analysis pertaining to delivering women physicians only, in order to assess how their earnings vary with pregnancy and childbirth. Earnings from all three time periods will be compared using regression methods for cost data (e.g. Poisson, negative binomial, gamma models); the specific model will be determined based on the distribution of earnings for the cohort.

We will then perform a comparative analysis of (a) delivering women physicians to non-delivering women physicians, and (b) delivering women physicians to men physicians. Earnings from the pre-pregnancy and post-pregnancy time periods, or dummy time periods in controls, will again be evaluated with appropriate regression methods for cost data.

Sample Size and Power

The CPSO dataset should have adequate power for all proposed analyses. To demonstrate this, we have calculated the power of our study to find differences in adverse pregnancy outcomes, specifically preterm birth, between women physicians and non-physicians (Specific Aim 2). Preterm birth is a major determinant of neonatal morbidity/mortality, and has significant long-term health consequences. Even a small increased risk of preterm birth would be of importance to women physicians.

If a conservative 5,000 physicians have at least one pregnancy during the study period, are compared to at least 25,000 non-physicians, and we assume a baseline preterm birth rate of

7.7 per 100 births (55) and an alpha of 0.05, we will have 80% power to detect a relative risk of 1.16 or greater, and 90% power to detect a relative risk of 1.19 or greater.

Patient and Public Involvement

The public were not involved in the design of this study. The proposed research questions aim to address issues of importance to physician health; the study team accordingly includes women physicians and physician parents.

SIGNIFICANCE

The linkage of physician information to population-based data on pregnancy presents a unique opportunity to evaluate physicians' reproductive patterns and perinatal health outcomes in a manner that addresses the limitations of previous studies. Ontario's fee-for-service system allows accurate ascertainment of physician work intensity and other work-related factors that may affect rates of reproduction and adverse pregnancy outcomes.

This work is needed; reproductive patterns and childbearing have not been rigorously studied in physicians, despite many barriers to pregnancy and risk factors for adverse outcomes inherent in their work. We will determine if physicians are at increased risk of adverse pregnancy outcomes compared to the general population, and clarify whether this risk is mediated by age or other occupational hazards. Understanding issues around pregnancy and leave, which may affect up to half of the physician workforce at some point during their careers, also has implications for the functioning of the healthcare system.

ETHICS & DISSEMINATION

This protocol was approved by the Research Ethics Board at St. Michael's Hospital (#18-248) and by the ICES Privacy & Legal Office. ICES is a prescribed entity under section 45 of Ontario's Personal Health Information Protection Act. Section 45 authorizes ICES to collect personal health information without consent for analyses related to the evaluation of, allocation of resources to, or planning for all or part of the health system. In accordance with ICES policy, we will suppress all cells with <6 individuals to prevent re-identification. All research outputs related to this work will undergo a re-identification risk assessment prior to submission.

Translation of the findings of our study into practices and policies will require engagement of physicians, physician leaders, and organizational bodies. The team of researchers includes clinician-investigators in obstetrics, surgery, medicine, and psychiatry who will provide important contextual information to the dissemination of our findings. We will engage bodies such as the Society of Obstetricians and Gynaecologists of Canada (SOGC), the Canadian Medical Association (CMA), and residency programs and department heads.

We anticipate that our findings will be presented at local and national conferences, and result in several peer-reviewed publications. Our findings should impact physicians, physicians-in-training, medical educators, residency program directors, department chairs, and hospitals and organizations where physicians work.

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AUTHOR CONTRIBUTIONS

All authors contributed to the design of this study. NNB, AXG, and ANS participated in data acquisition. MCC, NNB, RS, JGR, EM, and ANS developed the analytic plan. MCC, NNB, and ANS obtained ethics approval for this work. MCC and ANS prepared the first draft of the manuscript. All authors contributed to and approved the final version of the manuscript.

COMPETING INTERESTS STATEMENT

The authors have no conflicts of interest to disclose.

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TABLES

Table 1. Published studies of adverse pregnancy outcomes comparing physicians vs. non-physicians (1989 to 2019).

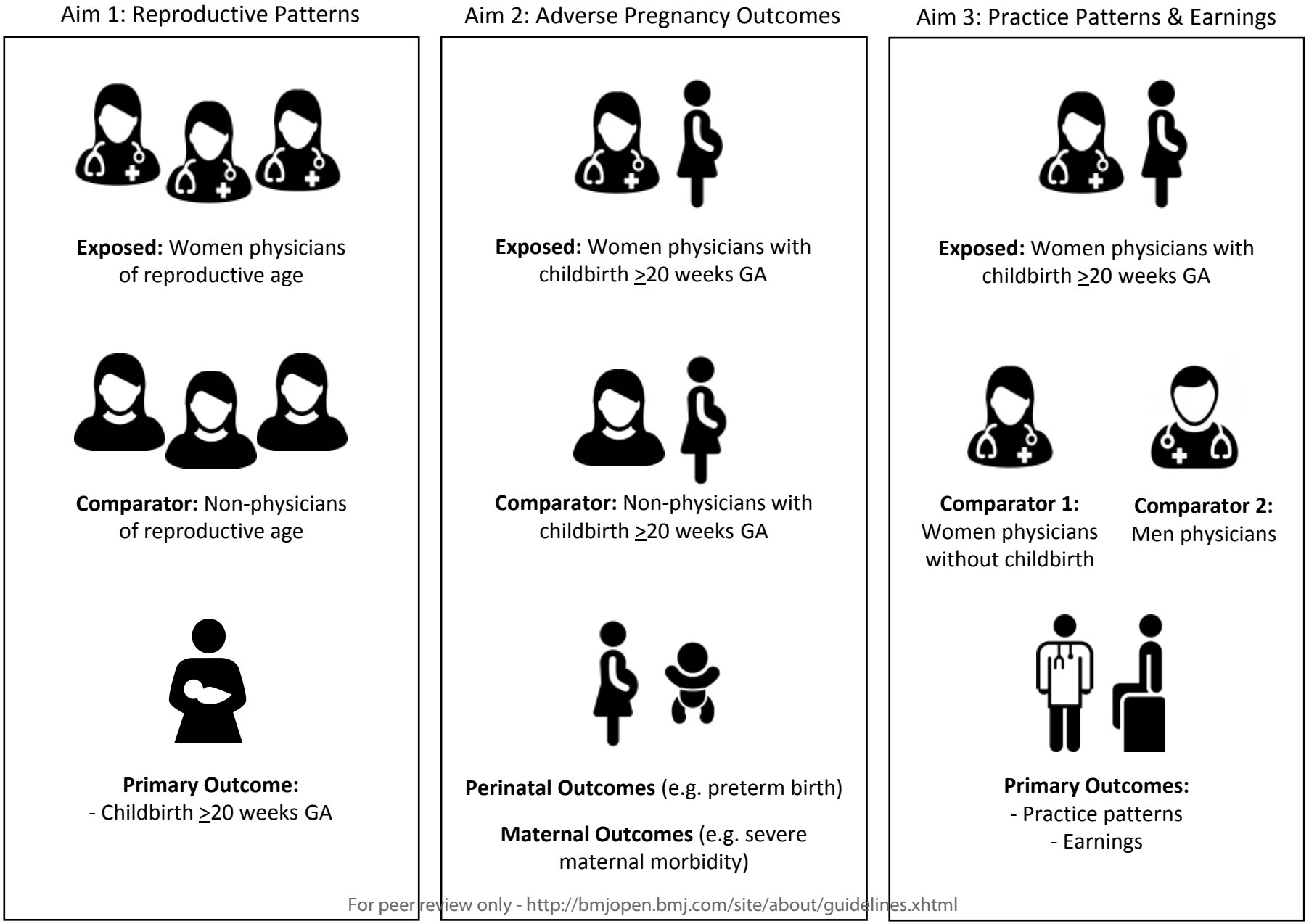
Study	Region	Exposed	Comparator	Response rate (%)	Relative direction of the outcome (exposed vs. comparator)					
					SA	HTN disorders	SGA	Preterm labour	Preterm birth	Stillbirth
Cross-sectional surveys										
Klebanoff, 1990 (27)	USA	Women residents (N=989)	Partners of male residents (N=1239)	86	↔	↑	↔	↑	↔	↔
Osborn, 1990 (28)	USA	Women residents (N=92)	Partners of male residents (N=144)	57	↔	↔	NR	↑	↔	↔
Pinhas-Hamiel, 1999 (29)	Israel	Women physicians (N=207)	General population (NR)	52	↔	↔	NR	NR	↑	↑
Gabbe, 2003(30)	USA	Women residents (N=302)	Partners of male residents (N=274)	96	NR	↑	↑	↑	NR	↔
Behbehani, 2015 (31)	Canada	Women residents (N=238)	General population (N=3767)	NR	↑	↑	↑	↔	NR	NR
Cohort studies										
Miller, 1989 (32)	USA	Women physicians (N=67)	General population (N=201)	NA	NR	NR	NR	↑	↑	NR
Heinonen, 2002 (33)	Finland	Women physicians (N=331)	General population (N=21,997)	NA	NR	↓	↔	NR	↔	↔
Quansah, 2009 (34)	Finland	Women physicians (N=7642)	Upper white collar workers (N=124,606)	NA	NR	NR	↔	NR	↔	↔

Abbreviations: NA (not applicable); NR (not reported); SA (spontaneous abortion); HTN (hypertensive); SGA (small for gestational age birthweight); ↔ no significant difference; ↑ increased risk; ↓ decreased risk

FIGURE LEGENDS

Figure 1. Overview of specific research aims, with study populations (including exposed and comparator groups) and study outcomes.

Figure 1



SUPPLEMENTAL INFORMATION

Supplemental Table 1. Variable list from the College of Physicians & Surgeons of Ontario

Supplemental Table 2. Datasets from CPSO and ICES for use in proposed research studies

Supplemental Table 3. Perinatal and maternal adverse pregnancy outcomes

Supplemental Table 1. Variable list from the College of Physicians & Surgeons of Ontario

Reported Fields	Field Description
CPSO #	CPSO license number and unique identifier
First name	First and middle names
Last name	Surname
Gender	Male or female designation provided by member upon application for license
Registration status (current status)	Membership status with the CPSO (current as of query date): i. Active ii. Expire iii. Suspended iv. Revoked
Registration class (status at time of registration)	Type of license member held at time of registration: i. Independent Practice (IP) – Permits independent practice in the areas of medicine in which the physician is educated and experienced. ii. Postgraduate Education (PG) – Permits supervised practice after graduation from medical school, and is required for postgraduate (residency) medical training at an Ontario medical school. iii. Restricted (R) – Must practice in accordance with the specific terms and conditions imposed on the certificate. iv. Academic Practice (AP) – May practice only in the medical school department in which the physician holds an academic appointment. v. NOT INCLUDED: Academic Visitor (AV) – May practice only in the medical school department in which the physician holds an academic appointment. vi. NOT INCLUDED: Short Duration (SD) – May practice only to the extent required by the short duration appointment at a public hospital, psychiatric facility or medical school.
First ever registration date	Date of initial registration with the CPSO (YYYMMDD)
Medical school	School where member obtained undergraduate medical degree
Graduation year	Year the member graduated from undergraduate medical school
Practice address type	Self-reported information that describes either: i. Primary Practice – Main practice location ii. Secondary Practice – Alterative practice location(s)
Practice address	Member's primary and secondary practice addresses (first practice address available on file; if no address available, leave blank)
Practice city	City or municipality of member's primary and secondary practice address
Practice province	Province of member's primary and secondary practice addresses
Practice postal code	Postal code of member's primary and secondary practice addresses
Specialty type	Specialty designation certified by one of the following: i. Royal College of Physicians and Surgeons of Canada ii. College of Family Physicians Canada iii. College of Physicians and Surgeons of Ontario

Specialty (status at time of registration)	Description of specialty or subspecialty as per RCPSC or CFPC (for example, obstetrics and gynecology; cardiology; orthopedic surgery, Family Medicine)
Specialty (current status)	Description of specialty or subspecialty as per RCPSC or CFPC (for example, obstetrics and gynecology; cardiology; orthopedic surgery, Family Medicine)
Language of practice (status at time of registration)	Language in which member is competent to conduct practice (self-reported)

Abbreviations: CPSO (College of Physicians and Surgeons of Ontario); RCPSC (Royal College of Physicians and Surgeons of Canada); CFPC (College of Family Physicians Canada)

Supplemental Table 2. Datasets from CPSO and ICES for use in proposed research studies

Database	Description	Data Elements	Available Range
College of Physicians and Surgeons of Ontario (CPSO)	Information about all physicians who initially registered for a license to practice medicine in Ontario.	Physician identifiers (encrypted), gender, date of initial registration, registration status, registration class, medical school, graduation year, practice information, specialty, language of practice	January 1, 1990 – November 26, 2018.
Ontario Health Insurance Plan (OHIP) Claims Database	Includes most claims paid by OHIP to physicians, groups, and laboratories from July 1991.	Physician and patient identifiers (encrypted), codes for services provided, date of service, associated diagnosis, fee paid	July 1991 – February 2020
Canadian Institute for Health Information (CIHI) Discharge Abstract Databases (DAD)	Contains patient-level data for acute, rehab, chronic and day surgery institutions in Ontario. Also contains information on patient co-morbidities at the time of admission. Includes ICD-10 codes.	Patient demographics (sex, date of birth, postal code, county/residence), clinical information (diagnoses, procedures, physicians), administrative data (institution number, admission category, length of stay, discharge disposition)	April 1988 – December 2019
CIHI Same Day Surgery Database (SDS)	Contains information on same-day surgical procedures.	Institution, procedures	April 1991 – March 2019
CIHI National Ambulatory Care Reporting System (NACRS)	Captures information of patient visits to hospital and community-based ambulatory care, including day surgery, outpatient clinics, and emergency department from July 2000 onwards.	Emergency room visits	July 2000 – March 2019
Ontario Mental Health Reporting System (OMHRS)	Data on patients in adult designated inpatient mental health beds.	Admission histories, reason for admission, psychiatric diagnoses	October 2005 – March 2019

Client Agency Program Enrolment (CAPE)	Data on the enrolment of patients in a primary care program with a specific practitioner or group. Obtained from the Ministry of Health and Long-Term Care.	Ascertainment of practice model for family physicians	March 1999 – Feb 2020
Ontario Laboratories Information System (OLIS)	Information on laboratory tests ordered by providers, including patient information and test results.	Patient demographics, provider information, specimen information, and results of laboratory tests	January 2007 – December 2017
ICES Physicians Database (IPDB)	Includes information from the Ontario Health Insurance Plan (OHIP) Corporate Provider Database (CPDB), the Ontario Physician Human Resource Data Centre (OPHRDC) database and the OHIP database of physician billings. It contains yearly information about all physicians in Ontario on a fiscal-year basis.	Physician demographics (age, sex); specialty; location; measures of physician activity (billings, workload, types or services provided)	January 1992 – December 2017
Registered Persons Database (RPDB)	A vital statistics registry; provides basic demographic information about anyone who has ever received an Ontario health card number. Data supplied by the Ontario Ministry and enriched with information from other ICES in-house datasets. April 1990 onwards.	Date of birth, sex, date of death, date of last contact, best known postal code, health care eligibility	April 1991 – January 2020
Ontario Census Area Profiles (CENSUS)	Information on constituent income and other demographic information, collected by Statistics Canada.	Income quintile	Up to 2016
Local Health Integration Network (LHIN)	Fourteen geographic areas within Ontario within which residents receive most of their hospital care from local hospitals.	LHIN number, name, population, localization index, number of high-volume hospitals, list of high-volume hospitals (names and institution numbers)	Up to 2009

Information about Ontario health care institutions funded by the Ministry of Health and Long-Term Care (INST)	Contains information about Ontario health care institutions funded by the Ministry of Health and Long-Term Care.	Hospital information	April 1987-December 2017
Ontario Mother-Baby Linked Database (MOMBABY)	Data on all inpatient admission records to mothers and their newborns delivered since 1988.	Perinatal health information, pregnancy information (includes stillbirths, terminations, live births)	April 1988 – March 2019
Ontario Marginalization Index (ONMARG)	Assesses socioeconomic vulnerability based on place of residence.	Residential instability, material deprivation, dependency and ethnic concentration	Up to 2016
Ontario Hypertension Database (HYPER)	ICES-derived cohort. Contains information on individuals diagnosed with hypertension.	Diagnosis of hypertension	April 1991 – March 2019
Ontario Diabetes Database (ODD)	ICES-derived cohort. Contains information on individuals being treated for diabetes.	Diagnosis of diabetes	April 1991 – March 2019
Office of the Registrar General – Deaths (ORGD)	A vital statistics registry for death and cause of death.	Date and cause of death	January 1990 – December 2017
Immigration, Refugees and Citizenship Canada (IRCC)'s Permanent Resident Database (CIC)	Contains landing records for every permanent legal immigrant to Canada from 1985-2012.	Date of landing, immigration class Canadian language ability, level of education	January 1985-May 2017
Better Outcomes Registry and Network (BORN)	Detailed variables on all Ontario hospital births over 20 weeks' gestational age. Data from fertility clinics, specialized antenatal clinics, prenatal screening laboratories, midwifery practice groups, and newborn screening laboratories.	Pregnancy: Antenatal provider, corticosteroid use, maternal body mass index, first trimester visit, flu-like illness in pregnancy, multiple gestation, health problems, prior obstetrical history, smoking, reproductive assistance, screening labs, fetal anomalies	April 2006 – March 2014

		Delivery: Mode/assistance, labour augmentation, Caesarean section indication, gestational age at birth, indication & method of induction, institution, fetal surveillance, labour type, maternal pain management, laceration, episiotomy, intrapartum complications) Baby: Large for gestational age, APGAR scores, cord pH, date of birth, sex, birthweight, linkage information, date of discharge or transfer, neonatal death, newborn resuscitation, reason for neonatal transfer Postpartum: Breastfeeding data	

Supplemental Table 3. Perinatal and maternal adverse pregnancy outcomes

Outcome	Definition	Source	Codes
Perinatal			
Preterm birth	Livebirth from 23-36 weeks GA	MOMBABY	M_STILLBIRTH=F 23 <= B_GESTWKS_DEL <= 36 (if missing use M_GESTWKS_DEL)
Extreme preterm birth	Livebirth at 23-31 weeks GA	MOMBABY	M_STILLBIRTH=F 23 <= B_GESTWKS_DEL <= 31 (if missing use M_GESTWKS_DEL)
Small for gestational age	Birthweight <10th percentile for sex and gestational age	MOMBABY	B_WEIGHT <10th percentile for B_SEX and B_GESTWKS_DEL (if missing use M_GESTWKS_DEL)
Severe small for gestational age	Birthweight <5th percentile for sex and gestational age	MOMBABY	B_WEIGHT <5th percentile for B_SEX and B_GESTWKS_DEL (if missing use M_GESTWKS_DEL)
NICU admission	Admission to neonatal intensive care for newborn on delivery admission	CIHI-DAD	SCU
Stillbirth	Stillbirth at ≥20 weeks GA	MOMBABY	M_STILLBIRTH=T
Neonatal death	Death of infant less than from birth until 28 days postpartum	MOMBABY	DTHDATE within 28 days of index date
Maternal			
Severe maternal morbidity	Composite endpoint of severe maternal complications	CIHI-DAD	See Ray et al., 2018: (48)
Hypertensive disorder of pregnancy	Composite endpoint of gestational hypertension, pre-eclampsia, and eclampsia	CIHI-DAD OHIP	Gestational hypertension: ICD9: 642.0, 642.3, 642.9; ICD10: O13, O16 Pre-eclampsia/eclampsia: ICD9: 642.4, 642.5, 642.6, 642.7; ICD10: O11, O14, O15; OHIP: 642

Preterm premature rupture of membranes	Defined as rupture of membranes prior to 37 weeks GA	CIHI-DAD, MOMBABY	ICD9: 658.1, 658.2 + MOM_GESTWKS_ADM<37 ICD10: O42 + MOM_GESTWKS_ADM<37
Preterm labour without preterm birth	Hospital visit or admission for threatened preterm labour but with delivery ≥37 weeks GA	CIHI-DAD, NACRS	ICD9: 644.0, 644.1 ICD10: O60.0
Maternal death	Death of mother from 20 weeks GA until 42 days postpartum	RPDB	DTHDATE from date of 20 weeks GA to date of 42 weeks postpartum

Abbreviations: GA (gestational age); MOMBABY (ICES-derived Mother Baby Linked Dataset); CIHI (Canadian Institute of Health Information); DAD (Discharge Abstract Database); OHIP (Ontario Health Insurance Plan); ICD (International Classification of Disease); NA (not applicable)

BMJ Open

Reproductive patterns, pregnancy outcomes, and parental leave practices of women physicians in Ontario, Canada: the Dr. Mom Cohort Study protocol

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Reproductive patterns, pregnancy outcomes, and parental leave practices of women physicians in Ontario, Canada: the Dr. Mom Cohort Study protocol

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ABSTRACT

Introduction: Surveys and qualitative studies suggest that women physicians may delay childbearing, be at increased risk of adverse peripartum complications when they do become pregnant, and face discrimination and lower earnings as a result of parenthood. Observational studies enrolling large, representative samples of women physicians are needed to accurately evaluate their reproductive patterns, pregnancy outcomes, parental leave practices, and earnings. This protocol provides a detailed research plan for such studies.

Methods & Analysis: The Dr. Mom Cohort Study encompasses a series of retrospective observational studies of women physicians in Ontario, Canada. All practicing physicians in Ontario are registered with the College of Physicians and Surgeons of Ontario (CPSO). By linking a dataset of physicians from the CPSO to existing provincial administrative databases, which hold health data and physician billing records, we will be able to retrospectively assess the healthcare utilization, work practices, and pregnancy outcomes of women physicians at the population-level. Specific outcomes of interest include: (1) rates and timing of pregnancy; (2) pregnancy-related care and complications; and (3) duration of parental leave and subsequent earnings, each of which will be evaluated with regression methods appropriate to the form of the outcome. We estimate that, at minimum, 5,000 women physicians will be eligible for inclusion.

Ethics & Dissemination: This protocol has been approved by the Research Ethics Board at St. Michael's Hospital in Toronto, Ontario, Canada (#18-248). We will disseminate findings through several peer-reviewed publications, presentations at national and international meetings, and engagement of physicians, residency programs, department heads, and medical societies.

STRENGTHS & LIMITATIONS OF THIS STUDY

- The observational studies proposed will be the largest to date of women physicians who have experienced pregnancy and childbirth.
- Linkage of the physician cohort to population-based administrative health databases will enable accurate ascertainment of occupational factors such as work intensity that may be associated with pregnancy outcomes.
- Due to the inherent limitations of such databases, we will be unable to account for sociodemographic factors such as relationship status and specific intentions with respect to pregnancy, family planning, and work leave practices. We will also be unable to determine the education level or occupation of non-physician controls.
- This study will be conducted in Ontario, Canada, and may not be generalizable to jurisdictions with major differences in medical training.

INTRODUCTION

Despite a marked increase in the number of women entering medicine over the last 50 years (1, 2), the challenges associated with becoming pregnant and having children during training or clinical practice have been minimally addressed (3). Evidence from qualitative studies and surveys of women physicians raise concerns that pregnancy and motherhood may jeopardize career advancement, reduce job and fellowship opportunities, negatively impact referral patterns, and result in resentment from colleagues who may feel hampered with a greater workload (3-10). Inconsistent institutional support for pregnant women and parents, and the reality that physician mothers usually bear a disproportionate burden of home and parenting obligations compared to physician fathers, may exacerbate these problems (11-16). In part because of these issues, it is thought that women physicians may delay childbearing to more advanced maternal ages, or have fewer or no children more often than non-physician women in the general population (3, 17-22). However, epidemiologic studies investigating such hypotheses are lacking.

Once pregnant, the demands faced by physicians may predispose them to an increased risk of adverse outcomes. Prolonged hours, shift/night work, and exposure to infectious agents and radiation have been described as potential risk factors for pregnancy complications (23-26). Advanced maternal age, due to delayed childbearing, is associated with subfertility as well as increased risks of pregnancy complications including hypertensive disorders, fetal growth restriction, placental abruption, preterm delivery, and stillbirth, among others (27).

Existing studies comparing pregnancy outcomes in physicians and non-physicians are almost exclusively survey-based and findings vary widely (Table 1). Some studies demonstrate that physicians have increased risks of certain adverse pregnancy outcomes, such as hypertensive disorders and threatened preterm labour (28-33), while others find no such relationship (34, 35).

In the only registry-based study published to date, physician occupation was not associated with preterm labour, low birth weight, or perinatal death compared to women with other white-collar jobs, but differences across specialties, trainee status, or work intensity were not investigated (35). Since an association between the nature of physicians' work and adverse pregnancy outcomes is biologically plausible, additional high-quality studies are needed.

Women physicians face many challenges after pregnancy, and the literature is limited in this area as well. Although many cross-sectional surveys have identified barriers to obtaining adequate maternity leave and managing clinical loads around delivery and return to work (5, 12, 36-38), few studies have systematically described the practice patterns of physician mothers (16). The impact of childbirth and parental leave on the subsequent earnings of women physicians is also unclear. In one survey, over half of physician mothers reported losing $10,000 or more in income due to leave (7). In other fields, a motherhood earnings penalty beyond the gender pay gap has been noted (39, 40). Although qualitative studies and surveys have underscored a possibly similar phenomenon in physicians (5-7), observational research is required.

SPECIFIC AIMS

In the proposed studies, we will harness unique data resources available in Ontario, Canada, to address unanswered questions in this field. We will first develop a cohort of all physicians who registered to practice in Ontario from 1990 to 2018 by linking physician registration data to existing provincial health administrative data. We will then conduct retrospective analyses within specific subgroups of this larger cohort and a representative sample of non-physicians (Figure 1) to address the following objectives:

1) Compare reproductive patterns between women physicians and non-physicians, and determine if physician work characteristics are associated with rates of pregnancy
2) Compare maternal outcomes, perinatal outcomes, and processes of obstetrical care between women physicians and non-physicians, and determine if physician work characteristics are associated with adverse pregnancy outcomes
3) Describe the pregnancy and postpartum work practices of women physicians who experience childbirth, and determine the impact of childbirth on practice patterns and earnings relative to men physicians and women physicians who do not experience childbirth

METHODS & ANALYSIS

Cohort development

Rationale & Overview

Existing studies examining issues around pregnancy in physicians are almost entirely self-report surveys with moderate response rates and small sample sizes, susceptible to selection and misclassification bias. We will address this limitation by developing and retrospectively studying a cohort of practicing physicians who registered with the College of Physicians and Surgeons of Ontario (CPSO) from 1990 to 2018, linked to existing Ontario population-based administrative databases.

Data Sources

CPSO Database

The CPSO is the body that regulates the practice of medicine in Ontario. Physicians are required to be members of the CPSO to practice medicine in the province. The CPSO also has a legislated mandate to continuously improve the quality of care provided by physicians, by maintaining standards of medical practice through peer assessment and remediation.

To do this, the CPSO maintains a database of all physicians who have registered to practice medicine in Ontario. We obtained a dataset of physicians who registered with the CPSO from January 1, 1990 to November 26, 2018 (Supplemental Table 1). This dataset has variables on physicians' registration status, medical school, year of graduation, practice location, and specialty, collected at one or two possible time points: (1) the date of physicians' initial registration, and/or (2) the most recent data query.

Physicians of all age and genders in the CPSO dataset were probabilistically linked to existing provincial administrative databases using physicians' given name, surname, gender, and date of birth. Subsets of this larger linked cohort will be used to address each aim (Figure 1). The linkage of the CPSO dataset to existing Ontario administrative databases enables assessment of physicians' health service utilization and health outcomes.

Ontario Administrative Databases

All provincial administrative databases (Supplemental Table 2) required to establish the cohorts, exposures, outcomes, and covariates specific to each aim are held at ICES, a non-profit research institute authorized to collect and use health data on Ontario residents for the purposes of health system evaluation and improvement. Collection and compilation of health records at ICES is possible because Ontario residents have universal access to physician services and

hospital-based care through the Ontario Health Insurance Plan (OHIP). ICES databases are linked using unique OHIP numbers that are assigned to each individual.

Demographic data will be identified from several ICES databases. Vital statistics and postal code of residence, used to derive rurality and area-level income quintile from Canadian census data, will be obtained from the Registered Persons Database (RPDB). Immigration status will be obtained from the Ontario portion of Immigration, Refugees, and Citizenship Canada's Permanent Resident Database. Marginalization, another area-level measure of socioeconomic status based on residential instability, material deprivation, dependency, and ethnic concentration, will be obtained from the Ontario Marginalization Index.

Comorbidities will be ascertained from the Canadian Institute for Health Information (CIHI) Discharge Abstract Database (DAD), which holds diagnostic/procedural information on inpatient hospital stays since 1988; the Same Day Surgery (SDS) database, which holds records for same day procedures since 1991; the National Ambulatory Care Reporting System (NACRS), which holds records on emergency department visits since 2000; and the OHIP database, which holds physician billing claims for health services since 1991. Several Ontario-specific registries and ICES-derived cohorts, including the Ontario Cancer Registry, Ontario Diabetes Dataset, and Ontario Hypertension Dataset, can also be used identify specific medical conditions.

Childbirths and other recognized pregnancies (e.g. spontaneous abortions, ectopic pregnancies) will be identified from the ICES-derived Mother-Baby Dataset (MOMBABY), which links the CIHI records of delivering mothers and their newborns; the Better Outcomes Registry and Network (BORN), Ontario's perinatal registry including data from fertility clinics, specialized antenatal clinics, hospitals, midwifery practice groups, and both prenatal & newborn screening laboratories; as well as the DAD, SDS, OHIP, and NACRS databases (Supplemental

Table 2-3). Adverse pregnancy-related and mental health outcomes will be obtained from these same databases and as the Ontario Mental Health Reporting System (OMHRS) database, which holds data on patients in adult designated inpatient mental health beds. Prenatal, antepartum, intrapartum, and postpartum health service utilization, including assisted reproductive technology, will be obtained from the OHIP, DAD/SDS, and BORN databases.

The work practices and earnings of Ontario physicians will be obtained from the OHIP database; 95% of specialists and 50% of primary care physicians receive their income from fee-for-service (FFS) billings, and all Ontario physicians are required to submit shadow billings for non-FFS services. The frequency and timing of physicians' billing claims for health services and surgical procedures will be used to establish measures of work intensity such as overnight work, and evening and weekend shiftwork, before, during, and after pregnancy. Physician earnings will be derived from total OHIP billings. Practice model for family physicians will be obtained from the Client Agency Program Enrolment (CAPE) database. Specialty, trainee status, and practice location, will be obtained from the CPSO dataset and the ICES-derived Physician Database (IPDB), which contains updated yearly information about physicians in Ontario.

Study Populations & Exposure Assessment

Study populations will depend on the aim (Figure 1). Aim 1 will include Ontario women of reproductive age (15-50 years). Aim 2 will include Ontario women of reproductive age who have had at least one childbirth ≥20 weeks gestational age (GA). In both Aims 1 and 2, physician occupation will be the main exposure of interest; we will compare all women physicians (exposed) to a representative sample of non-physicians (comparator). Physicians will be selected from the CPSO dataset. Non-physicians will be selected from the RPDB, and

randomly assigned a simulated CPSO registration date based on the distribution of registration dates in physicians.

Aim 3 will include women and men physicians of reproductive age. Childbirth ≥20 weeks GA will be the main exposure of interest; we will compare women physicians who have had at least one childbirth (exposed) to: (1) women physicians who have had no childbirths, and (2) men physicians (comparator). Comparator physicians will be randomly assigned a simulated date of childbirth based on the distribution of childbirth dates in women physicians.

Covariates

We will examine several covariates in physicians and non-physicians. Demographic factors will include age, year of cohort entry, income quintile, and immigration status. Clinical factors will include comorbidities, use of assisted reproductive technology, number of previous livebirths, and number of previous recognized pregnancies. We will group comorbidities into Aggregated Diagnosis Groups (ADGs) on the basis of similarity, chronicity, disability, and likelihood of requiring specialty care using the Johns Hopkins ACG® System (41).

We will also examine several covariates in physicians only. Trainee status, specialty, practice model, practice location, and measures of work intensity (e.g. weekend and overnight shifts, time spent operating) will be ascertained according to methodology described below and in previous work (42-44).

Anticipated Challenges & Mitigation Strategies

Variable Follow-Up

Physicians are a highly mobile population; 34% of Canadian medical graduates move outside of their home province for residency training (45), and 30% of Canadian physicians in independent practice obtained their medical degree internationally (1). We therefore anticipate that some physicians will have lived in Ontario for their entire reproductive lifespans (complete look-back), while others may have left Ontario periodically or arrived for the first time after medical school graduation (incomplete look-back).

Physicians with incomplete look-back prior to their CPSO registration may have insufficient data available to obtain study variables that rely on a historical period, particularly to ascertain previous pregnancies, thus introducing potential for misclassification. For example, a 32-year-old American physician with one prior childbirth moving to Ontario to practice would have no record of that birth in ICES databases. To mitigate this, we will truncate the look-back of non-physicians to mirror that of matched physicians so that they undergo an identical process of ascertaining covariates. This will facilitate appropriate comparison.

Determining Transition to Independent Practice

The CPSO database contains one variable describing the type of license (e.g. postgraduate education, independent practice, etc.) held by physicians at the time of their initial registration with the CPSO (Supplemental Table 1). Preliminary analyses demonstrate that 90% of reproductive-age physicians first registered as residents/fellows on a postgraduate education license. However, the CPSO database does not hold information on license changes, or when physicians transition from postgraduate education to independent practice.

To mitigate this, we plan to use OHIP data to identify the transition from training to practice. Physicians with a postgraduate education license receive a salary from the provincial

Ministry of Health and Long-Term Care, while physicians with an independent practice license receive an income by submitting billings to OHIP. We will use physicians' initiation of billings in OHIP as indicator of their transition from training to practice.

Determining Physician Specialty

The CPSO database contains two variables describing the specialty of physicians (Supplemental Table 1): one is collected at initial registration with the CPSO, and the other is collected at the most recent data query. Specialty is not formally assigned until after physicians finish residency training and are certified for practice by either the Royal College of Physicians and Surgeons of Canada or the College of Family Physicians of Canada, despite the fact that they have been working in that specialty for several years.

We will therefore assign specialty from the CPSO database based on information available at the time of either initial registration or the most recent data query. For physicians lacking specialty information, we will use linkages to IPDB and OHIP. If specialty information remains missing after searching all three data sources (CPSO, IPDB, OHIP) and the physician was a recent graduate from medical school (≤5 years), then such physicians be deemed active residents with specialty not yet determined.

Use of Administrative Data Sources

Use of ICES administrative data enables access to a large population-based sample of physicians and non-physicians, with comprehensive follow-up of all health encounters over the reproductive lifespan. However, ICES administrative data lacks granular variables that would be of interest in this study, such as relationship status and intentions with respect to family planning,

and is susceptible to misclassification due to coding errors. We cannot account for unmeasured variables; however, we can mitigate the possibility of information bias. We have purposefully selected main exposures, covariates, and outcomes that can be ascertained using established methodology and/or Ontario-specific algorithms to ensure accuracy (46-54); and have used databases that are validated (55, 56) or periodically re-abstracted (57).

Aim 1: Compare reproductive patterns in women physicians and non-physicians

Rationale & Overview

Numerous survey-based studies suggest that women physicians frequently delay childbearing and subsequently experience a higher rate of infertility compared to the general population (3, 17-20). This has been quantified in only one retrospective cohort study assessing birth trends among Taiwanese female physicians (21), which demonstrated that maternal age at delivery was up to four years later in physicians than non-physicians. Further studies are needed to characterize the timing and factors impacting pregnancy in physicians.

Analysis Plan

We will retrospectively evaluate reproductive patterns among Ontario women physicians and non-physicians of reproductive age (15-50 years). We will use MOMBABY to ascertain childbirth, and NACRS, OHIP, and CIHI-DAD to identify other recognized pregnancies. Unmatched time-to-event analyses will be performed to compare rates of childbirth between physicians and the general population, and matched or adjusted time-to-event analyses will be used to evaluate the independent association of physician occupation with rates of childbirth. We

will also examine secondary outcomes such as number of childbirths, number of recognized pregnancies, and maternal age at childbirth, among physicians and non-physicians.

We also aim to determine whether specific work-related factors faced by physicians impact their reproductive patterns and rates of childbirth. Adjusted time-to-event and Poisson regression models will be constructed in women physicians only to evaluate whether variables such as specialty, trainee status, and frequency of overnight work are associated rates of childbirth and other secondary outcomes respectively.

Aim 2: Compare adverse pregnancy outcomes in women physicians and non-physicians

Rationale & Overview

It is unclear how work as a physician impacts obstetrical outcomes. A recent systematic review demonstrated that pregnant women who work shifts or longer hours have increased odds of preterm birth and other adverse outcomes, but all included studies were at substantial risk of bias, and only one pertained specifically to physicians (26). We will be able to reliably establish work characteristics prior to and during pregnancy from OHIP, and thus provide unique insight into the association between physician occupation and adverse pregnancy outcomes.

Outcomes

We will retrospectively evaluate adverse pregnancy outcomes among Ontario women physicians and non-physicians of reproductive age who have experienced at least one childbirth ≥20 weeks GA. All outcomes of interest were chosen for their clinical relevance and established methodology for ascertainment from ICES databases such as MOMBABY, DAD, and OHIP, using standard diagnostic and procedural codes (46-54) (Supplemental Table 3).

Perinatal outcomes include: preterm birth (delivery at <37 weeks GA); low birthweight; stillbirth; neonatal intensive care unit (NICU) admission; and neonatal death at <28 days of life. Maternal outcomes include: severe maternal morbidity (a composite endpoint of potentially life-threatening complications occurring during the index pregnancy) (48); maternal death (from 20 weeks GA to ≤42 days postpartum); new onset hypertensive disorders in the index pregnancy; other obstetric (e.g. premature rupture of membranes) and non-obstetric complications (e.g. peripartum mood disorders); and processes of obstetrical care (e.g. antenatal care, labour induction, mode of delivery, epidural).

Analysis Plan

Unmatched logistic regression will be performed to compare each adverse pregnancy outcome specified above between physicians and the general population. Matched or adjusted logistic regression analyses, accounting for demographic and clinical covariates as described above, will be performed to isolate the independent association of physician occupation with adverse pregnancy outcomes. We also aim to determine whether specific work-related factors faced by physicians influence their pregnancy outcomes. Adjusted logistic regression models will be constructed in women physicians only to evaluate whether variables such as specialty, trainee status, and overnight work are associated with adverse pregnancy outcomes. For all analyses described, we will also consider use of log-binomial or modified Poisson regression models to determine risk ratios directly.

Aim 3: Compare practice patterns and earnings of women physicians experiencing childbirth to non-parent physicians

Rationale & Overview

Although the challenges faced by both medical trainees and practicing physicians in obtaining parental leave have been documented in the literature (5, 12, 36-38), the actual work and leave practices and remuneration of physician mothers are unknown. This data would be of importance to physicians practicing in Canada, as the majority are self-employed. We aim to describe the parental leave patterns and earnings of Ontario physicians using a rigorous observational design.

Analysis Plan

We will retrospectively evaluate practice patterns and earnings of men and women physicians in Ontario of reproductive age. We will hard-match women physicians who have had at least one childbirth to women physicians who have had no childbirths, and to men physicians, on their specialty and year of graduation from medical school. Physicians who have delivered will enter the study on their obstetrical delivery date, and physicians who have not delivered will be assigned a corresponding referent date.

In women physicians who have delivered, we will examine: (1) length of leave, defined by the absence of OHIP billings adjacent to the delivery date; and (2) timing of leave, defined in relation to the delivery date. In all physicians, we will examine: (1) work intensity, defined as mentioned previously through evaluation of measures such as overnight call practices and operating time; (4) earnings, as defined by OHIP billings.

We will compare earnings across three distinct 2-year periods: (1) pre-pregnancy, (2) peripartum; and (3) post-pregnancy. We will first perform a within-patient analysis pertaining to delivering women physicians only, in order to assess how their earnings vary with pregnancy and

childbirth. Earnings from all three time periods will be compared using regression methods for cost data (e.g. Poisson, negative binomial, gamma models); the specific model will be determined based on the distribution of earnings for the cohort.

We will then perform a comparative analysis of (a) delivering women physicians to non-delivering women physicians, and (b) delivering women physicians to men physicians. Earnings from the pre-pregnancy and post-pregnancy time periods, or dummy time periods in controls, will again be evaluated with appropriate regression methods for cost data.

Sample Size and Power

The CPSO dataset should have adequate power for all proposed analyses. To demonstrate this, we have calculated the power of our study to find differences in adverse pregnancy outcomes, specifically preterm birth, between women physicians and non-physicians (Specific Aim 2). Preterm birth is a major determinant of neonatal morbidity/mortality, and has significant long-term health consequences. Even a small increased risk of preterm birth would be of importance to women physicians.

If a conservative 5,000 physicians have at least one pregnancy during the study period, are compared to at least 25,000 non-physicians, and we assume a baseline preterm birth rate of 7.7 per 100 births (58) and an alpha of 0.05, we will have 80% power to detect a relative risk of 1.16 or greater, and 90% power to detect a relative risk of 1.19 or greater.

Patient and Public Involvement

The public were not involved in the design of this study. The proposed research questions aim to address issues of importance to physician health; the study team accordingly includes women physicians and physician parents.

SIGNIFICANCE

The linkage of physician information to population-based data on pregnancy presents a unique opportunity to evaluate physicians' reproductive patterns and perinatal health outcomes in a manner that addresses the limitations of previous studies. Ontario's fee-for-service system allows accurate ascertainment of physician work intensity and other work-related factors that may affect rates of reproduction and adverse pregnancy outcomes.

This work is needed; reproductive patterns and childbearing have not been rigorously studied in physicians, despite many barriers to pregnancy and risk factors for adverse outcomes inherent in their work. We will determine if physicians are at increased risk of adverse pregnancy outcomes compared to the general population, and clarify whether this risk is mediated by age or other occupational hazards. Understanding issues around pregnancy and leave, which may affect up to half of the physician workforce at some point during their careers, also has implications for the functioning of the healthcare system.

ETHICS & DISSEMINATION

This protocol was approved by the Research Ethics Board at St. Michael's Hospital (#18-248) and by the ICES Privacy & Legal Office. ICES is a prescribed entity under section 45 of Ontario's Personal Health Information Protection Act. Section 45 authorizes ICES to collect personal health information without consent for analyses related to the evaluation of, allocation

of resources to, or planning for all or part of the health system. In accordance with ICES policy, we will suppress all cells with <6 individuals to prevent re-identification. All research outputs related to this work will undergo a re-identification risk assessment prior to submission.

Translation of the findings of our study into practices and policies will require engagement of physicians, physician leaders, and organizational bodies. The team of researchers includes clinician-investigators in obstetrics, surgery, medicine, and psychiatry who will provide important contextual information to the dissemination of our findings. We will engage bodies such as the Society of Obstetricians and Gynaecologists of Canada (SOGC), the Canadian Medical Association (CMA), and residency programs and department heads.

We anticipate that our findings will be presented at local and national conferences, and result in several peer-reviewed publications. All manuscripts will adhere to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Supplemental Table 4). Our findings should impact physicians, physicians-in-training, medical educators, residency program directors, department chairs, and hospitals and organizations where physicians work.

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AUTHOR CONTRIBUTIONS

All authors (MCC, NNB, RS, JGR, AXG, EM, SV, and ANS) contributed to the design of this study. NNB, AXG, and ANS participated in data acquisition. MCC, NNB, RS, JGR, EM, and ANS developed the analytic plan. MCC, NNB, and ANS obtained ethics approval for this work. MCC prepared the first draft of the manuscript. All authors contributed to and approved the final version of the manuscript.

COMPETING INTERESTS STATEMENT

The authors have no conflicts of interest to disclose.

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TABLES

Table 1. Published studies of adverse pregnancy outcomes comparing physicians vs. non-physicians (1989 to 2019).

Study	Region	Exposed	Comparator	Response rate (%)	Relative direction of the outcome (exposed vs. comparator)					
					SA	HTN disorders	SGA	Preterm labour	Preterm birth	Stillbirth
Cross-sectional surveys										
Klebanoff, 1990 (28)	USA	Women residents (N=989)	Partners of male residents (N=1239)	86	↔	↑	↔	↑	↔	↔
Osborn, 1990 (29)	USA	Women residents (N=92)	Partners of male residents (N=144)	57	↔	↔	NR	↑	↔	↔
Pinhas-Hamiel, 1999 (30)	Israel	Women physicians (N=207)	General population (NR)	52	↔	↔	NR	NR	↑	↑
Gabbe, 2003(31)	USA	Women residents (N=302)	Partners of male residents (N=274)	96	NR	↑	↑	↑	NR	↔
Behbehani, 2015 (32)	Canada	Women residents (N=238)	General population (N=3767)	NR	↑	↑	↑	↔	NR	NR
Cohort studies										
Miller, 1989 (33)	USA	Women physicians (N=67)	General population (N=201)	NA	NR	NR	NR	↑	↑	NR
Heinonen, 2002 (34)	Finland	Women physicians (N=331)	General population (N=21,997)	NA	NR	↓	↔	NR	↔	↔
Quansah, 2009 (35)	Finland	Women physicians (N=7642)	Upper white collar workers (N=124,606)	NA	NR	NR	↔	NR	↔	↔

Abbreviations: NA (not applicable); NR (not reported); SA (spontaneous abortion); HTN (hypertensive); SGA (small for gestational age birthweight); ↔ no significant difference; ↑ increased risk; ↓ decreased risk

FIGURE LEGENDS

Figure 1. Overview of specific research aims, with study populations (including exposed and comparator groups) and study outcomes.

Figure 1

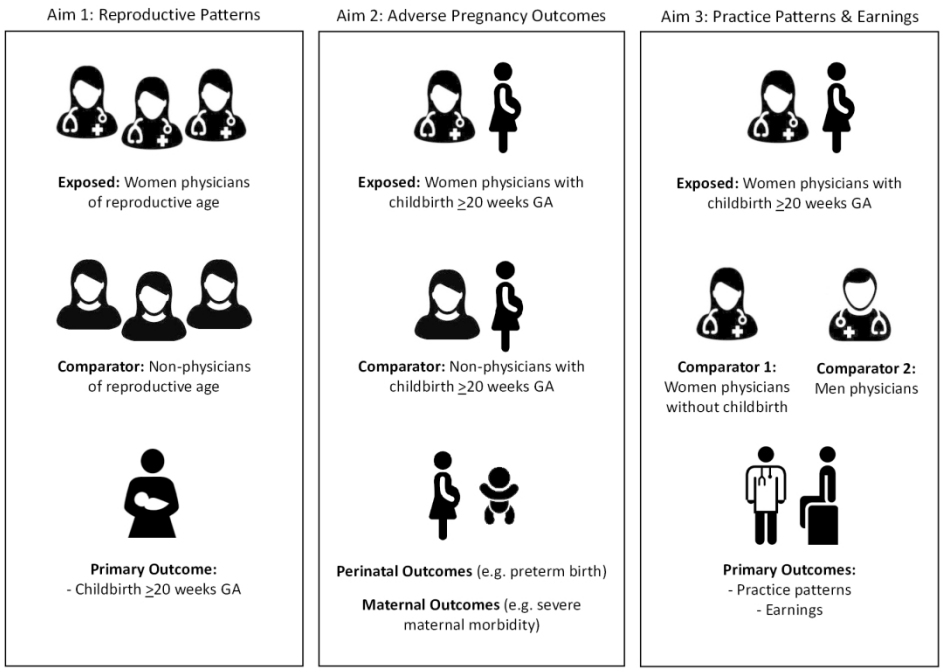

Figure 1. Overview of specific research aims, with study populations (including exposed and comparator groups) and study outcomes.

254x190mm (200 x 200 DPI)

SUPPLEMENTAL INFORMATION

Supplemental Table 1. Variable list from the College of Physicians & Surgeons of Ontario

Supplemental Table 2. Datasets from CPSO and ICES for use in proposed research studies

Supplemental Table 3. Perinatal and maternal adverse pregnancy outcomes

Supplemental Table 4. STROBE checklist for study

Supplemental Table 1. Variable list from the College of Physicians & Surgeons of Ontario

Reported Fields	Field Description
CPSO #	CPSO license number and unique identifier
First name	First and middle names
Last name	Surname
Gender	Male or female designation provided by member upon application for license
Registration status (current status)	Membership status with the CPSO (current as of query date): i. Active ii. Expire iii. Suspended iv. Revoked
Registration class (status at time of registration)	Type of license member held at time of registration: i. Independent Practice (IP) – Permits independent practice in the areas of medicine in which the physician is educated and experienced. ii. Postgraduate Education (PG) – Permits supervised practice after graduation from medical school, and is required for postgraduate (residency) medical training at an Ontario medical school. iii. Restricted (R) – Must practice in accordance with the specific terms and conditions imposed on the certificate. iv. Academic Practice (AP) – May practice only in the medical school department in which the physician holds an academic appointment. v. NOT INCLUDED: Academic Visitor (AV) – May practice only in the medical school department in which the physician holds an academic appointment. vi. NOT INCLUDED: Short Duration (SD) – May practice only to the extent required by the short duration appointment at a public hospital, psychiatric facility or medical school.
First ever registration date	Date of initial registration with the CPSO (YYYMMDD)
Medical school	School where member obtained undergraduate medical degree
Graduation year	Year the member graduated from undergraduate medical school
Practice address type	Self-reported information that describes either: i. Primary Practice – Main practice location ii. Secondary Practice – Alterative practice location(s)
Practice address	Member's primary and secondary practice addresses (first practice address available on file; if no address available, leave blank)
Practice city	City or municipality of member's primary and secondary practice address
Practice province	Province of member's primary and secondary practice addresses
Practice postal code	Postal code of member's primary and secondary practice addresses
Specialty type	Specialty designation certified by one of the following: i. Royal College of Physicians and Surgeons of Canada ii. College of Family Physicians Canada iii. College of Physicians and Surgeons of Ontario

Specialty (status at time of registration)	Description of specialty or subspecialty as per RCPSC or CFPC (for example, obstetrics and gynecology; cardiology; orthopedic surgery, Family Medicine)
Specialty (current status)	Description of specialty or subspecialty as per RCPSC or CFPC (for example, obstetrics and gynecology; cardiology; orthopedic surgery, Family Medicine)
Language of practice (status at time of registration)	Language in which member is competent to conduct practice (self-reported)

Abbreviations: CPSO (College of Physicians and Surgeons of Ontario); RCPSC (Royal College of Physicians and Surgeons of Canada); CFPC (College of Family Physicians Canada)

Supplemental Table 2. Datasets from CPSO and ICES for use in proposed research studies

Database	Description	Data Elements	Available Range
College of Physicians and Surgeons of Ontario (CPSO)	Information about all physicians who initially registered for a license to practice medicine in Ontario.	Physician identifiers (encrypted), gender, date of initial registration, registration status, registration class, medical school, graduation year, practice information, specialty, language of practice	January 1, 1990 – November 26, 2018.
Ontario Health Insurance Plan (OHIP) Claims Database	Includes most claims paid by OHIP to physicians, groups, and laboratories from July 1991.	Physician and patient identifiers (encrypted), codes for services provided, date of service, associated diagnosis, fee paid	July 1991 – February 2020
Canadian Institute for Health Information (CIHI) Discharge Abstract Databases (DAD)	Contains patient-level data for acute, rehab, chronic and day surgery institutions in Ontario. Also contains information on patient co-morbidities at the time of admission. Includes ICD-10 codes.	Patient demographics (sex, date of birth, postal code, county/residence), clinical information (diagnoses, procedures, physicians), administrative data (institution number, admission category, length of stay, discharge disposition)	April 1988 – December 2019
CIHI Same Day Surgery Database (SDS)	Contains information on same-day surgical procedures.	Institution, procedures	April 1991 – March 2019
CIHI National Ambulatory Care Reporting System (NACRS)	Captures information of patient visits to hospital and community-based ambulatory care, including day surgery, outpatient clinics, and emergency department from July 2000 onwards.	Emergency room visits	July 2000 – March 2019
Ontario Mental Health Reporting System (OMHRS)	Data on patients in adult designated inpatient mental health beds.	Admission histories, reason for admission, psychiatric diagnoses	October 2005 – March 2019

Client Agency Program Enrolment (CAPE)	Data on the enrolment of patients in a primary care program with a specific practitioner or group. Obtained from the Ministry of Health and Long-Term Care.	Ascertainment of practice model for family physicians	March 1999 – Feb 2020
Ontario Laboratories Information System (OLIS)	Information on laboratory tests ordered by providers, including patient information and test results.	Patient demographics, provider information, specimen information, and results of laboratory tests	January 2007 – December 2017
ICES Physicians Database (IPDB)	Includes information from the Ontario Health Insurance Plan (OHIP) Corporate Provider Database (CPDB), the Ontario Physician Human Resource Data Centre (OPHRDC) database and the OHIP database of physician billings. It contains yearly information about all physicians in Ontario on a fiscal-year basis.	Physician demographics (age, sex); specialty; location; measures of physician activity (billings, workload, types or services provided)	January 1992 – December 2017
Registered Persons Database (RPDB)	A vital statistics registry; provides basic demographic information about anyone who has ever received an Ontario health card number. Data supplied by the Ontario Ministry and enriched with information from other ICES in-house datasets. April 1990 onwards.	Date of birth, sex, date of death, date of last contact, best known postal code, health care eligibility	April 1991 – January 2020
Ontario Census Area Profiles (CENSUS)	Information on constituent income and other demographic information, collected by Statistics Canada.	Income quintile	Up to 2016
Local Health Integration Network (LHIN)	Fourteen geographic areas within Ontario within which residents receive most of their hospital care from local hospitals.	LHIN number, name, population, localization index, number of high-volume hospitals, list of high-volume hospitals (names and institution numbers)	Up to 2009

Information about Ontario health care institutions funded by the Ministry of Health and Long-Term Care (INST)	Contains information about Ontario health care institutions funded by the Ministry of Health and Long-Term Care.	Hospital information	April 1987-December 2017
Ontario Mother-Baby Linked Database (MOMBABY)	Data on all inpatient admission records to mothers and their newborns delivered since 1988.	Perinatal health information, pregnancy information (includes stillbirths, terminations, live births)	April 1988 – March 2019
Ontario Marginalization Index (ONMARG)	Assesses socioeconomic vulnerability based on place of residence.	Residential instability, material deprivation, dependency and ethnic concentration	Up to 2016
Ontario Hypertension Database (HYPER)	ICES-derived cohort. Contains information on individuals diagnosed with hypertension.	Diagnosis of hypertension	April 1991 – March 2019
Ontario Diabetes Database (ODD)	ICES-derived cohort. Contains information on individuals being treated for diabetes.	Diagnosis of diabetes	April 1991 – March 2019
Office of the Registrar General – Deaths (ORGD)	A vital statistics registry for death and cause of death.	Date and cause of death	January 1990 – December 2017
Immigration, Refugees and Citizenship Canada (IRCC)'s Permanent Resident Database (CIC)	Contains landing records for every permanent legal immigrant to Canada from 1985-2012.	Date of landing, immigration class Canadian language ability, level of education	January 1985-May 2017
Better Outcomes Registry and Network (BORN)	Detailed variables on all Ontario hospital births over 20 weeks' gestational age. Data from fertility clinics, specialized antenatal clinics, prenatal screening laboratories, midwifery practice groups, and newborn screening laboratories.	Pregnancy: Antenatal provider, corticosteroid use, maternal body mass index, first trimester visit, flu-like illness in pregnancy, multiple gestation, health problems, prior obstetrical history, smoking, reproductive assistance, screening labs, fetal anomalies	April 2006 – March 2014

		Delivery: Mode/assistance, labour augmentation, Caesarean section indication, gestational age at birth, indication & method of induction, institution, fetal surveillance, labour type, maternal pain management, laceration, episiotomy, intrapartum complications) Baby: Large for gestational age, APGAR scores, cord pH, date of birth, sex, birthweight, linkage information, date of discharge or transfer, neonatal death, newborn resuscitation, reason for neonatal transfer Postpartum: Breastfeeding data	

Supplemental Table 3. Perinatal and maternal adverse pregnancy outcomes

Outcome	Definition	Source	Codes
Perinatal			
Preterm birth	Livebirth from 23-36 weeks GA	MOMBABY	M_STILLBIRTH=F 23 <= B_GESTWKS_DEL <= 36 (if missing use M_GESTWKS_DEL)
Extreme preterm birth	Livebirth at 23-31 weeks GA	MOMBABY	M_STILLBIRTH=F 23 <= B_GESTWKS_DEL <= 31 (if missing use M_GESTWKS_DEL)
Small for gestational age	Birthweight <10th percentile for sex and gestational age	MOMBABY	B_WEIGHT <10th percentile for B_SEX and B_GESTWKS_DEL (if missing use M_GESTWKS_DEL)
Severe small for gestational age	Birthweight <5th percentile for sex and gestational age	MOMBABY	B_WEIGHT <5th percentile for B_SEX and B_GESTWKS_DEL (if missing use M_GESTWKS_DEL)
NICU admission	Admission to neonatal intensive care for newborn on delivery admission	CIHI-DAD	SCU
Stillbirth	Stillbirth at ≥20 weeks GA	MOMBABY	M_STILLBIRTH=T
Neonatal death	Death of infant less than from birth until 28 days postpartum	MOMBABY	DTHDATE within 28 days of index date
Maternal			
Severe maternal morbidity	Composite endpoint of severe maternal complications	CIHI-DAD	See Ray et al., 2018: (48)
Hypertensive disorder of pregnancy	Composite endpoint of gestational hypertension, pre-eclampsia, and eclampsia	CIHI-DAD OHIP	Gestational hypertension: ICD9: 642.0, 642.3, 642.9; ICD10: O13, O16 Pre-eclampsia/eclampsia: ICD9: 642.4, 642.5, 642.6, 642.7; ICD10: O11, O14, O15; OHIP: 642

Preterm premature rupture of membranes	Defined as rupture of membranes prior to 37 weeks GA	CIHI-DAD, MOMBABY	ICD9: 658.1, 658.2 + MOM_GESTWKS_ADM<37 ICD10: O42 + MOM_GESTWKS_ADM<37
Preterm labour without preterm birth	Hospital visit or admission for threatened preterm labour but with delivery ≥37 weeks GA	CIHI-DAD, NACRS	ICD9: 644.0, 644.1 ICD10: O60.0
Maternal death	Death of mother from 20 weeks GA until 42 days postpartum	RPDB	DTHDATE from date of 20 weeks GA to date of 42 weeks postpartum

Abbreviations: GA (gestational age); MOMBABY (ICES-derived Mother Baby Linked Dataset); CIHI (Canadian Institute of Health Information); DAD (Discharge Abstract Database); OHIP (Ontario Health Insurance Plan); ICD (International Classification of Disease); NA (not applicable)

Supplemental Table 4. STROBE checklist for study

	Item No	Recommendation	Page Location
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	3	State specific objectives, including any pre-specified hypotheses	6-7
Methods			
Study design	4	Present key elements of study design early in the paper	7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-11
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	10-11
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	10-11
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	10-11, 14-18
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	7-14
Bias	9	Describe any efforts to address potential sources of bias	4, 11-14
Study size	10	Explain how the study size was arrived at	N/A
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	N/A
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	14-18
		(*b*) Describe any methods used to examine subgroups and interactions	14-18

		(*c*) Explain how missing data were addressed	11-14
		(*d*) If applicable, explain how loss to follow-up was addressed	11
		(*e*) Describe any sensitivity analyses	N/A
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	N/A
		(b) Give reasons for non-participation at each stage	N/A
		(c) Consider use of a flow diagram	N/A
Descriptive data	14*	(a) Give characteristics of study participants (e.g. demographic, clinical, social) and information on exposures and potential confounders	N/A
		(b) Indicate number of participants with missing data for each variable of interest	N/A
		(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	N/A
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	N/A
		(*b*) Report category boundaries when continuous variables were categorized	N/A
		(*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—e.g. analyses of subgroups and interactions, and sensitivity analyses	N/A
Discussion			
Key results	18	Summarise key results with reference to study objectives	N/A
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	4, 11-14
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	N/A

Generalisability	21	Discuss the generalisability (external validity) of the study results	N/A
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	20-21

*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.