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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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3 **1 Reproductive patterns, pregnancy outcomes, and parental leave practices of women**
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5 **2 physicians in Ontario, Canada: the Dr. Mom Cohort Study protocol**
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1
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3 24 **ABSTRACT**
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6 25 **Introduction:** Surveys and qualitative studies suggest that women physicians may delay
7
8 26 childbearing, be at increased risk of adverse peripartum complications when they do become
9
10 27 pregnant, and face discrimination and lower earnings as a result of parenthood. Observational
11
12 28 studies enrolling large, representative samples of women physicians are needed to accurately
13
14 29 evaluate their reproductive patterns, pregnancy outcomes, parental leave practices, and
15
16 30 earnings. This protocol provides a detailed research plan for such studies.
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19

20 31 **Methods & Analysis:** All practicing physicians in Ontario, Canada, are registered with the
21
22 32 College of Physicians and Surgeons of Ontario (CPSO). By linking a dataset of physicians from
23
24 33 the CPSO to existing provincial administrative databases, which hold health data and physician
25
26 34 billing records, we will be able to assess the reproductive healthcare utilization, work practices,
27
28 35 and pregnancy outcomes of women physicians at the population-level. Specific outcomes of
29
30 36 interest include: (1) rates and timing of pregnancy; (2) pregnancy-related care and complications;
31
32 37 and (3) duration of parental leave and subsequent earnings.
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37 38 **Ethics & Dissemination:** This protocol has been approved by the Research Ethics Board at St.
38
39 39 Michael's Hospital in Toronto, Ontario, Canada (#18-248). We will disseminate findings through
40
41 40 several peer-reviewed publications, presentations at national and international meetings, and
42
43 41 engagement of physicians, residency programs, department heads, and medical societies.
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47 42 **Keywords:** Epidemiology; Obstetrics; Maternal Medicine; General Medicine; Medical
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49 43 Education & Training; Surgery
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45 STRENGTHS & LIMITATIONS OF THIS STUDY

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

58 INTRODUCTION

59 Despite a marked increase in the number of women entering medicine over the last
60 50 years (1, 2), the challenges associated with becoming pregnant and having children during
61 training or clinical practice have been minimally addressed (3). Evidence from qualitative studies
62 and surveys of women physicians raise concerns that pregnancy and motherhood may jeopardize
63 career advancement, reduce job and fellowship opportunities, negatively impact referral patterns,
64 and result in resentment from colleagues who may feel hampered with a greater workload (3-10).
65 Inconsistent institutional support for pregnant women and parents, and the reality that physician
66 mothers usually bear a disproportionate burden of home and parenting obligations compared to
67 physician fathers, may exacerbate these problems (11-16). In part because of these issues, it is
68 thought that women physicians may delay childbearing, have fewer children, or even remain
69 childless more often than men physicians and non-physician women (3, 17-21). However,
70 epidemiologic studies investigating such hypotheses are lacking.

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

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

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3 81 In the only registry-based study published to date, physician occupation was not associated with
4
5 82 preterm labour, low birth weight, or perinatal death compared to women with other white-collar
6
7 83 jobs, but differences across specialties, trainee status, or work intensity were not investigated
8
9
10 84 (34). Since an association between the nature of physicians' work and adverse pregnancy
11
12 85 outcomes is biologically plausible, additional high-quality studies are needed.

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14
15 86 Women physicians face many challenges after pregnancy, and the literature is limited
16
17 87 in this area as well. Although many cross-sectional surveys have identified barriers to obtaining
18
19 88 adequate maternity leave and managing clinical loads around delivery and return to work (5, 12,
20
21 89 35-37), few studies have systematically described the practice patterns of physician mothers (16).
22
23 90 The impact of childbirth and parental leave on the subsequent earnings of women physicians is
24
25 91 also unclear. In one survey, over half of physician mothers reported losing \$10,000 or more in
26
27 92 income due to leave (7). In other fields, a motherhood earnings penalty beyond the gender pay
28
29 93 gap has been noted (38, 39). Although qualitative studies and surveys have underscored a
30
31 94 possibly similar phenomenon in physicians (5-7), observational research is required.

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36 37 96 **SPECIFIC AIMS**

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40 97 In the proposed studies, we will harness unique data resources available in Ontario,
41
42 98 Canada, to address unanswered questions in this field. We will first develop a representative
43
44 99 cohort of Ontario physicians by linking physician registration data to existing provincial health
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46
47 100 administrative data. We will then conduct analyses within specific subgroups of this larger
48
49 101 cohort (Figure 1) to address the following objectives:

- 50
51 102 1) Compare reproductive patterns between women physicians and non-physicians, and
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54 103 determine if physician work characteristics are associated with rates of pregnancy
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3 104 2) Compare pregnancy outcomes and processes of obstetrical care between women
4
5 105 physicians and non-physicians, and determine if physician work characteristics are
6
7 106 associated with adverse pregnancy outcomes
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9
10 107 3) Describe the pregnancy and postpartum work practices of women physicians, and
11
12 108 determine the impact of childbirth on subsequent practice patterns and earnings
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15 109

17 110 **METHODS & ANALYSIS**

19 111 **Cohort development**

21 112 *Rationale & Overview*

23
24 113 Existing studies examining issues around pregnancy in physicians are almost entirely
25
26 114 self-report surveys with moderate response rates and small sample sizes, susceptible to selection
27
28 115 and misclassification bias. We will address this limitation by developing and studying a cohort of
29
30 116 practicing physicians registered with the College of Physicians and Surgeons of Ontario (CPSO),
31
32 117 linked to existing Ontario population-based administrative databases.
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37 119 *Data Sources*

40 120 *CPSO Database*

42 121 The CPSO is the body that regulates the practice of medicine in Ontario. Physicians are
43
44 122 required to be members of the CPSO to practice medicine in the province. The CPSO also has a
45
46 123 legislated mandate to continuously improve the quality of care provided by physicians, by
47
48 124 maintaining standards of medical practice through peer assessment and remediation.
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51 125 To do this, the CPSO maintains a database of all physicians who have registered to
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53 126 practice medicine in Ontario. We obtained a dataset of physicians who registered with the CPSO
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3 127 from January 1, 1990 to November 26, 2018 (Supplemental Table 1). This dataset has variables
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5 128 on physicians' registration status, medical school, year of graduation, practice location, and
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7 129 specialty, collected at one or two possible time points: (1) the date of physicians' initial
8
9
10 130 registration, and/or (2) the most recent data query.

11
12 131 Physicians of all age and genders in the CPSO dataset were probabilistically linked to
13
14 132 existing provincial administrative databases using physicians' given name, surname, gender, and
15
16 133 date of birth. Subsets of this larger linked cohort will be used to address each aim (Figure 1). The
17
18 134 linkage of the CPSO dataset to existing Ontario administrative databases enables assessment of
19
20 135 physicians' health service utilization and health outcomes.
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24 136 25 26 137 *Ontario Administrative Databases*

27
28 138 All provincial administrative databases (Supplemental Table 2) required to establish the
29
30 139 cohorts, exposures, outcomes, and covariates specific to each aim are held at ICES, a non-profit
31
32 140 research institute authorized to collect and use health data on Ontario residents for the purposes
33
34 141 of health system evaluation and improvement. Collection and compilation of health records at
35
36 142 ICES is possible because Ontario residents have universal access to physician services and
37
38 143 hospital-based care through the Ontario Health Insurance Plan (OHIP). ICES databases
39
40 144 are linked using unique OHIP numbers that are assigned to each individual.
41
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44 145 Demographic data will be identified from several ICES databases. Vital statistics and
45
46 146 postal code of residence, used to derive rurality and area-level income quintile from Canadian
47
48 147 census data, will be obtained from the Registered Persons Database (RPDB). Immigration status
49
50 148 will be obtained from the Ontario portion of Immigration, Refugees, and Citizenship Canada's
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53 149 Permanent Resident Database. Marginalization, another area-level measure of socioeconomic
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3 150 status based on residential instability, material deprivation, dependency, and ethnic
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5 151 concentration, will be obtained from the Ontario Marginalization Index.
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7
8 152 Comorbidities will be ascertained from the Canadian Institute for Health Information
9
10 153 (CIHI) Discharge Abstract Database (DAD), which holds diagnostic/procedural information on
11
12 154 inpatient hospital stays since 1988; the Same Day Surgery (SDS) database, which holds records
13
14 155 for same day procedures since 1991; the National Ambulatory Care Reporting System (NACRS),
15
16 156 which holds records on emergency department visits since 2000; and the OHIP database, which
17
18 157 holds physician billing claims for health services since 1991. Several Ontario-specific registries
19
20 158 and ICES-derived cohorts, including the Ontario Cancer Registry, Ontario Diabetes Dataset,
21
22 159 and Ontario Hypertension Dataset, can also be used identify specific medical conditions.
23
24

25
26 160 Childbirths and other recognized pregnancies (e.g. spontaneous abortions, ectopic
27
28 161 pregnancies) will be identified from the ICES-derived Mother-Baby Dataset (MOMBABY),
29
30 162 which links the CIHI records of delivering mothers and their newborns; the Better Outcomes
31
32 163 Registry and Network (BORN), Ontario's perinatal registry including data from fertility clinics,
33
34 164 specialized antenatal clinics, hospitals, midwifery practice groups, and both prenatal & newborn
35
36 165 screening laboratories; as well as the DAD, SDS, OHIP, and NACRS databases (Supplemental
37
38 166 Table 2-3). Adverse pregnancy-related and mental health outcomes will be obtained from these
39
40 167 same databases and as the Ontario Mental Health Reporting System (OMHRS) database, which
41
42 168 holds data on patients in adult designated inpatient mental health beds. Prenatal, antepartum,
43
44 169 intrapartum, and postpartum health service utilization, including assisted reproductive
45
46 170 technology, will be obtained from the OHIP, DAD/SDS, and BORN databases.
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51 171 The work practices and earnings of Ontario physicians will be obtained from the OHIP
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53 172 database; 95% of specialists and 50% of primary care physicians receive their income from fee-
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3 173 for-service (FFS) billings, and all Ontario physicians are required to submit shadow billings for
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5 174 non-FFS services. The frequency and timing of physicians' billing claims for health services and
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7 175 surgical procedures will be used to establish measures of work intensity such as overnight work,
8
9 176 and evening and weekend shiftwork, before, during, and after pregnancy. Physician earnings will
10
11 177 be derived from total OHIP billings. Practice model for family physicians will be obtained from
12
13 178 the Client Agency Program Enrolment (CAPE) database. Specialty, trainee status, and practice
14
15 179 location, will be obtained from the CPSO dataset and the ICES-derived Physician Database
16
17 180 (IPDB), which contains updated yearly information about physicians in Ontario.
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182 ***Study Populations & Exposure Assessment***

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26 183 Study populations will depend on the aim (Figure 1). Aim 1 will include Ontario
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28 184 women of reproductive age (15-50 years). Aim 2 will include Ontario women of reproductive
29
30 185 age who have had at least one childbirth ≥ 20 weeks gestational age (GA). In both Aims 1 and 2,
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32 186 physician occupation will be the main exposure of interest; we will compare women physicians
33
34 187 (exposed) to non-physicians (comparator). Physicians will be selected from the CPSO dataset.
35
36 188 Non-physicians will be selected from the RPDB, and randomly assigned a simulated CPSO
37
38 189 registration date based on the distribution of registration dates in physicians.
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42 190 Aim 3 will include women and men physicians of reproductive age. Childbirth ≥ 20
43
44 191 weeks GA will be the main exposure of interest; we will compare women physicians who have
45
46 192 had at least one childbirth (exposed) to: (1) women physicians who have had no childbirths, and
47
48 193 (2) men physicians (comparator). Comparator physicians will be randomly assigned a simulated
49
50 194 date of childbirth based on the distribution of childbirth dates in women physicians.
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195

196 ***Covariates***

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

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

208 ***Anticipated Challenges & Mitigation Strategies***

209 *Variable Follow-Up*

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

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

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3 219 a 32-year-old American physician with one prior childbirth moving to Ontario to practice would
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5 220 have no record of that birth in ICES databases. To mitigate this, we will truncate the look-back
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7 221 of non-physicians to mirror that of matched physicians so that they undergo an identical
8
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10 222 process of ascertaining covariates. This will facilitate appropriate comparison.
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12 223

14 224 *Determining Transition to Independent Practice*

16
17 225 The CPSO database contains one variable describing the type of license (e.g.
18
19 226 postgraduate education, independent practice, etc.) held by physicians at the time of their initial
20
21 227 registration with the CPSO (Supplemental Table 1). Preliminary analyses demonstrate that 90%
22
23 228 of reproductive-age physicians first registered as residents/fellows on a postgraduate education
24
25 229 license. However, the CPSO database does not hold information on license changes, or when
26
27 230 physicians transition from postgraduate education to independent practice.
28
29

30
31 231 To mitigate this, we plan to use OHIP data to identify the transition from training to
32
33 232 practice. Physicians with a postgraduate education license receive a salary from the provincial
34
35 233 Ministry of Health and Long-Term Care, while physicians with an independent practice license
36
37 234 receive an income by submitting billings to OHIP. We will use physicians' initiation of billings
38
39 235 in OHIP as indicator of their transition from training to practice.
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42 236

44 237 *Determining Physician Specialty*

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47 238 The CPSO database contains two variables describing the specialty of physicians
48
49 239 (Supplemental Table 1): one is collected at initial registration with the CPSO, and the other is
50
51 240 collected at the most recent data query. Specialty is not formally assigned until after physicians
52
53 241 finish residency training and are certified for practice by either the Royal College of Physicians
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242 and Surgeons of Canada or the College of Family Physicians of Canada, despite the fact that
243 they have been working in that specialty for several years.

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

250

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

252 *Rationale & Overview*

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

259

260 *Analysis Plan*

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

1
2
3 265 general population, and matched or adjusted time-to-event analyses will be used to evaluate the
4
5 266 independent association of physician occupation with rates of childbirth. We will also examine
6
7 267 secondary outcomes such as number of childbirths, number of recognized pregnancies, and
8
9 268 maternal age at childbirth, among physicians and non-physicians.

12 269 We also aim to determine whether specific work-related factors faced by physicians
13
14 270 impact their reproductive patterns and rates of childbirth. Adjusted time-to-event and Poisson
15
16 271 regression models will be constructed in women physicians only to evaluate whether variables
17
18 272 such as specialty, trainee status, and frequency of overnight work are associated rates of
19
20 273 childbirth and other secondary outcomes respectively.
21
22 274

26 275 **Aim 2: Compare adverse pregnancy outcomes in women physicians and non-physicians**

28 276 *Rationale & Overview*

31 277 It is unclear how work as a physician and related characteristics such as night shifts
32
33 278 and working hours impact obstetrical outcomes. A recent systematic review demonstrated that
34
35 279 pregnant women who work shifts or longer hours have increased odds of preterm birth and other
36
37 280 adverse outcomes, but all included studies were at substantial risk of bias, and only one pertained
38
39 281 specifically to physicians (25). Surveys of residents show an association between increased work
40
41 282 intensity and adverse outcomes, but exposures were obtained by recall and defined inconsistently
42
43 283 across studies (27, 31, 45). We will be able to reliably establish work characteristics prior to and
44
45 284 during pregnancy from OHIP, and thus provide unique insight into the association between
46
47 285 physician occupation and adverse pregnancy outcomes.
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49 286

54 287 *Outcomes*

1
2
3 288 We will evaluate adverse pregnancy outcomes among Ontario women physicians and
4
5 289 non-physicians of reproductive age who have experienced at least one childbirth ≥ 20 weeks GA.
6
7
8 290 All outcomes of interest were chosen for their clinical relevance and established methodology for
9
10 291 ascertainment from ICES databases such as MOMBABY, DAD, and OHIP, using standard
11
12 292 diagnostic and procedural codes (46-54) (Supplemental Table 3).

13
14 293 Perinatal outcomes include: preterm birth (delivery at < 37 weeks GA); low birthweight;
15
16 294 stillbirth; neonatal intensive care unit (NICU) admission; and neonatal death at < 28 days of life.
17
18
19 295 Maternal outcomes include: severe maternal morbidity (a composite endpoint of potentially life-
20
21 296 threatening complications occurring during the index pregnancy) (48); maternal death (from 20
22
23 297 weeks GA to ≤ 42 days postpartum); new onset hypertensive disorders in the index pregnancy;
24
25 298 other obstetric (e.g. premature rupture of membranes) and non-obstetric complications (e.g.
26
27 299 peripartum mood disorders); and processes of obstetrical care (e.g. antenatal care, labour
30
31 300 induction, mode of delivery, epidural).

32
33 301

34 35 302 ***Analysis Plan***

36
37 303 Unmatched logistic regression will be performed to compare each adverse pregnancy
38
39 304 outcome specified above between physicians and the general population. Matched or adjusted
40
41 305 logistic regression analyses, accounting for demographic and clinical covariates as described
42
43 306 above, will be performed to isolate the independent association of physician occupation with
44
45 307 adverse pregnancy outcomes. We also aim to determine whether specific work-related factors
46
47 308 faced by physicians influence their pregnancy outcomes. Adjusted logistic regression models
48
49 309 will be constructed in women physicians only to evaluate whether variables such as specialty,
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51 310 trainee status, and overnight work are associated with adverse pregnancy outcomes. For all
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3 311 analyses described, we will also consider use of log-binomial or modified Poisson
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5 312 regression models to determine risk ratios directly.
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10 314 **Aim 3: Compare practice patterns and earnings of women physicians experiencing**
11
12 315 **childbirth to non-parent physicians**
13

14 316 ***Rationale & Overview***

15
16
17 317 Although the challenges faced by both medical trainees and practicing physicians in
18
19 318 taking parental leave have been documented in the literature (5, 12, 35-37), the work and leave
20
21 319 practices of physician mothers in Canada are unknown. The financial implications of pregnancy
22
23 320 and childbirth on physician earnings are also unclear. Whether a “motherhood earnings penalty”
24
25 321 exists for physicians (38, 39) remains unclear but would be of significant concern to physicians
26
27 322 practicing in Canada, the majority of whom are self-employed. We aim to describe the parental
28
29 323 leave patterns and earnings of Ontario physicians using a rigorous observational design.
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33 324
34
35 325 ***Analysis Plan***

36
37 326 We will evaluate practice patterns and earnings of men and women physicians in Ontario
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39 327 of reproductive age. We will hard-match women physicians who have had at least one childbirth
40
41 328 to women physicians who have had no childbirths, and to men physicians, on their specialty and
42
43 329 year of graduation from medical school. Physicians who have delivered will enter the study on
44
45 330 their obstetrical delivery date, and physicians who have not delivered will be assigned a
46
47 331 corresponding referent date.
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51 332 In women physicians who have delivered, we will examine: (1) length of leave, defined
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53 333 by the absence of OHIP billings adjacent to the delivery date; and (2) timing of leave, defined in
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3 334 relation to the delivery date. In all physicians, we will examine: (1) work intensity, defined as
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5 335 mentioned previously through evaluation of measures such as overnight call practices and
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8 336 operating time; (4) earnings, as defined by OHIP billings.
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10 337 We will compare earnings across three distinct 2-year periods: (1) pre-pregnancy, (2)
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12 338 peripartum; and (3) post-pregnancy. We will first perform a within-patient analysis pertaining to
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14 339 delivering women physicians only, in order to assess how their earnings vary with pregnancy and
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16 340 childbirth. Earnings from all three time periods will be compared using regression methods for
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18 341 cost data (e.g. Poisson, negative binomial, gamma models); the specific model will be
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20 342 determined based on the distribution of earnings for the cohort.
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24 343 We will then perform a comparative analysis of (a) delivering women physicians to non-
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26 344 delivering women physicians, and (b) delivering women physicians to men physicians. Earnings
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28 345 from the pre-pregnancy and post-pregnancy time periods, or dummy time periods in controls,
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30 346 will again be evaluated with appropriate regression methods for cost data.
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34 348 **Sample Size and Power**

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37 349 The CPSO dataset should have adequate power for all proposed analyses. To
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39 350 demonstrate this, we have calculated the power of our study to find differences in adverse
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41 351 pregnancy outcomes, specifically preterm birth, between women physicians and non-physicians
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43 352 (Specific Aim 2). Preterm birth is a major determinant of neonatal morbidity/mortality, and has
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45 353 significant long-term health consequences. Even a small increased risk of preterm birth would
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47 354 be of importance to women physicians.
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51 355 If a conservative 5,000 physicians have at least one pregnancy during the study period,
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53 356 are compared to at least 25,000 non-physicians, and we assume a baseline preterm birth rate of
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3 357 7.7 per 100 births (55) and an alpha of 0.05, we will have 80% power to detect a relative risk of
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5 358 1.16 or greater, and 90% power to detect a relative risk of 1.19 or greater.
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9 10 360 **Patient and Public Involvement**

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12 361 The public were not involved in the design of this study. The proposed research questions
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14 362 aim to address issues of importance to physician health; the study team accordingly includes
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17 363 women physicians and physician parents.
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20 21 365 **SIGNIFICANCE**

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24 366 The linkage of physician information to population-based data on pregnancy presents a
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26 367 unique opportunity to evaluate physicians' reproductive patterns and perinatal health outcomes
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28 368 in a manner that addresses the limitations of previous studies. Ontario's fee-for-service system
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31 369 allows accurate ascertainment of physician work intensity and other work-related factors that
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33 370 may affect rates of reproduction and adverse pregnancy outcomes.
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35 371 This work is needed; reproductive patterns and childbearing have not been rigorously
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37 372 studied in physicians, despite many barriers to pregnancy and risk factors for adverse outcomes
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39 373 inherent in their work. We will determine if physicians are at increased risk of adverse pregnancy
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41 374 outcomes compared to the general population, and clarify whether this risk is mediated by age or
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43 375 other occupational hazards. Understanding issues around pregnancy and leave, which may affect
44
45 376 up to half of the physician workforce at some point during their careers, also has implications for
46
47 377 the functioning of the healthcare system.
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52 53 379 **ETHICS & DISSEMINATION**

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3 380 This protocol was approved by the Research Ethics Board at St. Michael's Hospital
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5 381 (#18-248) and by the ICES Privacy & Legal Office. ICES is a prescribed entity under section 45
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7 382 of Ontario's Personal Health Information Protection Act. Section 45 authorizes ICES to collect
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9 383 personal health information without consent for analyses related to the evaluation of, allocation
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11 384 of resources to, or planning for all or part of the health system. In accordance with ICES policy,
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13 385 we will suppress all cells with <6 individuals to prevent re-identification. All research outputs
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15 386 related to this work will undergo a re-identification risk assessment prior to submission.
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19 387 Translation of the findings of our study into practices and policies will require
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21 388 engagement of physicians, physician leaders, and organizational bodies. The team of researchers
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23 389 includes clinician-investigators in obstetrics, surgery, medicine, and psychiatry who will provide
24
25 390 important contextual information to the dissemination of our findings. We will engage bodies
26
27 391 such as the Society of Obstetricians and Gynaecologists of Canada (SOGC), the Canadian
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29 392 Medical Association (CMA), and residency programs and department heads.
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33 393 We anticipate that our findings will be presented at local and national conferences, and
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35 394 result in several peer-reviewed publications. Our findings should impact physicians, physicians-
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37 395 in-training, medical educators, residency program directors, department chairs, and hospitals and
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39 396 organizations where physicians work.
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13
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22
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35 413 **AUTHOR CONTRIBUTIONS**
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38 414 All authors contributed to the design of this study. NNB, AXG, and ANS participated in
39
40 415 data acquisition. MCC, NNB, RS, JGR, EM, and ANS developed the analytic plan. MCC, NNB,
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42 416 and ANS obtained ethics approval for this work. MCC and ANS prepared the first draft of the
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44 417 manuscript. All authors contributed to and approved the final version of the manuscript.
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49 419 **COMPETING INTERESTS STATEMENT**
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52 420 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

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3 **FIGURE LEGENDS**
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8 **Figure 1.** Overview of specific research aims, with study populations (including exposed and
9 comparator groups) and study outcomes.
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Aim 1: Reproductive Patterns



Exposed: Women physicians of reproductive age



Comparator: Non-physicians of reproductive age



Primary Outcome:
- Childbirth ≥ 20 weeks GA

Aim 2: Adverse Pregnancy Outcomes



Exposed: Women physicians with childbirth ≥ 20 weeks GA



Comparator: Non-physicians with childbirth ≥ 20 weeks GA



Perinatal Outcomes (e.g. preterm birth)

Maternal Outcomes (e.g. severe maternal morbidity)

Aim 3: Practice Patterns & Earnings



Exposed: Women physicians with childbirth ≥ 20 weeks GA



Comparator 1:
Women physicians without childbirth



Comparator 2:
Men physicians



Primary Outcomes:
- Practice patterns
- Earnings

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3 **SUPPLEMENTAL INFORMATION**
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8 **Supplemental Table 1.** Variable list from the College of Physicians & Surgeons of Ontario
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12 **Supplemental Table 2.** Datasets from CPSO and ICES for use in proposed research studies
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17 **Supplemental Table 3.** Perinatal and maternal adverse pregnancy outcomes
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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): <ul style="list-style-type: none"> i. Active ii. Expire iii. Suspended iv. Revoked
Registration class (status at time of registration)	Type of license member held at time of registration: <ul style="list-style-type: none"> 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 (YYMMDD)
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: <ul style="list-style-type: none"> i. Primary Practice – Main practice location ii. Secondary Practice – Alternative 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: <ul style="list-style-type: none"> 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

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		<p>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)</p> <p>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</p> <p>Postpartum: Breastfeeding data</p>	
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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 <10 th 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 <5 th 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 \geq 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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3 **1 Reproductive patterns, pregnancy outcomes, and parental leave practices of women**
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5 **2 physicians in Ontario, Canada: the Dr. Mom Cohort Study protocol**
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26

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3 **29 ABSTRACT**
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6 **30 Introduction:** Surveys and qualitative studies suggest that women physicians may delay
7
8 **31** childbearing, be at increased risk of adverse peripartum complications when they do become
9
10 **32** pregnant, and face discrimination and lower earnings as a result of parenthood. Observational
11
12 **33** studies enrolling large, representative samples of women physicians are needed to accurately
13
14 **34** evaluate their reproductive patterns, pregnancy outcomes, parental leave practices, and
15
16 **35** earnings. This protocol provides a detailed research plan for such studies.
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20 **36 Methods & Analysis:** The Dr. Mom Cohort Study encompasses a series of retrospective
21
22 **37** observational studies of women physicians in Ontario, Canada. All practicing physicians in
23
24 **38** Ontario are registered with the College of Physicians and Surgeons of Ontario (CPSO). By
25
26 **39** linking a dataset of physicians from the CPSO to existing provincial administrative databases,
27
28 **40** which hold health data and physician billing records, we will be able to retrospectively assess the
29
30 **41** healthcare utilization, work practices, and pregnancy outcomes of women physicians at the
31
32 **42** population-level. Specific outcomes of interest include: (1) rates and timing of pregnancy; (2)
33
34 **43** pregnancy-related care and complications; and (3) duration of parental leave and subsequent
35
36 **44** earnings, each of which will be evaluated with regression methods appropriate to the form of the
37
38 **45** outcome. We estimate that, at minimum, 5,000 women physicians will be eligible for inclusion.
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44 **46 Ethics & Dissemination:** This protocol has been approved by the Research Ethics Board at St.
45
46 **47** Michael's Hospital in Toronto, Ontario, Canada (#18-248). We will disseminate findings through
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48 **48** several peer-reviewed publications, presentations at national and international meetings, and
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50 **49** engagement of physicians, residency programs, department heads, and medical societies.
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50 STRENGTHS & LIMITATIONS OF THIS STUDY

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

63 INTRODUCTION

64 Despite a marked increase in the number of women entering medicine over the last
65 50 years (1, 2), the challenges associated with becoming pregnant and having children during
66 training or clinical practice have been minimally addressed (3). Evidence from qualitative studies
67 and surveys of women physicians raise concerns that pregnancy and motherhood may jeopardize
68 career advancement, reduce job and fellowship opportunities, negatively impact referral patterns,
69 and result in resentment from colleagues who may feel hampered with a greater workload (3-10).
70 Inconsistent institutional support for pregnant women and parents, and the reality that physician
71 mothers usually bear a disproportionate burden of home and parenting obligations compared to
72 physician fathers, may exacerbate these problems (11-16). In part because of these issues, it is
73 thought that women physicians may delay childbearing to more advanced maternal ages, or
74 have fewer or no children more often than non-physician women in the general population
75 (3, 17-22). However, epidemiologic studies investigating such hypotheses are lacking.

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

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

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3 86 In the only registry-based study published to date, physician occupation was not associated with
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5 87 preterm labour, low birth weight, or perinatal death compared to women with other white-collar
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7 88 jobs, but differences across specialties, trainee status, or work intensity were not investigated
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10 89 (35). Since an association between the nature of physicians' work and adverse pregnancy
11
12 90 outcomes is biologically plausible, additional high-quality studies are needed.

13
14 91 Women physicians face many challenges after pregnancy, and the literature is limited
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16 92 in this area as well. Although many cross-sectional surveys have identified barriers to obtaining
17
18 93 adequate maternity leave and managing clinical loads around delivery and return to work (5, 12,
19
20 94 36-38), few studies have systematically described the practice patterns of physician mothers (16).
21
22 95 The impact of childbirth and parental leave on the subsequent earnings of women physicians is
23
24 96 also unclear. In one survey, over half of physician mothers reported losing \$10,000 or more in
25
26 97 income due to leave (7). In other fields, a motherhood earnings penalty beyond the gender pay
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28 98 gap has been noted (39, 40). Although qualitative studies and surveys have underscored a
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30 99 possibly similar phenomenon in physicians (5-7), observational research is required.

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36 37 101 **SPECIFIC AIMS**

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39 102 In the proposed studies, we will harness unique data resources available in Ontario,
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41 103 Canada, to address unanswered questions in this field. We will first develop a cohort of all
42
43 104 physicians who registered to practice in Ontario from 1990 to 2018 by linking physician
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45 105 registration data to existing provincial health administrative data. We will then conduct
46
47 106 retrospective analyses within specific subgroups of this larger cohort and a representative sample
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49 107 of non-physicians (Figure 1) to address the following objectives:
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3 108 1) Compare reproductive patterns between women physicians and non-physicians, and
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5 109 determine if physician work characteristics are associated with rates of pregnancy
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8 110 2) Compare maternal outcomes, perinatal outcomes, and processes of obstetrical care
9
10 111 between women physicians and non-physicians, and determine if physician work
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12 112 characteristics are associated with adverse pregnancy outcomes
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15 113 3) Describe the pregnancy and postpartum work practices of women physicians who
16
17 114 experience childbirth, and determine the impact of childbirth on practice patterns and
18
19 115 earnings relative to men physicians and women physicians who do not experience
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21 116 childbirth
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26 118 **METHODS & ANALYSIS**

28 119 **Cohort development**

30 120 *Rationale & Overview*

32
33 121 Existing studies examining issues around pregnancy in physicians are almost entirely
34
35 122 self-report surveys with moderate response rates and small sample sizes, susceptible to selection
36
37 123 and misclassification bias. We will address this limitation by developing and retrospectively
38
39 124 studying a cohort of practicing physicians who registered with the College of Physicians and
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41 125 Surgeons of Ontario (CPSO) from 1990 to 2018, linked to existing Ontario population-based
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43 126 administrative databases.
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49 128 *Data Sources*

51 129 *CPSO Database*

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3 130 The CPSO is the body that regulates the practice of medicine in Ontario. Physicians are
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5 131 required to be members of the CPSO to practice medicine in the province. The CPSO also has a
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8 132 legislated mandate to continuously improve the quality of care provided by physicians, by
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10 133 maintaining standards of medical practice through peer assessment and remediation.

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12 134 To do this, the CPSO maintains a database of all physicians who have registered to
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14 135 practice medicine in Ontario. We obtained a dataset of physicians who registered with the CPSO
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16 136 from January 1, 1990 to November 26, 2018 (Supplemental Table 1). This dataset has variables
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18 137 on physicians' registration status, medical school, year of graduation, practice location, and
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20 138 specialty, collected at one or two possible time points: (1) the date of physicians' initial
21
22 139 registration, and/or (2) the most recent data query.

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26 140 Physicians of all age and genders in the CPSO dataset were probabilistically linked to
27
28 141 existing provincial administrative databases using physicians' given name, surname, gender, and
29
30 142 date of birth. Subsets of this larger linked cohort will be used to address each aim (Figure 1). The
31
32 143 linkage of the CPSO dataset to existing Ontario administrative databases enables assessment of
33
34 144 physicians' health service utilization and health outcomes.

35 36 37 38 39 40 146 *Ontario Administrative Databases*

41
42 147 All provincial administrative databases (Supplemental Table 2) required to establish the
43
44 148 cohorts, exposures, outcomes, and covariates specific to each aim are held at ICES, a non-profit
45
46 149 research institute authorized to collect and use health data on Ontario residents for the purposes
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48 150 of health system evaluation and improvement. Collection and compilation of health records at
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50 151 ICES is possible because Ontario residents have universal access to physician services and
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3 152 hospital-based care through the Ontario Health Insurance Plan (OHIP). ICES databases
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5 153 are linked using unique OHIP numbers that are assigned to each individual.
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8 154 Demographic data will be identified from several ICES databases. Vital statistics and
9
10 155 postal code of residence, used to derive rurality and area-level income quintile from Canadian
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12 156 census data, will be obtained from the Registered Persons Database (RPDB). Immigration status
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14 157 will be obtained from the Ontario portion of Immigration, Refugees, and Citizenship Canada's
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16 158 Permanent Resident Database. Marginalization, another area-level measure of socioeconomic
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18 159 status based on residential instability, material deprivation, dependency, and ethnic
19
20 160 concentration, will be obtained from the Ontario Marginalization Index.
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23
24 161 Comorbidities will be ascertained from the Canadian Institute for Health Information
25
26 162 (CIHI) Discharge Abstract Database (DAD), which holds diagnostic/procedural information on
27
28 163 inpatient hospital stays since 1988; the Same Day Surgery (SDS) database, which holds records
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30 164 for same day procedures since 1991; the National Ambulatory Care Reporting System (NACRS),
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32 165 which holds records on emergency department visits since 2000; and the OHIP database, which
33
34 166 holds physician billing claims for health services since 1991. Several Ontario-specific registries
35
36 167 and ICES-derived cohorts, including the Ontario Cancer Registry, Ontario Diabetes Dataset,
37
38 168 and Ontario Hypertension Dataset, can also be used identify specific medical conditions.
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41
42 169 Childbirths and other recognized pregnancies (e.g. spontaneous abortions, ectopic
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44 170 pregnancies) will be identified from the ICES-derived Mother-Baby Dataset (MOMBABY),
45
46 171 which links the CIHI records of delivering mothers and their newborns; the Better Outcomes
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48 172 Registry and Network (BORN), Ontario's perinatal registry including data from fertility clinics,
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50 173 specialized antenatal clinics, hospitals, midwifery practice groups, and both prenatal & newborn
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52 174 screening laboratories; as well as the DAD, SDS, OHIP, and NACRS databases (Supplemental
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1
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3 175 Table 2-3). Adverse pregnancy-related and mental health outcomes will be obtained from these
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5 176 same databases and as the Ontario Mental Health Reporting System (OMHRS) database, which
6
7 177 holds data on patients in adult designated inpatient mental health beds. Prenatal, antepartum,
8
9
10 178 intrapartum, and postpartum health service utilization, including assisted reproductive
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12 179 technology, will be obtained from the OHIP, DAD/SDS, and BORN databases.
13

14
15 180 The work practices and earnings of Ontario physicians will be obtained from the OHIP
16
17 181 database; 95% of specialists and 50% of primary care physicians receive their income from fee-
18
19 182 for-service (FFS) billings, and all Ontario physicians are required to submit shadow billings for
20
21 183 non-FFS services. The frequency and timing of physicians' billing claims for health services and
22
23 184 surgical procedures will be used to establish measures of work intensity such as overnight work,
24
25 185 and evening and weekend shiftwork, before, during, and after pregnancy. Physician earnings will
26
27 186 be derived from total OHIP billings. Practice model for family physicians will be obtained from
28
29 187 the Client Agency Program Enrolment (CAPE) database. Specialty, trainee status, and practice
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31 188 location, will be obtained from the CPSO dataset and the ICES-derived Physician Database
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33 189 (IPDB), which contains updated yearly information about physicians in Ontario.
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39 40 191 ***Study Populations & Exposure Assessment***

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42 192 Study populations will depend on the aim (Figure 1). Aim 1 will include Ontario
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44 193 women of reproductive age (15-50 years). Aim 2 will include Ontario women of reproductive
45
46 194 age who have had at least one childbirth ≥ 20 weeks gestational age (GA). In both Aims 1 and 2,
47
48 195 physician occupation will be the main exposure of interest; we will compare all women
49
50 196 physicians (exposed) to a representative sample of non-physicians (comparator). Physicians will
51
52 197 be selected from the CPSO dataset. Non-physicians will be selected from the RPDB, and
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3 198 randomly assigned a simulated CPSO registration date based on the distribution of registration
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5 199 dates in physicians.

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8 200 Aim 3 will include women and men physicians of reproductive age. Childbirth ≥ 20
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10 201 weeks GA will be the main exposure of interest; we will compare women physicians who have
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12 202 had at least one childbirth (exposed) to: (1) women physicians who have had no childbirths, and
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14
15 203 (2) men physicians (comparator). Comparator physicians will be randomly assigned a simulated
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17 204 date of childbirth based on the distribution of childbirth dates in women physicians.
18

19 205

20 206 *Covariates*

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23
24 207 We will examine several covariates in physicians and non-physicians. Demographic
25
26 208 factors will include age, year of cohort entry, income quintile, and immigration status. Clinical
27
28 209 factors will include comorbidities, use of assisted reproductive technology, number of previous
29
30
31 210 livebirths, and number of previous recognized pregnancies. We will group comorbidities into
32
33 211 Aggregated Diagnosis Groups (ADGs) on the basis of similarity, chronicity, disability, and
34
35 212 likelihood of requiring specialty care using the Johns Hopkins ACG® System (41).
36

37
38 213 We will also examine several covariates in physicians only. Trainee status, specialty,
39
40 214 practice model, practice location, and measures of work intensity (e.g. weekend and overnight
41
42 215 shifts, time spent operating) will be ascertained according to methodology described below and
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44
45 216 in previous work (42-44).
46

47 217

48 218 *Anticipated Challenges & Mitigation Strategies*

49 219 *Variable Follow-Up*

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3 220 Physicians are a highly mobile population; 34% of Canadian medical graduates move
4
5 221 outside of their home province for residency training (45), and 30% of Canadian physicians in
6
7 222 independent practice obtained their medical degree internationally (1). We therefore anticipate
8
9
10 223 that some physicians will have lived in Ontario for their entire reproductive lifespans (complete
11
12 224 look-back), while others may have left Ontario periodically or arrived for the first time after
13
14
15 225 medical school graduation (incomplete look-back).

16
17 226 Physicians with incomplete look-back prior to their CPSO registration may have
18
19 227 insufficient data available to obtain study variables that rely on a historical period, particularly
20
21 228 to ascertain previous pregnancies, thus introducing potential for misclassification. For example,
22
23 229 a 32-year-old American physician with one prior childbirth moving to Ontario to practice would
24
25
26 230 have no record of that birth in ICES databases. To mitigate this, we will truncate the look-back
27
28 231 of non-physicians to mirror that of matched physicians so that they undergo an identical
29
30
31 232 process of ascertaining covariates. This will facilitate appropriate comparison.

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33 233

34 35 234 *Determining Transition to Independent Practice*

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37 235 The CPSO database contains one variable describing the type of license (e.g.
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39 236 postgraduate education, independent practice, etc.) held by physicians at the time of their initial
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41
42 237 registration with the CPSO (Supplemental Table 1). Preliminary analyses demonstrate that 90%
43
44 238 of reproductive-age physicians first registered as residents/fellows on a postgraduate education
45
46
47 239 license. However, the CPSO database does not hold information on license changes, or when
48
49 240 physicians transition from postgraduate education to independent practice.

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51 241 To mitigate this, we plan to use OHIP data to identify the transition from training to
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54 242 practice. Physicians with a postgraduate education license receive a salary from the provincial

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3 243 Ministry of Health and Long-Term Care, while physicians with an independent practice license
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5 244 receive an income by submitting billings to OHIP. We will use physicians' initiation of billings
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7 245 in OHIP as indicator of their transition from training to practice.
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11 12 247 *Determining Physician Specialty* 13

14
15 248 The CPSO database contains two variables describing the specialty of physicians
16
17 249 (Supplemental Table 1): one is collected at initial registration with the CPSO, and the other is
18
19 250 collected at the most recent data query. Specialty is not formally assigned until after physicians
20
21 251 finish residency training and are certified for practice by either the Royal College of Physicians
22
23 252 and Surgeons of Canada or the College of Family Physicians of Canada, despite the fact that
24
25 253 they have been working in that specialty for several years.
26
27

28 254 We will therefore assign specialty from the CPSO database based on information
29
30 255 available at the time of either initial registration or the most recent data query. For physicians
31
32 256 lacking specialty information, we will use linkages to IPDB and OHIP. If specialty information
33
34 257 remains missing after searching all three data sources (CPSO, IPDB, OHIP) and the physician
35
36 258 was a recent graduate from medical school (≤ 5 years), then such physicians be deemed active
37
38 259 residents with specialty not yet determined.
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43 44 261 *Use of Administrative Data Sources* 45

46
47 262 Use of ICES administrative data enables access to a large population-based sample of
48
49 263 physicians and non-physicians, with comprehensive follow-up of all health encounters over the
50
51 264 reproductive lifespan. However, ICES administrative data lacks granular variables that would be
52
53 265 of interest in this study, such as relationship status and intentions with respect to family planning,
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3 266 and is susceptible to misclassification due to coding errors. We cannot account for unmeasured
4
5 267 variables; however, we can mitigate the possibility of information bias. We have purposefully
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7
8 268 selected main exposures, covariates, and outcomes that can be ascertained using established
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10 269 methodology and/or Ontario-specific algorithms to ensure accuracy (46-54); and have
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12 270 used databases that are validated (55, 56) or periodically re-abstracted (57).
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17 272 **Aim 1: Compare reproductive patterns in women physicians and non-physicians**

19 273 *Rationale & Overview*

21 274 Numerous survey-based studies suggest that women physicians frequently delay
22
23 275 childbearing and subsequently experience a higher rate of infertility compared to the general
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25
26 276 population (3, 17-20). This has been quantified in only one retrospective cohort study assessing
27
28 277 birth trends among Taiwanese female physicians (21), which demonstrated that maternal age at
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30
31 278 delivery was up to four years later in physicians than non-physicians. Further studies are needed
32
33 279 to characterize the timing and factors impacting pregnancy in physicians.
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38 281 *Analysis Plan*

40 282 We will retrospectively evaluate reproductive patterns among Ontario women physicians
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42 283 and non-physicians of reproductive age (15-50 years). We will use MOMBABY to ascertain
43
44 284 childbirth, and NACRS, OHIP, and CIHI-DAD to identify other recognized pregnancies.
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46
47 285 Unmatched time-to-event analyses will be performed to compare rates of childbirth between
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49 286 physicians and the general population, and matched or adjusted time-to-event analyses will be
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51 287 used to evaluate the independent association of physician occupation with rates of childbirth. We
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1
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3 288 will also examine secondary outcomes such as number of childbirths, number of recognized
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5 289 pregnancies, and maternal age at childbirth, among physicians and non-physicians.
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7
8 290 We also aim to determine whether specific work-related factors faced by physicians
9
10 291 impact their reproductive patterns and rates of childbirth. Adjusted time-to-event and Poisson
11
12 292 regression models will be constructed in women physicians only to evaluate whether variables
13
14 293 such as specialty, trainee status, and frequency of overnight work are associated rates of
15
16 294 childbirth and other secondary outcomes respectively.
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19 295

21 296 **Aim 2: Compare adverse pregnancy outcomes in women physicians and non-physicians**

23 297 ***Rationale & Overview***

24
25
26 298 It is unclear how work as a physician impacts obstetrical outcomes. A recent systematic
27
28 299 review demonstrated that pregnant women who work shifts or longer hours have increased odds
29
30 300 of preterm birth and other adverse outcomes, but all included studies were at substantial risk of
31
32 301 bias, and only one pertained specifically to physicians (26). We will be able to reliably establish
33
34 302 work characteristics prior to and during pregnancy from OHIP, and thus provide unique insight
35
36 303 into the association between physician occupation and adverse pregnancy outcomes.
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42 305 ***Outcomes***

43
44 306 We will retrospectively evaluate adverse pregnancy outcomes among Ontario women
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46 307 physicians and non-physicians of reproductive age who have experienced at least one childbirth
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48 308 ≥ 20 weeks GA. All outcomes of interest were chosen for their clinical relevance and established
49
50 309 methodology for ascertainment from ICES databases such as MOMBABY, DAD, and OHIP,
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52 310 using standard diagnostic and procedural codes (46-54) (Supplemental Table 3).
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3 311 Perinatal outcomes include: preterm birth (delivery at <37 weeks GA); low birthweight;
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5 312 stillbirth; neonatal intensive care unit (NICU) admission; and neonatal death at <28 days of life.
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8 313 Maternal outcomes include: severe maternal morbidity (a composite endpoint of potentially life-
9
10 314 threatening complications occurring during the index pregnancy) (48); maternal death (from 20
11
12 315 weeks GA to \leq 42 days postpartum); new onset hypertensive disorders in the index pregnancy;
13
14 316 other obstetric (e.g. premature rupture of membranes) and non-obstetric complications (e.g.
15
16 317 peripartum mood disorders); and processes of obstetrical care (e.g. antenatal care, labour
17
18 318 induction, mode of delivery, epidural).

319

320 *Analysis Plan*

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

331

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

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3 334 ***Rationale & Overview***
4

5 335 Although the challenges faced by both medical trainees and practicing physicians in
6
7 336 obtaining parental leave have been documented in the literature (5, 12, 36-38), the actual work
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9
10 337 and leave practices and remuneration of physician mothers are unknown. This data would be of
11
12 338 importance to physicians practicing in Canada, as the majority are self-employed. We aim to
13
14 339 describe the parental leave patterns and earnings of Ontario physicians using a rigorous
15
16 340 observational design.
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20
21 342 ***Analysis Plan***
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23
24 343 We will retrospectively evaluate practice patterns and earnings of men and women
25
26 344 physicians in Ontario of reproductive age. We will hard-match women physicians who have had
27
28 345 at least one childbirth to women physicians who have had no childbirths, and to men physicians,
29
30 346 on their specialty and year of graduation from medical school. Physicians who have delivered
31
32 347 will enter the study on their obstetrical delivery date, and physicians who have not delivered will
33
34 348 be assigned a corresponding referent date.
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36

37
38 349 In women physicians who have delivered, we will examine: (1) length of leave, defined
39
40 350 by the absence of OHIP billings adjacent to the delivery date; and (2) timing of leave, defined in
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42 351 relation to the delivery date. In all physicians, we will examine: (1) work intensity, defined as
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44 352 mentioned previously through evaluation of measures such as overnight call practices and
45
46 353 operating time; (4) earnings, as defined by OHIP billings.
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48

49 354 We will compare earnings across three distinct 2-year periods: (1) pre-pregnancy, (2)
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51 355 peripartum; and (3) post-pregnancy. We will first perform a within-patient analysis pertaining to
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53 356 delivering women physicians only, in order to assess how their earnings vary with pregnancy and
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3 357 childbirth. Earnings from all three time periods will be compared using regression methods for
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5 358 cost data (e.g. Poisson, negative binomial, gamma models); the specific model will be
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8 359 determined based on the distribution of earnings for the cohort.
9

10 360 We will then perform a comparative analysis of (a) delivering women physicians to non-
11
12 361 delivering women physicians, and (b) delivering women physicians to men physicians. Earnings
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14 362 from the pre-pregnancy and post-pregnancy time periods, or dummy time periods in controls,
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16
17 363 will again be evaluated with appropriate regression methods for cost data.
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21 365 **Sample Size and Power**

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23
24 366 The CPSO dataset should have adequate power for all proposed analyses. To
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26 367 demonstrate this, we have calculated the power of our study to find differences in adverse
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28 368 pregnancy outcomes, specifically preterm birth, between women physicians and non-physicians
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30 369 (Specific Aim 2). Preterm birth is a major determinant of neonatal morbidity/mortality, and has
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32
33 370 significant long-term health consequences. Even a small increased risk of preterm birth would
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36 371 be of importance to women physicians.

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38 372 If a conservative 5,000 physicians have at least one pregnancy during the study period,
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40 373 are compared to at least 25,000 non-physicians, and we assume a baseline preterm birth rate of
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42 374 7.7 per 100 births (58) and an alpha of 0.05, we will have 80% power to detect a relative risk of
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45 375 1.16 or greater, and 90% power to detect a relative risk of 1.19 or greater.
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48 49 377 **Patient and Public Involvement**

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3 378 The public were not involved in the design of this study. The proposed research questions
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5 379 aim to address issues of importance to physician health; the study team accordingly includes
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7
8 380 women physicians and physician parents.
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10 381

11 382 **SIGNIFICANCE**

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14 383 The linkage of physician information to population-based data on pregnancy presents a
15
16 384 unique opportunity to evaluate physicians' reproductive patterns and perinatal health outcomes
17
18 385 in a manner that addresses the limitations of previous studies. Ontario's fee-for-service system
19
20 386 allows accurate ascertainment of physician work intensity and other work-related factors that
21
22 387 may affect rates of reproduction and adverse pregnancy outcomes.
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26 388 This work is needed; reproductive patterns and childbearing have not been rigorously
27
28 389 studied in physicians, despite many barriers to pregnancy and risk factors for adverse outcomes
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30 390 inherent in their work. We will determine if physicians are at increased risk of adverse pregnancy
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32 391 outcomes compared to the general population, and clarify whether this risk is mediated by age or
33
34 392 other occupational hazards. Understanding issues around pregnancy and leave, which may affect
35
36 393 up to half of the physician workforce at some point during their careers, also has implications for
37
38 394 the functioning of the healthcare system.
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43 396 **ETHICS & DISSEMINATION**

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46 397 This protocol was approved by the Research Ethics Board at St. Michael's Hospital
47
48 398 (#18-248) and by the ICES Privacy & Legal Office. ICES is a prescribed entity under section 45
49
50 399 of Ontario's Personal Health Information Protection Act. Section 45 authorizes ICES to collect
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52 400 personal health information without consent for analyses related to the evaluation of, allocation
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3 401 of resources to, or planning for all or part of the health system. In accordance with ICES policy,
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5 402 we will suppress all cells with <6 individuals to prevent re-identification. All research outputs
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7 403 related to this work will undergo a re-identification risk assessment prior to submission.
8
9

10 404 Translation of the findings of our study into practices and policies will require
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12 405 engagement of physicians, physician leaders, and organizational bodies. The team of researchers
13
14 406 includes clinician-investigators in obstetrics, surgery, medicine, and psychiatry who will provide
15
16 407 important contextual information to the dissemination of our findings. We will engage bodies
17
18 408 such as the Society of Obstetricians and Gynaecologists of Canada (SOGC), the Canadian
19
20 409 Medical Association (CMA), and residency programs and department heads.
21
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23

24 410 We anticipate that our findings will be presented at local and national conferences, and
25
26 411 result in several peer-reviewed publications. All manuscripts will adhere to the Strengthening the
27
28 412 Reporting of Observational Studies in Epidemiology (STROBE) guidelines (Supplemental Table
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30 413 4). Our findings should impact physicians, physicians-in-training, medical educators, residency
31
32 414 program directors, department chairs, and hospitals and organizations where physicians work.
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36 415

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39
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20
21 432 All authors (MCC, NNB, RS, JGR, AXG, EM, SV, and ANS) contributed to the design
22
23 433 of this study. NNB, AXG, and ANS participated in data acquisition. MCC, NNB, RS, JGR, EM,
24
25 434 and ANS developed the analytic plan. MCC, NNB, and ANS obtained ethics approval for this
26
27 435 work. MCC prepared the first draft of the manuscript. All authors contributed to and approved
28
29 436 the final version of the manuscript.
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35 438 **COMPETING INTERESTS STATEMENT**

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37 439 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

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3 **FIGURE LEGENDS**
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8 **Figure 1.** Overview of specific research aims, with study populations (including exposed and
9 comparator groups) and study outcomes.
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Figure 1

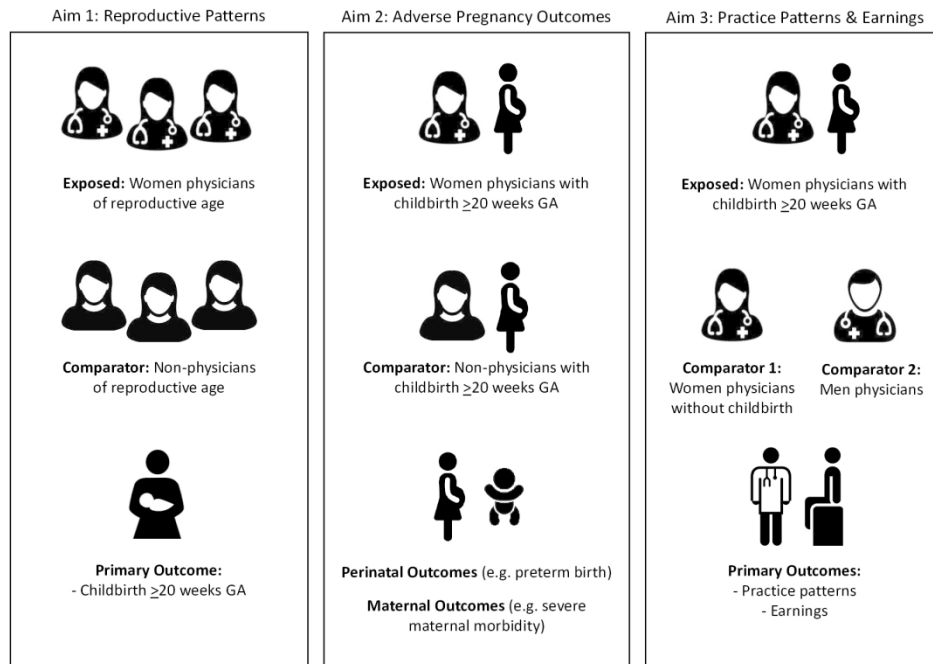


Figure 1. Overview of specific research aims, with study populations (including exposed and comparator groups) and study outcomes.

254x190mm (200 x 200 DPI)

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3 **SUPPLEMENTAL INFORMATION**
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8 **Supplemental Table 1.** Variable list from the College of Physicians & Surgeons of Ontario
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12 **Supplemental Table 2.** Datasets from CPSO and ICES for use in proposed research studies
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17 **Supplemental Table 3.** Perinatal and maternal adverse pregnancy outcomes
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21 **Supplemental Table 4.** STROBE checklist for study
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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): <ul style="list-style-type: none"> i. Active ii. Expire iii. Suspended iv. Revoked
Registration class (status at time of registration)	Type of license member held at time of registration: <ul style="list-style-type: none"> 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 (YYYYMMDD)
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: <ul style="list-style-type: none"> i. Primary Practice – Main practice location ii. Secondary Practice – Alternative 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: <ul style="list-style-type: none"> 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

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		<p>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)</p> <p>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</p> <p>Postpartum: Breastfeeding data</p>	
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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 <10 th 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 <5 th 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 \geq 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

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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>.