Title: Emergency department use by pregnant women: a population-based study within a universal healthcare system

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Abstract

Background: Emergency Department (ED) utilization "peri-pregnancy" may be common, but data specific to universal healthcare systems like Canada are lacking, where pregnancy care is supposed to be standardized.

Methods: This retrospective population-based cohort study included all recognized pregnancies in Ontario, conceived between April 1, 2002 and March 31, 2017. Peri-pregnancy ED utilization was defined as any ED visit from 0-42 weeks' gestation, or within 42 days after the end of pregnancy.

Results: Peri-pregnancy ED utilization occurred among 1,075,991 of 2,728,236 recognized pregnancies (39.4%), including among 35.8% of livebirths, 47.3% of stillbirths, 73.7% of miscarriages, and 84.8% of threatened abortions. ED utilization peaked in the first trimester and in the first week postpartum. Women residing in rural areas had an odds ratio (OR) of 3.44 (95% CI 3.39 to 3.49) for ≥ 3 ED visits, compared to those in urban areas. Women with 3-5 (OR 1.99 95% CI 1.97-2.01), 5-6 (OR 3.55, 95% CI 3.49 to 3.61) or ≥ 7 (OR 7.59, 95% CI 7.39 to 7.78) pre-pregnancy comorbidities were more likely to have ≥ 3 peri-pregnancy ED visits than those with 0-2 comorbidities. Of all recognized pregnancies in the cohort, only 106,989 (3.9%) had an injury-related ED visit.

Interpretation: Peri-pregnancy ED utilization occurs in nearly 40% of pregnancies, notably in the first trimester and immediately postpartum. Efforts are needed to streamline rapid access to ambulatory obstetrical care during these peak periods, when women are vulnerable to either a miscarriage, or a complication after a livebirth.

Background

Pregnancy marks a period in a woman's life of greater health care system utilization. For an uncomplicated pregnancy, guidelines recommend 7 to 12 scheduled obstetrical provider visits -- monthly in the first and second trimester, more frequently in the third trimester, and then once at about 6 weeks after birth.[1] In Canada, the majority of antenatal care in the first trimester is provided by a woman's family physician[2], and then continued by her family physician, midwife or obstetrician in the second and third trimester.[1]

An unforeseen or new-onset health condition -- whether in pregnancy or soon after birth -- may necessitate an unplanned health care visit(s), including to an emergency department (ED)[3]. The same may be so if a woman experiences a pregnancy loss and has not yet secured an obstetrical care provider. In other cases, ED visits may be the norm in areas with limited access to obstetrical or midwifery care[4]. A limited number of studies suggested that ED use in pregnancy is often associated with suboptimal antenatal care, psychosocial instability and worse maternal and infant outcomes[5,6]. They also documented a higher rate of ED use among pregnant women with pre-existing co-morbidities[5-7]. In the US, ED use during pregnancy varies between 21% to 58%, with a higher frequency of repeat ED visits than seen among non-pregnant women[5-8]. As a major limitation, these previously published studies were comprised of either commercially-insured or low-income patient populations in the US, who likely differ considerably from women who receive care within a universally-insured health care system, like Canada. Prior research was also largely limited to livebirths, omitting the many pregnancies ending in miscarriage or induced abortion. In Ontario, Canada's most populous province, induced abortions are covered under the provincial health insurance programme, and thus, are largely recorded within provincial health databases[9,10].

The current study was undertaken to quantify and characterize ED utilization among all Ontarian women who had a recognized pregnancy, including by trimester and within 42 days after pregnancy, and further stratified by pregnancy outcome, namely, livebirth, stillbirth, miscarriage and induced abortion; as well as women who had a threatened abortion in early pregnancy without a subsequent recognized pregnancy outcome.

Methods

Study population

This retrospective population-based cohort study included all women in the province of Ontario, with a recognized pregnancy -- a livebirth at ≥ 20 weeks' gestation, stillbirth at ≥ 20 weeks' gestation, miscarriage [including ectopic pregnancy] at < 20 weeks' gestation, induced abortion at any gestational week, or threatened abortion [including other or unspecified hemorrhage] at < 20 weeks' gestation without a subsequent recognized pregnancy outcome -- having an estimated date of conception between April 1, 2002 and March 31, 2017. All healthcare, including access to obstetrical care services, is universally funded for Ontario's residents. Excluded were those without a valid Ontario Health Insurance Plan (OHIP) number, non-Ontario residence at any point during the index peri-pregnancy period, or those aged < 10 years or > 55 years at the index pregnancy start date.

Data sources

This study used administrative health databases for the entire province of Ontario, housed at ICES. The databases used herein were the Canadian Institute of Health Information (CIHI)'s Discharge Abstract Database (DAD), Same Day Surgery database (SDS), and the National Ambulatory Care Reporting System (NACRS) database; as well as the OHIP claims database; the Immigration, Refugees and Citizenship Canada (IRCC)'s Permanent Resident Database; and the ICES MOMBABY database, which identifies all hospital liveborn and stillborn maternal-infant pairs (**Supplemental file 1**). Income quintile and rural residence were defined using Statistics Canada census data.[11] These datasets were linked using unique encoded identifiers and analyzed at ICES.

Outcome measures

The primary study outcome was "peri-pregnancy" ED utilization, namely, an ED visit either during pregnancy or up to 42 days thereafter. The 42-day window after pregnancy is a standard interval used to monitor postpartum health. ED visits were further delineated by each trimester of pregnancy, as well as within the 42-day postpartum period. The latter was

necessarily restricted to livebirths, who not only represent the majority of pregnancies, but for which the exact gestational age at birth is known, proving greater certainty about the timing of any ED visit. All ED visits were identified in the NACRS database. An ED is a hospital facility that serves unscheduled patients whose conditions may require immediate care, and is that is staffed by physicians 24 hours per day, 7 days a week. An ED visit is an encounter in the ED between a patient seeking care and a physician or another healthcare provider (i.e., a physician assistant or nurse practitioner working under physician supervision).

Statistical analysis

Baseline variables, identified at the estimated clinical start of pregnancy (i.e. 0 weeks' gestation), were contrasted between those with any ED visit in pregnancy or 42 days postpartum and those without an ED visit, using standardized differences.

In the main analysis, modified Poisson regression was used to generate relative risks (RR) and 95% confidence intervals (CI) for the outcome of any peri-pregnancy ED utilization in association with maternal age (< 25, 25-34 [referent] and ≥ 35 years); parity (nulliparous vs. parous [referent]); residential income quintile (Q1 to Q5 [referent]; rural or urban location of residence [referent]; immigrant status (foreign-born or Canadian-born/long-term resident [referent]); antenatal care provider (obstetrician [referent], family physician/nurse practitioner, other provider, or none/unknown); and number of comorbidities within 120 days before the clinical start of pregnancy (expressed as the total number of Aggregated Diagnosis Groups [ADGs] obtained using the Johns Hopkins ACG System®: 0-2 [referent], 3-4, 5-6 and 7-32). All RRs except for number of comorbidities were further adjusted for the number of ADGs. Generalized estimating equations were utilized to account for the possibility of more than one pregnancy per woman during the study period.

The main analysis was stratified by trimester of ED utilization (first [0 to 13 gestational weeks], second [14 to 26 gestational weeks], third [27 to 42 gestational weeks], or post-partum [0 to 42 days' post-partum]) and pregnancy outcome (livebirth, stillbirth, miscarriage, induced abortion, and threatened abortion). For livebirth deliveries, we also calculated the proportion

and 95% CI of 1) first peri-pregnancy ED visits and 2) all peri-pregnancy ED visits, by gestational or post-partum week.

A dose-response analysis evaluated the odds of a woman having 1, 2 or ≥ 3 ED visits during the peri-pregnancy period, in relation to each of the characteristics stratified by above. Unadjusted odds ratios (OR) and 95% CI were generated using multinomial logistic regression models.

Data were analyzed using SAS statistical software, version 9.4 for UNIX (SAS Institute Inc., Cary, NC) and the Johns Hopkins ACG® System Version 10. All cell sizes ≤ 5 were suppressed to prevent re-identification.

Ethics approval

The use of data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act, which does not require review by a Research Ethics Board.

Results

There were 2,751,829 eligible pregnancies identified, of which 23,593 (0.85%) were excluded, primarily due to an invalid OHIP number, duplicate delivery record, extreme maternal age, or non-Ontario residency (**Figure 1**). Of all 2,728,236 recognized pregnancies, 71.8% resulted in a livebirth, 0.4% in a stillbirth, 8.1% in a miscarriage, 13.5% in an induced abortion, and 6.1% in a threatened abortion without a recognized pregnancy outcome (**Figure 1**).

Out of 2,728,236 recognized pregnancies, 1,075,991 (39.4%) had a peri-pregnancy ED visit (**Table 1**). Women who used the ED vs. those did not were more likely to be younger, Canadian-born/long-term residents, reside in a rural area (13.7% vs. 6.9%), have a greater number of ADGs, and less likely to have an obstetrician (53.2% vs. 60.5%) (**Table 1**). Women who had an ED visit were more likely to have a pregnancy ending in a miscarriage (15.2% vs. 3.5%) or threatened abortion (13.1% vs. 1.5%), and were less likely to have a livebirth (65.2% vs. 76.1%) or an induced abortion (6.0% vs. 18.4%) (**Table 1**). The rate of any peri-pregnancy ED use was greater in women who had a threatened abortion (84.8%) or miscarriage (73.7%), compared to those who had a stillbirth (47.3%), livebirth (35.8%) or induced abortion (17.5%).

Among all recognized pregnancies, a peri-pregnancy ED visit was more likely among women who were under 25 years of age (adjusted RR 1.16, 95% CI 1.16 to 1.17), nulliparous (adjusted RR 1.13, 95% CI 1.13 to 1.13), residing in the lowest income quintile area (adjusted RR 1.16, 95% CI 1.15 to 1.16) or in a rural area (adjusted RR 1.50, 95% CI 1.50 to 1.51), Canadian-born (adjusted RR 1.22, 95% CI 1.22 to 1.23), not seen by an obstetrician (adjusted RR 1.66, 95% CI 1.54 to 1.80), or having a greater number of ADGs (**Figure 2**). These associations persisted across the trimester of presentation (**Supplemental files 2a to 2d**), and regardless of the pregnancy outcome (**Supplemental files 3a to 3e**), with the exception of care provider and trimester of pregnancy.

Among women with a livebirth, ED utilization was most frequent in first trimester, peaking between 6 to 8 weeks' gestation, and then within the first week postpartum (**Figure 3**). The same pattern was seen for all ED visits, combining first and subsequent ED encounters (**Supplemental file 4**).

A dose-response effect was seen in the number of peri-pregnancy ED visits in relation certain maternal characteristics (**Table 2**). For example, women residing in a rural area had an OR of 3.44 (95% CI 3.39 to 3.49) of having ≥ 3 ED visits compared to women residing in an urban area. Women with 5 to 6 (OR 3.55, 95% CI 3.49 to 3.61) or ≥ 7 (OR 7.59, 95% CI 7.39 to 7.78) ADGs were much more likely to have ≥ 3 ED visits than those with 0 to 2 ADGs (**Table 2**).

The most frequent diagnoses at the ED visit were threatened abortion (7.7%), unspecified hemorrhage in early pregnancy (6.4%) and spontaneous abortion (4.5%). Additionally, the most prevalent diagnoses for ED visits within 42 days after a recognized pregnancy were spontaneous abortion (13.2%), missed abortion (4.9%) and threatened abortion (3.8%). Of all recognized pregnancies in the cohort, only 106,989 (3.9%) had an injury-related ED visit.

Interpretation

Nearly 40% of women in Ontario had an ED visit around the time of pregnancy. ED utilization was significantly more likely to occur in first trimester and in the first week postpartum. Overall, the most common ED diagnoses were for conditions arising in the first

trimester: threatened abortion, unspecified hemorrhage in early pregnancy, and spontaneous abortion.

These findings are comparable with US data on peri-pregnancy ED utilization. In one study of 157,786 commercially insured pregnant patients ED utilization was 19.9%[7], and as high as 57.5% in another study of low-income pregnant women receiving US Medicaid [8]. However, the current study is the first to describe ED utilization within a single payer, universal health care system.

Consistent with previous studies[5-8] is the present observation that women with greater antecedent comorbidity tended to have multiple peri-pregnancy ED visits. This highlights at least one group who may benefit from better coordinated care in pregnancy, possibly reducing the number of acute unscheduled healthcare visits. Prior research also identified other maternal and system-wide factors associated with peri-pregnancy ED use, including insufficient antenatal care, social instability and worse obstetrical outcomes[5]. Herein, ED utilization spiked at times when a woman is least likely to have access to an obstetrical care provider, namely, in the first trimester and immediately after pregnancy[1].This pattern was evident for livebirths, as well as for women with a miscarriage or threatened abortion. Of note, only a very small proportion of ED visits appeared to be for conditions such as injury, for which an ED is most equipped to assess and treat.

Unfortunately, the evidence suggests that women with a pregnancy-related complications in the first trimester often experience long ED wait times, due to lack of ED resources, such as urgent ultrasound assessment.[12] Continuity of care is an additional concern, as many of these women are discharged from the ED without a clear care plan or access to a pregnancy care provider.[13] A recent survey of Ontario hospitals confirmed that the majority of EDs are tasked with providing ongoing care to women experiencing early pregnancy complications, such as a stable ectopic pregnancy or a pregnancy of unknown location. [14] The survey also found that the lack of clinical resources and specialized personnel makes longitudinal care through the ED unrealistic, potentially exposing these women to undue risk and complications.[14]

The immediate postpartum period is increasingly recognized as a time for greater maternal morbidity and mortality[15]. The current study, and that by others[16], suggests that the early postpartum period is paralleled by a marked increase in ED utilization. In response, the American College of Obstetricians and Gynecologists (ACOG) proposed a new paradigm of early postpartum care, with ongoing care over several visits within the first 3 weeks postpartum, rather than the conventional single visit after 6 weeks[17]. It is unknown whether this ACOG approach can be viably adopted in Canada, especially in rural areas, where obstetrical resources are scarce[18]. Certainly, future research is needed to assess whether dedicated pregnancy care in the first-trimester and postpartum can improve maternal health outcomes and psychological well-being.

Limitations

This study has several limitations. Women who experienced a miscarriage, but had no pregnancy-related health care visit, would be missed herein. Additionally, the fate was unknown for those diagnosed with a threatened abortion/hemorrhage in early pregnancy, and no documented pregnancy outcome thereafter. As midwifery billings are not captured in the OHIP database at ICES, a woman whose pregnancy care was provided entirely by a midwife, including an out-of-hospital birth, would have been excluded herein. Granular data were also lacking about the acuity of a woman's condition at her ED presentation, or the care resources and referrals that ensued in the ED or upon discharge.

Conclusion

Within a universal healthcare system that aims to provide comprehensive prenatal and postnatal care to all women, more than 1 in 3 women utilized the ED peri-pregnancy. Several factors identified herein, associated with peri-pregnancy ED utilization, could enhance ongoing efforts to streamline access to ambulatory obstetrical care during peak time points, such as the first trimester for miscarriage, and early postpartum following a livebirth delivery.

Contributors: All of the authors contributed substantially to this study. CV and JGR designed the study, interpreted analyses, and wrote and revised the manuscript. ALP helped with study design, data interpretation, and performed cohort creation and data analyses. DL helped with drafting of the manuscript and presentation of the data. All of the authors revised the manuscript critically for important intellectual content, approved the version to be published and agreed to be accountable for all aspect of the work.

Data sharing: The dataset from this study is held securely in coded form at ICES. While data sharing agreements prohibit ICES from making the dataset publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at www.ices.on.ca/DAS. The full dataset creation plan and underlying analytic code are available from the authors upon request, understanding that the computer programs may rely upon coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

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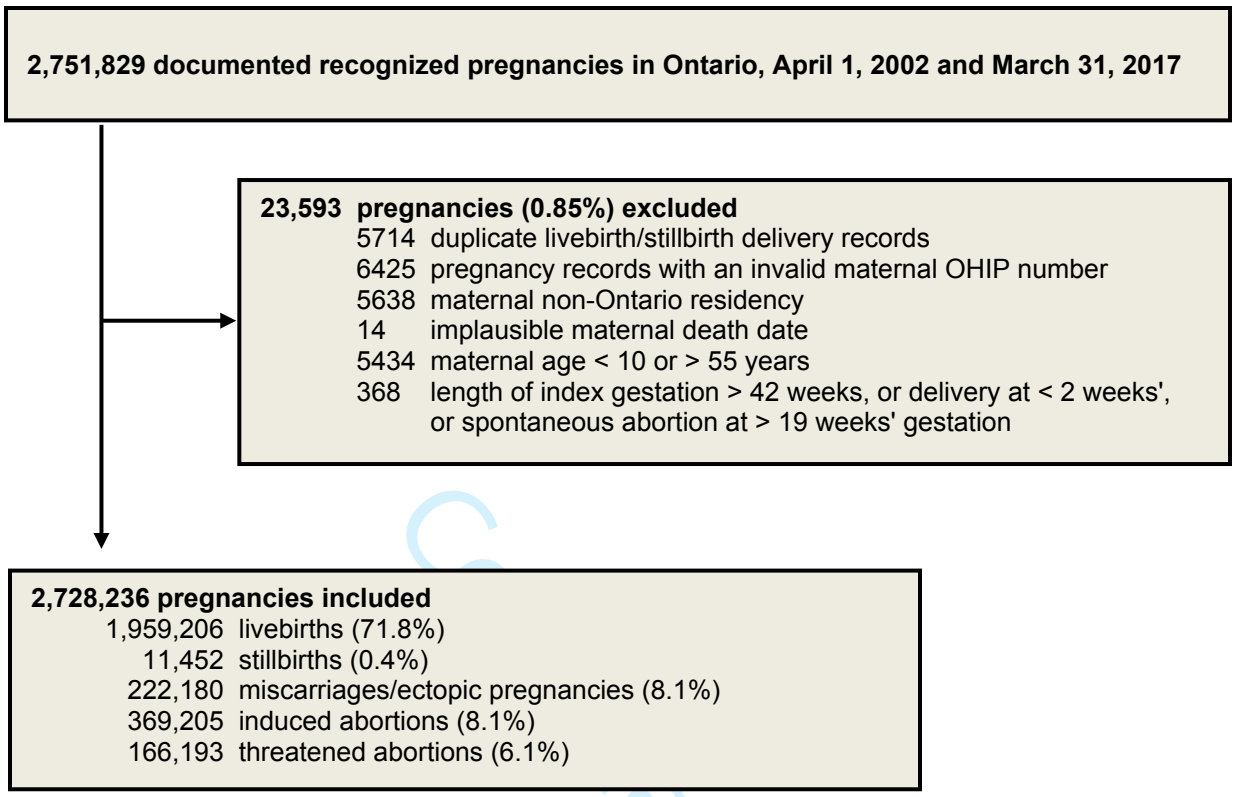
Figure 1. Flow diagram of cohort creation



OHIP Ontario Health Insurance Plan

Table 1. Baseline characteristics of pregnant women with, and without, a peri-pregnancy emergency department (ED) visit in pregnancy, or up to 42 days thereafter. All data are presented as a number (%) unless otherwise indicated.

Maternal characteristic	Any peri-pregnancy ED visit (N = 1,075,991)	No peri-pregnancy ED visit (N = 1,652,245)	Standardized difference
At the start of pregnancy			
Age, years			
Mean ± SD	28.6 ± 6.3	29.4 ± 5.9	0.13
10-19	87,466 (8.1)	99,890 (6.0)	0.08
20-24	201,922 (18.8)	243,707 (14.8)	0.10
25-29	304,324 (28.3)	457,282 (27.7)	0.01
30-34	290,357 (27.0)	526,941 (31.9)	0.11
35-39	147,461 (13.7)	261,792 (15.8)	0.06
40-44	39,497 (3.7)	56,970 (3.4)	0.01
45-55	4964 (0.5)	5663 (0.3)	0.02
Parity			
Median (IQR)	1.0 (0.0-1.0)	1.0 (0.0-1.0)	0.06
0	346,360 (32.2)	591,500 (35.8)	0.08
1	241,345 (22.4)	498,319 (30.2)	0.18
2	99,127 (9.2)	192,334 (11.6)	0.08
≥ 3	52,969 (4.9)	92,190 (5.6)	0.03
Missing	336,190 (31.2)	277,902 (16.8)	0.34
Residential income quintile			
1 (lowest)	278,342 (25.9)	373,190 (22.6)	0.08
2	225,928 (21.0)	335,965 (20.3)	0.02
3	213,068 (19.8)	331,653 (20.1)	0.01
4	200,811 (18.7)	331,749 (20.1)	0.04
5 (highest)	152,539 (14.2)	274,042 (16.6)	0.07
Missing	5303 (0.5)	5646 (0.3)	0.02
Rural location of residence	147,290 (13.7)	113,739 (6.9)	0.23
Foreign-born	241,984 (22.5)	501,151 (30.3)	0.18
Antenatal care provider in pregnancy			
Obstetrician	572,077 (53.2)	1,000,313 (60.5)	0.15
Family physician/nurse practitioner	180,902 (16.8)	223,570 (13.5)	0.09
Other provider	260 (0.0)	154 (0.0)	0.01
None/unknown	322,752 (30.0)	428,208 (25.9)	0.09
No. ADGs within 120 days before the start of pregnancy*			

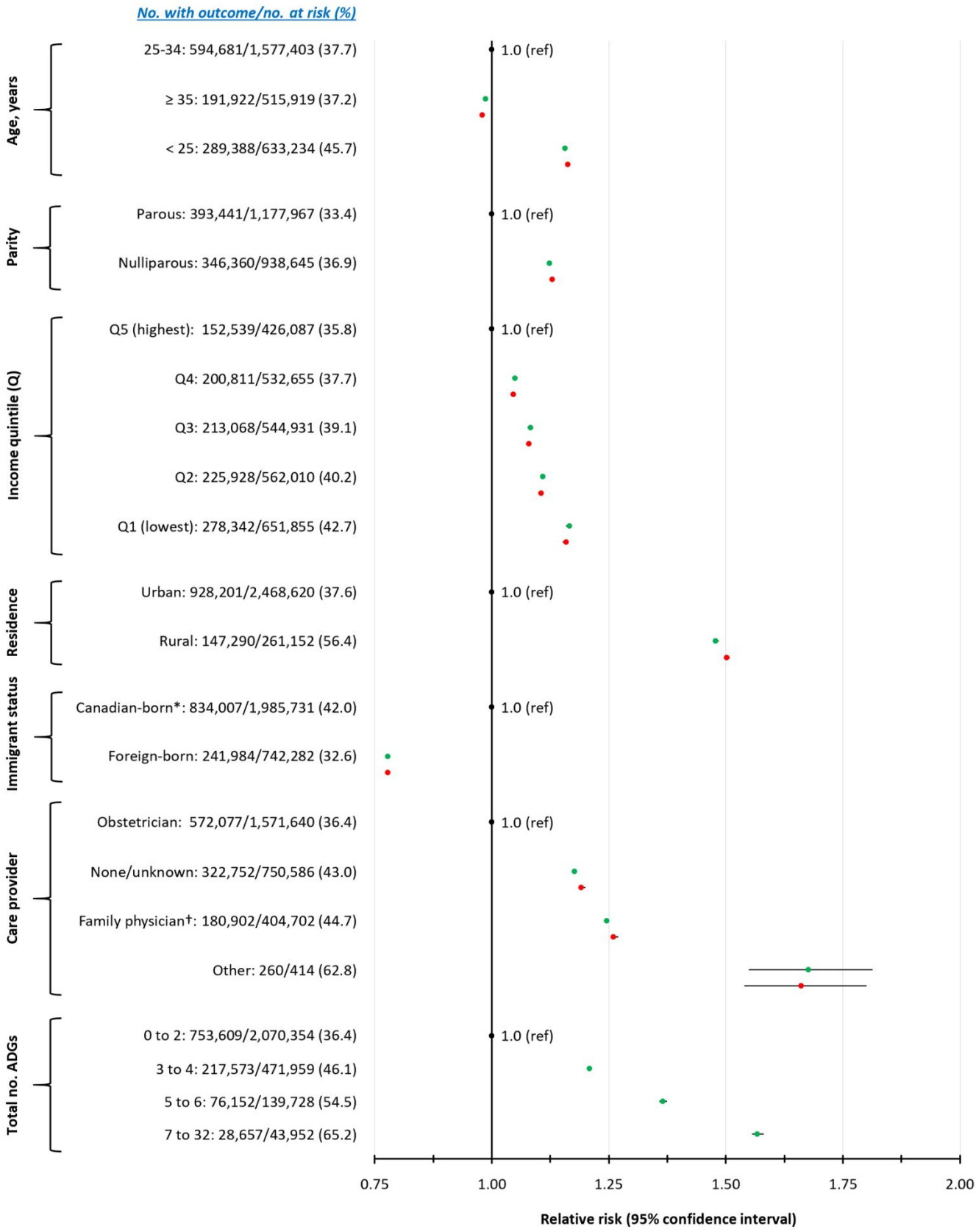
Maternal characteristic	Any peri-pregnancy ED visit (N = 1,075,991)	No peri-pregnancy ED visit (N = 1,652,245)	Standardized difference
0 to 2	753,609 (70.0)	1,319,263 (79.8)	0.23
3 to 4	217,573 (20.2)	254,062 (15.4)	0.13
5 to 6	76,152 (7.1)	63,630 (3.9)	0.14
7 to 32	28,657 (2.7)	15,290 (0.9)	0.13
At the end of pregnancy			
Multifetal birth†	15,994 (2.3)	20,307 (1.6)	0.05
Mean (SD) weeks' gestation at birth†	38.6 ± 2.4	38.9 ± 1.9	0.13
Preterm birth at 20-36 weeks' gestation†	67,526 (9.6)	80,728 (6.4)	0.12
Outcome of pregnancy			
Livebirth at ≥ 20 weeks' gestation	701,370 (65.2)	1,257,836 (76.1)	0.24
Stillbirth at ≥ 20 weeks' gestation	5,422 (0.5)	6,030 (0.4)	0.02
Miscarriage at < 20 weeks' gestation	163,747 (15.2)	58,433 (3.5)	0.41
Induced abortion at any gestational week	64,599 (6.0)	304,606 (18.4)	0.39
Threatened abortion at < 20 weeks' gestation	140,853 (13.1)	25,340 (1.5)	0.46

*Using the Johns Hopkins ACG System® Aggregated Diagnosis Groups (ADGs) within the 120 days before the clinical start of the index pregnancy.

† Restricted to 1,970,658 obstetric deliveries resulting in a livebirth or stillbirth.

ED emergency department, IQR interquartile range, SD standardized difference, ADG Johns Hopkins ACG System® Aggregated Diagnosis Groups

Figure 2. Risk of an emergency department visit in pregnancy, or up to 42 days thereafter, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown); and total number of Johns Hopkins Aggregated Diagnosis Groups (ADGs) (3 to 4, 5 to 6, 7 to 32 vs 0 to 2 [ref]). Relative risks are unadjusted (green dots) and adjusted (red dots) for number of ADGs.



*Includes long-term residents.

† Includes nurse practitioners.

Figure 3. Proportion of first emergency department (ED) visits occurring in pregnancy, or up to 42 days postpartum, among livebirths deliveries.

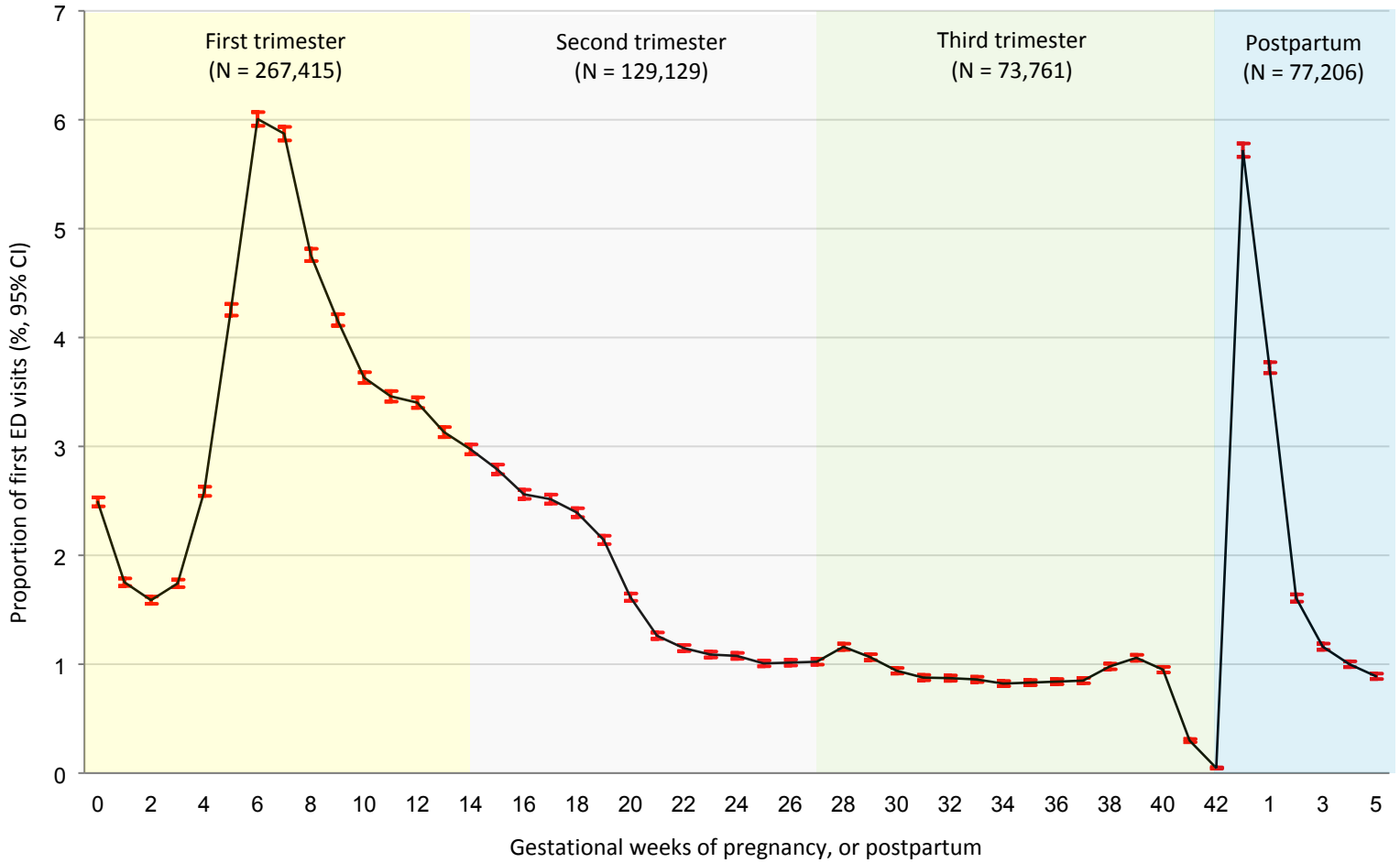


Table 2. Odds of a woman having 1, 2 or ≥ 3 peri-pregnancy emergency department (ED) visits in pregnancy, or up to 42 days thereafter, in relation to certain maternal characteristics.

	1 peri-pregnancy ED visit		2 peri-pregnancy ED visits		3+ peri-pregnancy ED visits	
Maternal characteristic	**Number (%)**	**OR* (95% CI)**	**Number (%)**	**OR* (95% CI)**	**Number (%)**	**OR* (95% CI)**
Age, years						
25 to 34	317,124 (20.1)	1.00 (referent)	155,174 (9.8)	1.00 (referent)	122,383 (7.8)	1.00 (referent)
≥ 35	106,652 (20.7)	1.02 (1.01-1.03)	51,977 (10.1)	1.02 (1.01-1.03)	33,293 (6.4)	0.83 (0.81-0.84)
< 25	130,923 (20.7)	1.18 (1.17-1.19)	72,826 (11.5)	1.34 (1.33-1.36)	85,639 (13.5)	2.00 (1.98-2.03)
Parity						
Parous	213,201 (18.1)	1.00 (referent)	93,113 (7.9)	1.00 (referent)	87,127 (7.4)	1.00 (referent)
Nulliparous	182,167 (19.4)	1.13 (1.12-1.14)	83,689 (8.9)	1.19 (1.18 - 1.20)	80,504 (8.6)	1.22 (1.21-1.23)
Residential income quintile						
5 (highest)	83,998 (19.7)	1.00 (referent)	38,890 (9.1)	1.00 (referent)	29,651 (7.0)	1.00 (referent)
4	107,929 (20.3)	1.06 (1.05-1.07)	52,174 (9.8)	1.11 (1.09 - 1.12)	40,708 (7.6)	1.13 (1.12-1.15)
3	111,847 (20.5)	1.10 (1.09-1.11)	55,616 (10.2)	1.18 (1.16 - 1.20)	45,605 (8.4)	1.27 (1.25-1.29)
2	114,556 (20.4)	1.11 (1.10-1.12)	59,007 (10.5)	1.24 (1.22 - 1.26)	52,365 (9.3)	1.44 (1.42-1.46)
1 (lowest)	134,037 (20.6)	1.17 (1.16-1.18)	73,029 (11.2)	1.38 (1.36 - 1.40)	71,276 (10.9)	1.77 (1.74-1.79)
Location of residence						
Urban	492,363 (20.0)	1.00 (referent)	243,572 (9.9)	1.00 (referent)	192,266 (7.8)	1.00 (referent)
Rural	62,075 (23.8)	1.70 (1.69-1.72)	36,279 (13.9)	2.01 (1.99-2.04)	48,936 (18.7)	3.44 (3.39-3.49)
Immigrant status						
Canadian-born/long-term resident	420,188 (21.2)	1.00 (referent)	214,463 (10.8)	1.00 (referent)	199,356 (10.0)	1.00 (referent)
Foreign-born	134,511 (18.1)	0.74 (0.73- 0.74)	65,514 (8.8)	0.70 (0.69-0.71)	41,959 (5.6)	0.48 (0.48-0.49)
Antenatal care provider						
Obstetrician	303,147 (19.3)	1.00 (referent)	139,075 (8.8)	1.00 (referent)	129,855 (8.3)	1.00 (referent)
Family physician/nurse practitioner	89,278 (22.1)	1.32 (1.31-1.33)	47,797 (11.8)	1.54 (1.52-1.56)	43,827 (10.8)	1.51 (1.49-1.53)
Other provider	116 (28.0)	2.49 (1.96-3.15)	78 (18.8)	3.64 (2.77-4.79)	66 (15.9)	3.30 (2.46-4.42)
None/unknown	162,158 (21.6)	1.25 (1.24-1.26)	93,027 (12.4)	1.56 (1.55-1.58)	67,567 (9.0)	1.22 (1.20-1.23)
No. ADGs within 120 days						

	1 peri-pregnancy ED visit		2 peri-pregnancy ED visits		3+ peri-pregnancy ED visits	
Maternal characteristic	**Number (%)**	**OR* (95% CI)**	**Number (%)**	**OR* (95% CI)**	**Number (%)**	**OR* (95% CI)**
before the start of pregnancy*						
0 to 2	408,827 (19.7)	1.00 (referent)	197,831 (9.5)	1.00 (referent)	146,951 (7.1)	1.00 (referent)
3 to 4	104,690 (22.2)	1.33 (1.32-1.34)	56,589 (12.0)	1.49 (1.47-1.50)	56,294 (11.9)	1.99 (1.97-2.01)
5 to 6	31,828 (22.8)	1.61 (1.59-1.64)	19,173 (13.7)	2.01 (1.98-2.04)	25,151 (18.0)	3.55 (3.49-3.61)
7 to 32	9,354 (21.3)	1.97 (1.92-2.03)	6,384 (14.5)	2.78 (2.70-2.87)	12,919 (29.4)	7.59 (7.39-7.78)

* Odds ratios were calculated using multinomial logistic regression analysis.
† Using the Johns Hopkins ACG System® Aggregated Diagnosis Groups (ADGs) within the 120 days before the clinical start of the index pregnancy.

CI confidence interval, OR odds ratio

Supplemental file 1: Variables used to define cohort entry and exclusion criteria, outcomes and adjustment variables

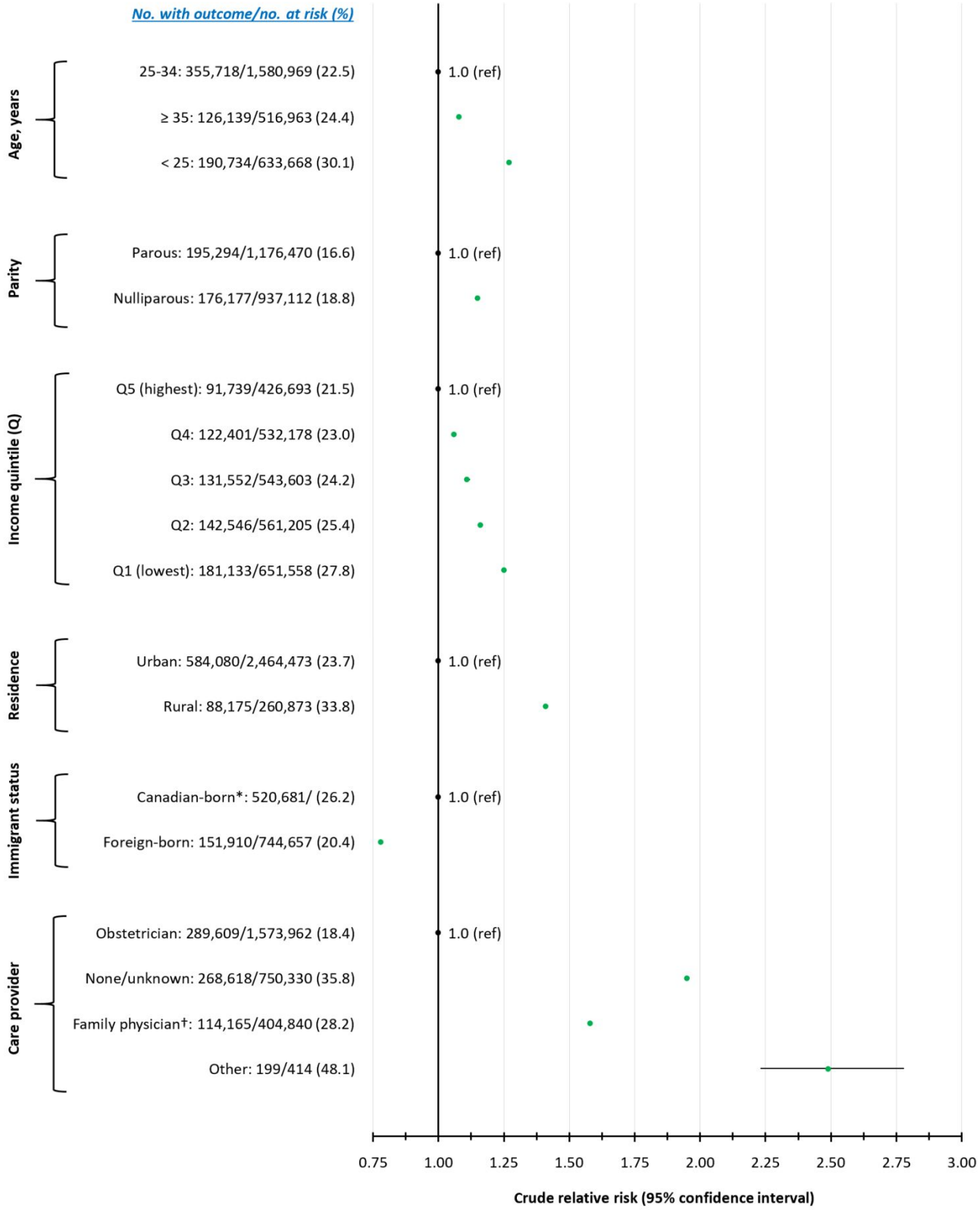
Assessment	Timing	Disease, procedure or measure	ICD-9 [ICD-10-CA] diagnostic codes and CCP [CCI] procedure codes*, in DAD, SDS and NACRS	Fee codes and ICD-9 diagnostic in OHIP {or other sources}
Cohort entry criteria	At the index pregnancy end date (where the estimated clinical start of pregnancy [i.e. 0 weeks' gestation] is between April 1, 2002 and March 31, 2017)	Women with an obstetrically delivered livebirth or stillbirth at ≥ 20 weeks' gestation	MOMBABY (https://datadictionary.ices.on.ca/Applications/DataDictionary/Library.aspx?Library=MOMBABY) Livebirth: m_stillbirth='F' Stillbirth: m_stillbirth='T'	--
	Same	Induced abortion at any gestational week	635 [O04, O08] AND 81.01*, 87.0*, 87.1*, 87.21*, 87.29* [5CA89*, 5CA88*, 5CA20FK*, 5CA24*] AND prsuff not in 8, 9	Fee code: S785, A920, P001 AND ICD-9: 635, 895; OR Fee code: S752 and ICD-9: 635, 895
	Same	Miscarriage or ectopic pregnancy at < 20 weeks' gestation	632, 633, 634 [O00, O021, O03]	Fee code: A920, P001 AND ICD-9: 632, 633, 634, 640; OR Fee code: A922; OR Fee code: S752, S785 AND ICD-9: 632, 633, 634, 640; OR Fee code: S756, S768, S784, S770
	Same	Threatened abortion or other/unspecified hemorrhage at < 20 weeks' gestation (without a recognized pregnancy outcome)	640 [O20]	640
Exclusion criteria	From 0 weeks' gestation up to and including 42 days' postpartum	Woman had an invalid healthcare number or hospital number	--	{RPDB contains demographic information and encrypted healthcare numbers for all individuals eligible for OHIP}
	Same	Woman was a non-Ontario resident at any time during the perinatal period	--	{RPDB}
	Same	Not OHIP eligible during the entire perinatal period	--	{RPDB}

Assessment	Timing	Disease, procedure or measure	ICD-9 [ICD-10-CA] diagnostic codes and CCP [CCI] procedure codes*, in DAD, SDS and NACRS	Fee codes and ICD-9 diagnostic in OHIP {or other sources}
	Estimated clinical start of pregnancy	Death date before start of pregnancy	--	{RPDB}
	Same	Woman's age is missing or < 10 or > 55 years	--	{RPDB}
Main outcome	From the estimated clinical start of pregnancy (i.e. 0 weeks' gestation) up to and including 42 days' postpartum	ED visit during the perinatal period	Any ICD code in NACRS	--
	Same	Main diagnostic code for the ED visit	--	--
Secondary outcomes	From the estimated clinical start of pregnancy (i.e. 0 weeks' gestation) up to 13 weeks' gestation	ED visit during 1st trimester	Any ICD code in NACRS	--
	From 14 to 26 weeks' gestation	ED visit during 2nd trimester	Any ICD code in NACRS	--
	From 27 to 42 weeks' gestation	ED visit during 3rd trimester	Any ICD code in NACRS	--
	After the date of delivery and up to and including 42 days after the delivery	ED visit post-partum	Any ICD code in NACRS	--
Covariates	At the estimated clinical start of pregnancy (i.e. 0 weeks' gestation)	Woman's age	--	{RPDB}
	Same	Woman's area-level income quintile	--	{Statistics Canada census data}
	Same	Woman's rural residence	--	{Statistics Canada census data}
	Same	Woman's immigrant status	--	{IRCC Permanent Resident Database}
	At the index pregnancy end date	Woman's number of previous deliveries at 20 completed weeks onward	CIHI PREVTERM + PREVPRETERM	Not available for miscarriages or abortions identified in OHIP
	Within 120 days before the estimated clinical start of pregnancy (i.e. 0 weeks' gestation)	Total number of Johns Hopkins Aggregated Diagnosis Groups (ADGs; 0 to 2, 3 to 4, 5 to 6, 7-32)	ADGs were obtained from diagnosis codes in DAD, SDS and NACRS using ACG System software	ADGs were obtained from diagnosis codes in DAD, SDS and NACRS using ACG System software

Assessment	Timing	Disease, procedure or measure	ICD-9 [ICD-10-CA] diagnostic codes and CCP [CCI] procedure codes*, in DAD, SDS and NACRS	Fee codes and ICD-9 diagnostic in OHIP {or other sources}
	During the index pregnancy	Antenatal care provider	--	Fee code: P002, P003, P004, or P005 AND provider Specialty code: 1) Obstetrics (20) 2) Family physician (00) or nurse practitioner (76) 3) Other provider (not 20, 00 or 76) 4) No provider/unknown *If more than one provider specialty bills an antenatal fee code, then priority is assigned in the above order.*

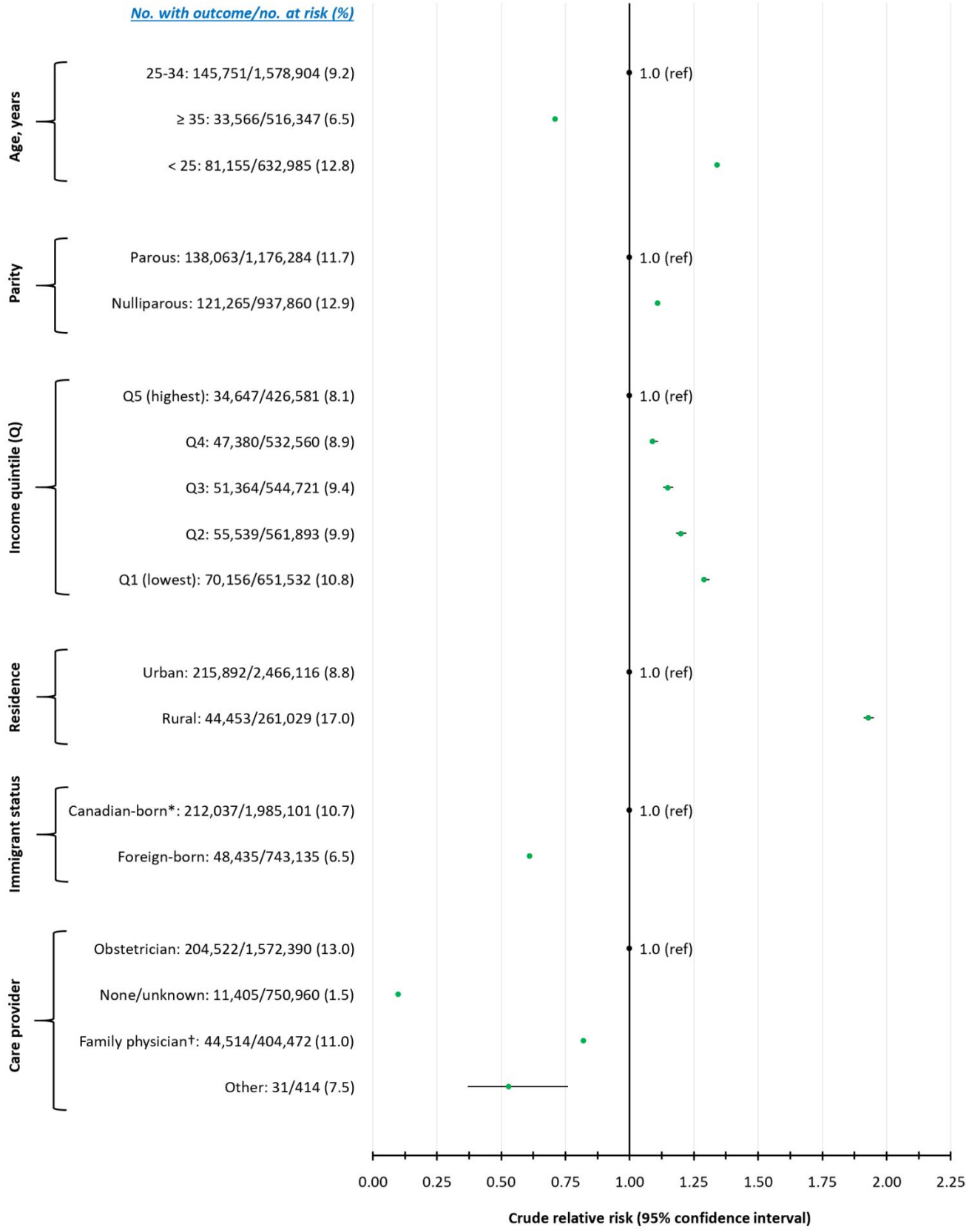
ACG Adjusted Clinical Group; CCI Canadian Classification of Interventions; CCP Canadian Classification of Diagnoses and Procedures; ICD-9 International Classification of Diseases, 9th Revision.; ICD-10-CA International Classification of Diseases, 10th Revision, Canada; IRCC Immigration, Refugees, and Citizenship Canada; NACRS National Ambulatory Care Reporting System; OHIP Ontario Health Insurance Plan; SDS Same Day Surgery Database; RPDB Registered Persons Database

Supplemental file 2a. Crude relative risk (green dots) of an emergency department visit in the first trimester of pregnancy, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown).



* Includes long-term residents.
† Includes nurse practitioners.

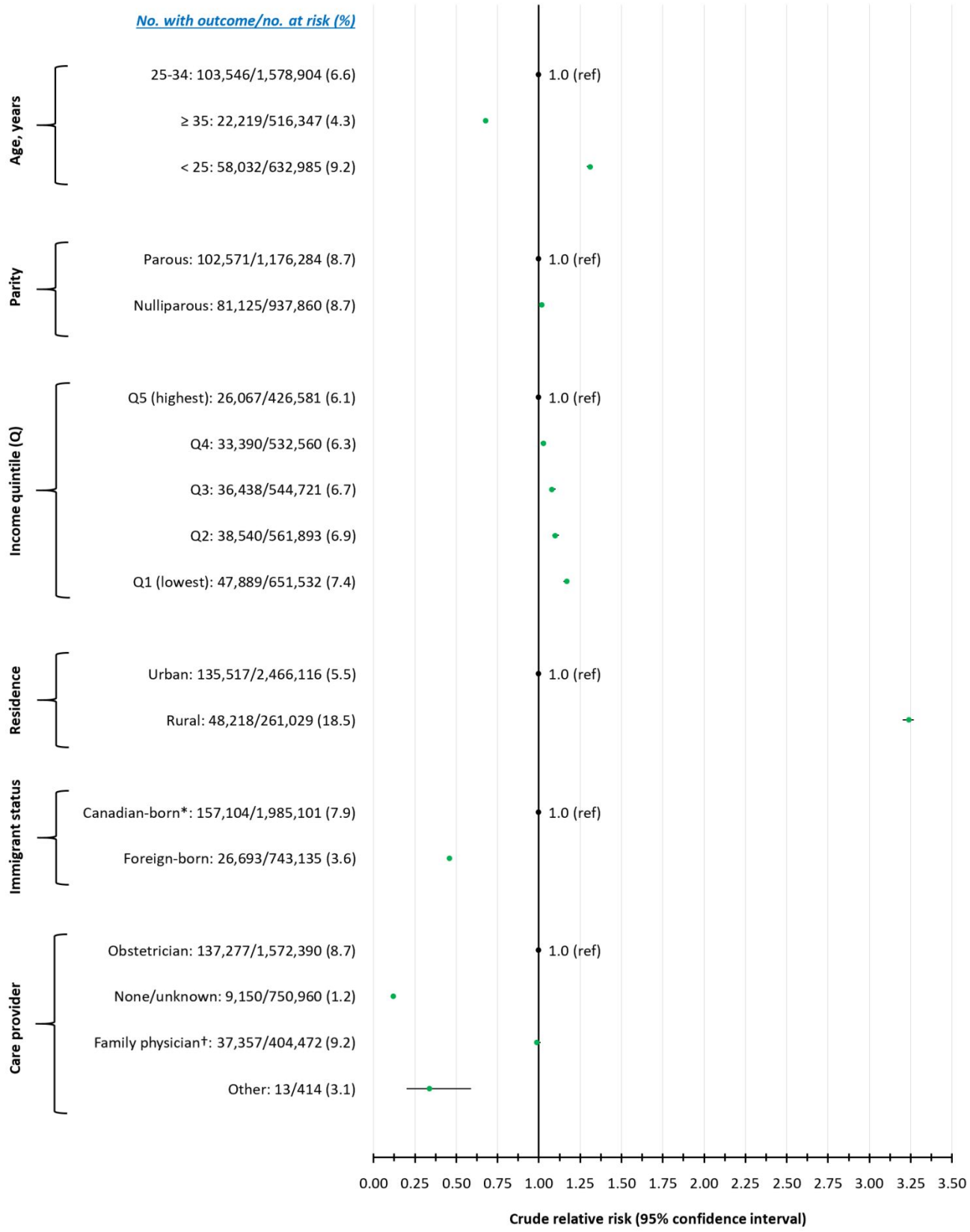
Supplemental file 2b. Crude relative risk (green dots) of an emergency department visit in the second trimester of pregnancy, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown).



* Includes long-term residents.

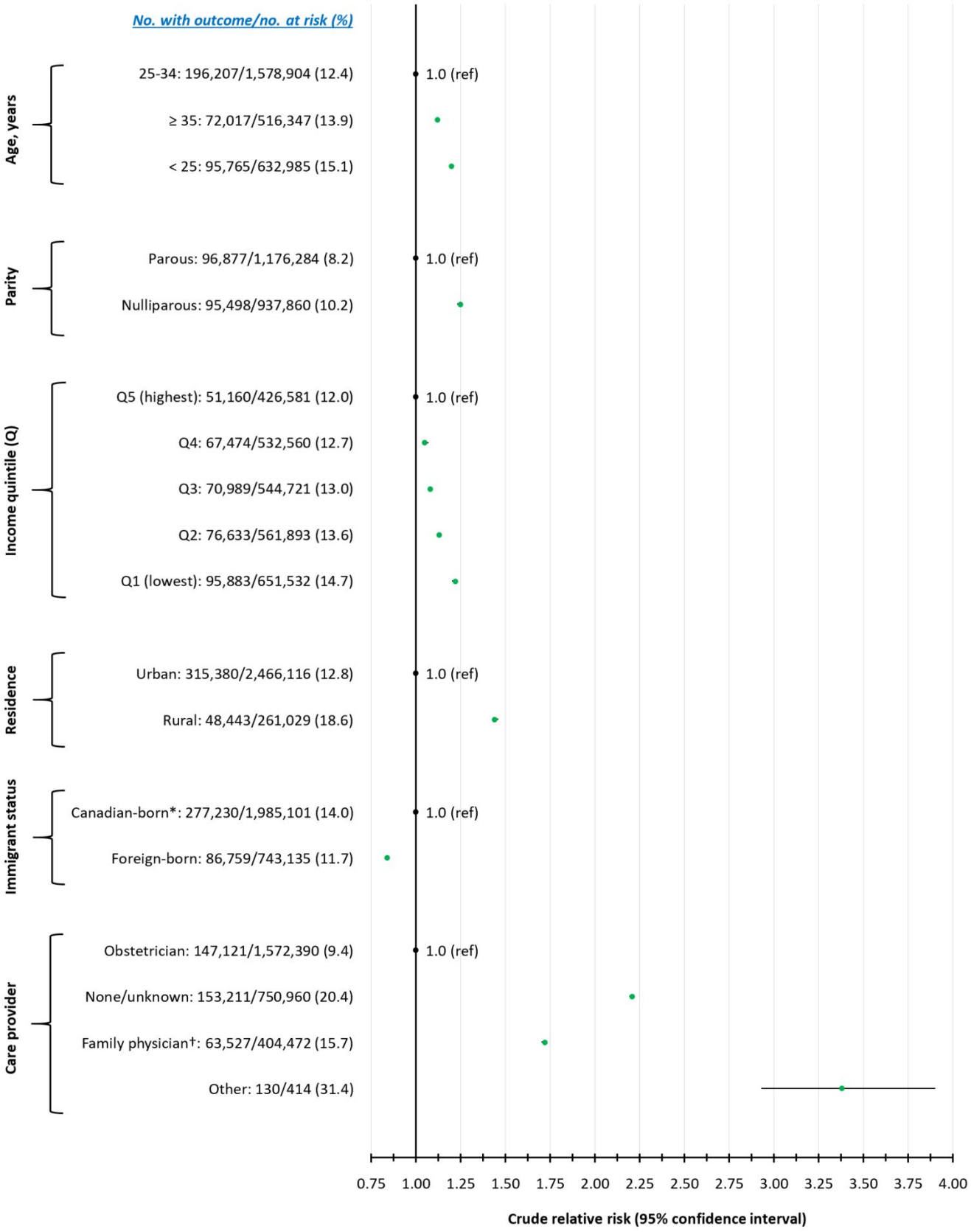
† Includes nurse practitioners.

Supplemental file 2c. Crude relative risk (green dots) of an emergency department visit in the third trimester of pregnancy, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown).



* Includes long-term residents.
† Includes nurse practitioners.

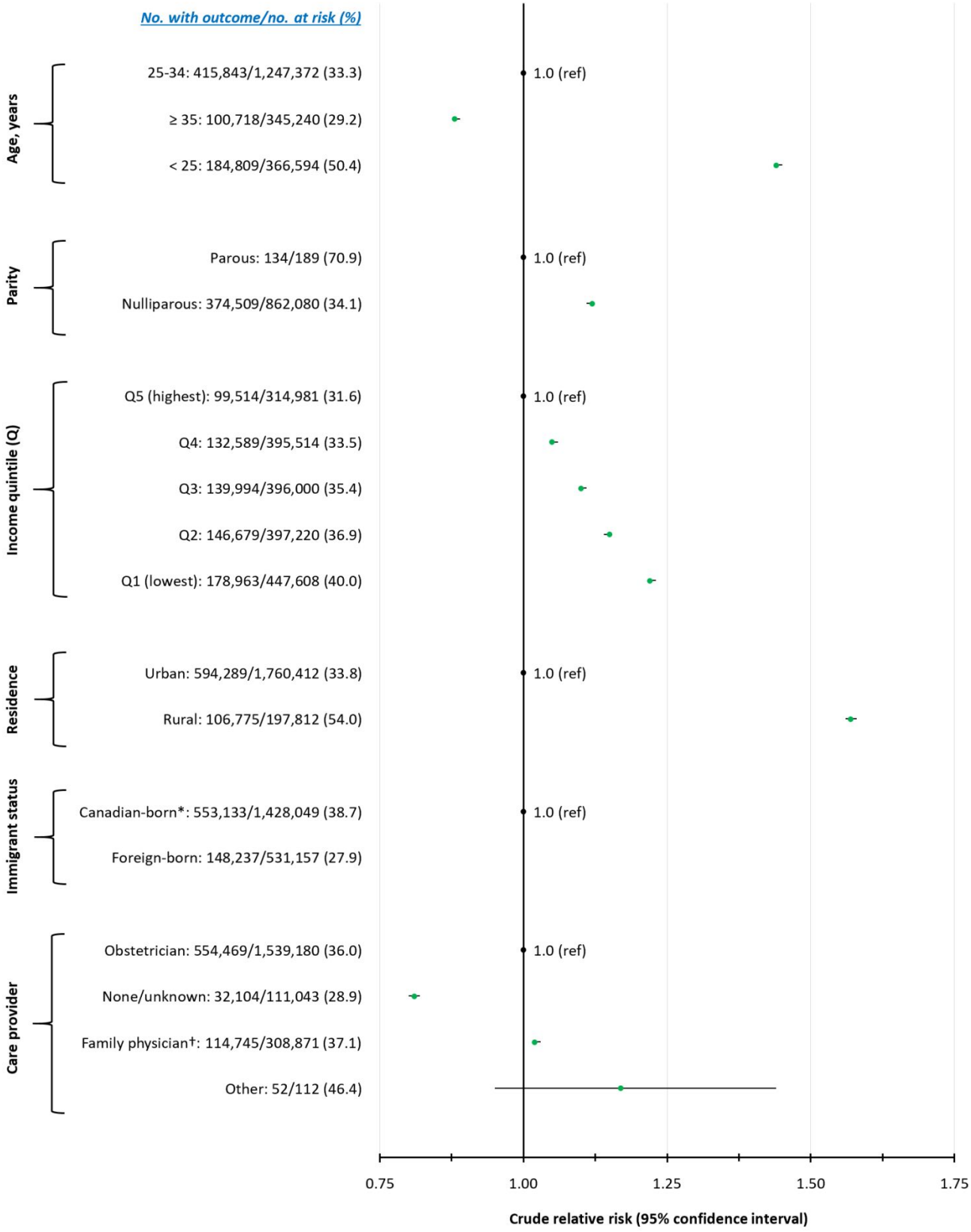
Supplemental file 2d. Crude relative risk (green dots) of an emergency department within 42 days after pregnancy outcome, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown).



* Includes long-term residents.

† Includes nurse practitioners.

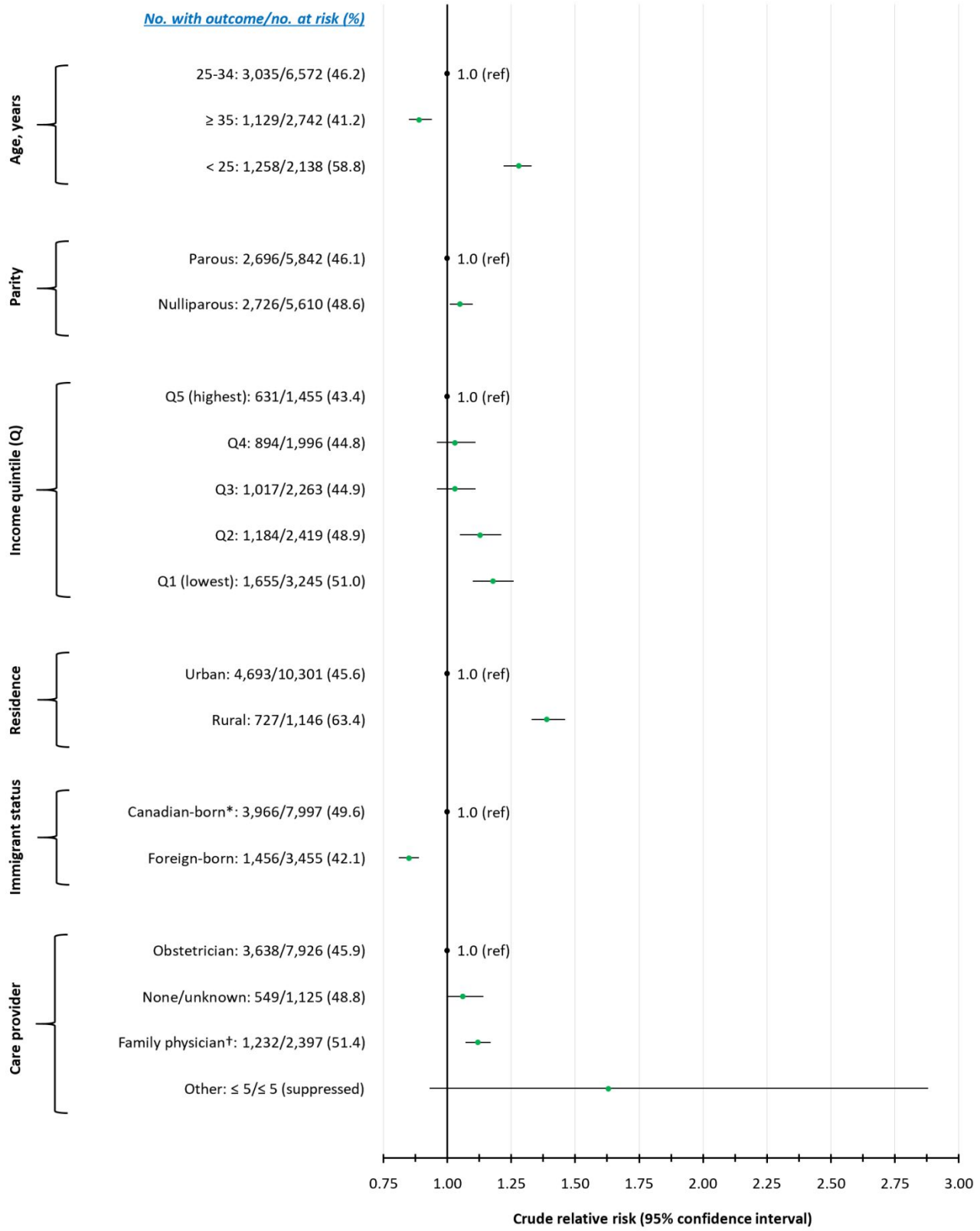
Supplemental file 3a. Crude relative risk (green dots) of an emergency department visit in pregnancy, or up to 42 days thereafter, for patients with a livebirth, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown).



* Includes long-term residents.

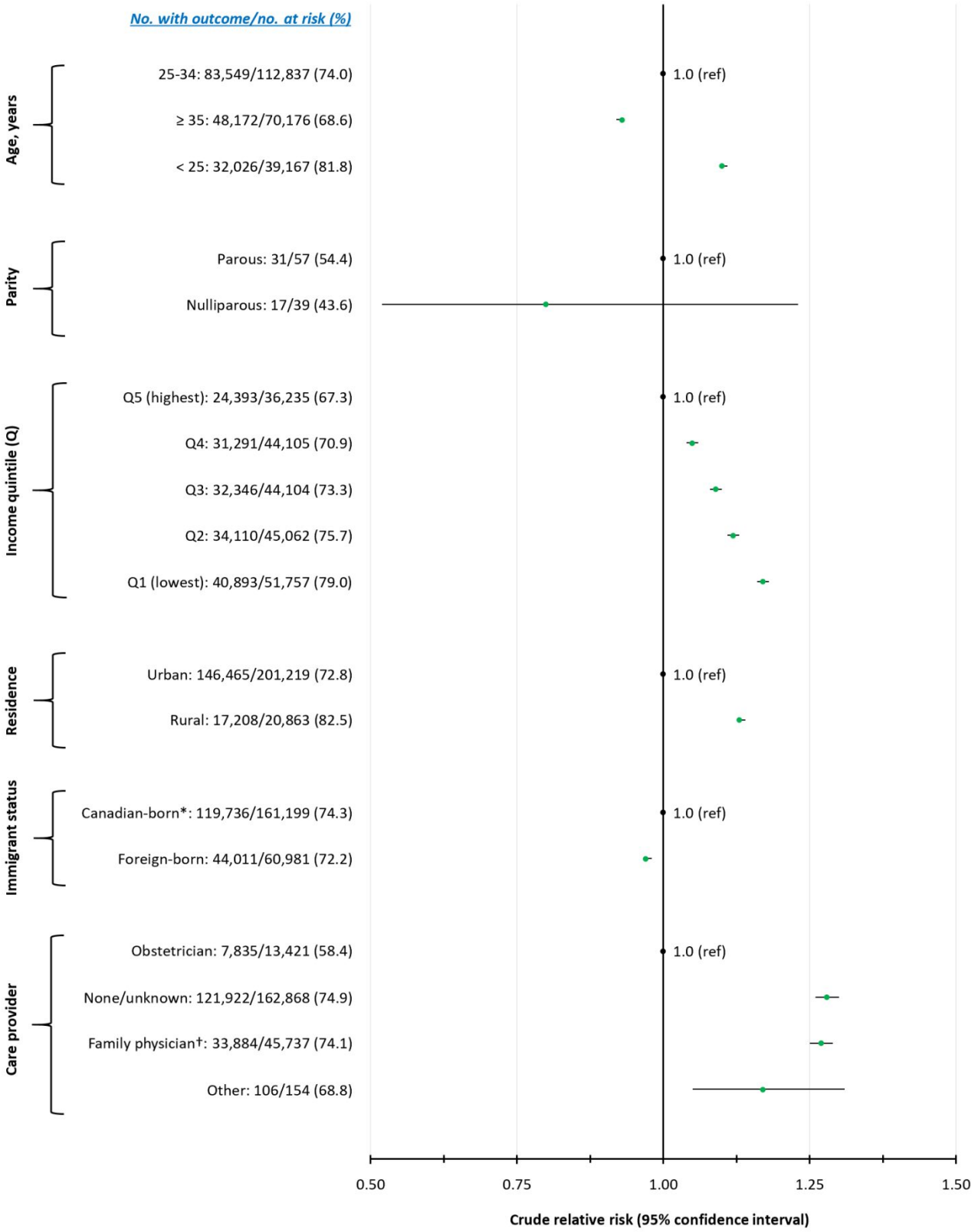
† Includes nurse practitioners.

Supplemental file 3b. Crude relative risk (green dots) of an emergency department visit in pregnancy, or up to 42 days thereafter, for patients with a stillbirth, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown).



* Includes long-term residents.
† Includes nurse practitioners.

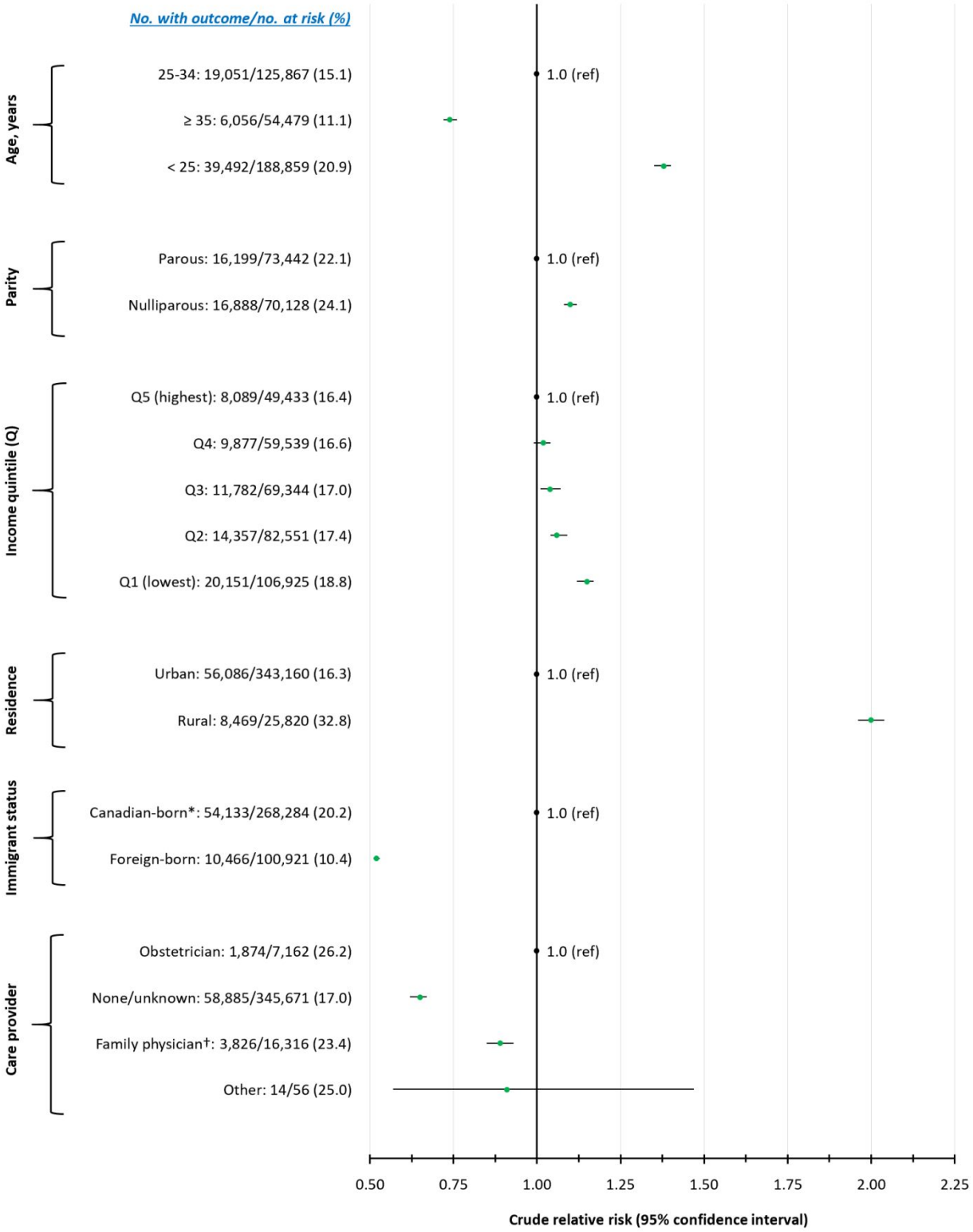
Supplemental file 3c. Crude relative risk (green dots) of an emergency department visit in pregnancy, or up to 42 days thereafter, for patients with a miscarriage, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown).



* Includes long-term residents.

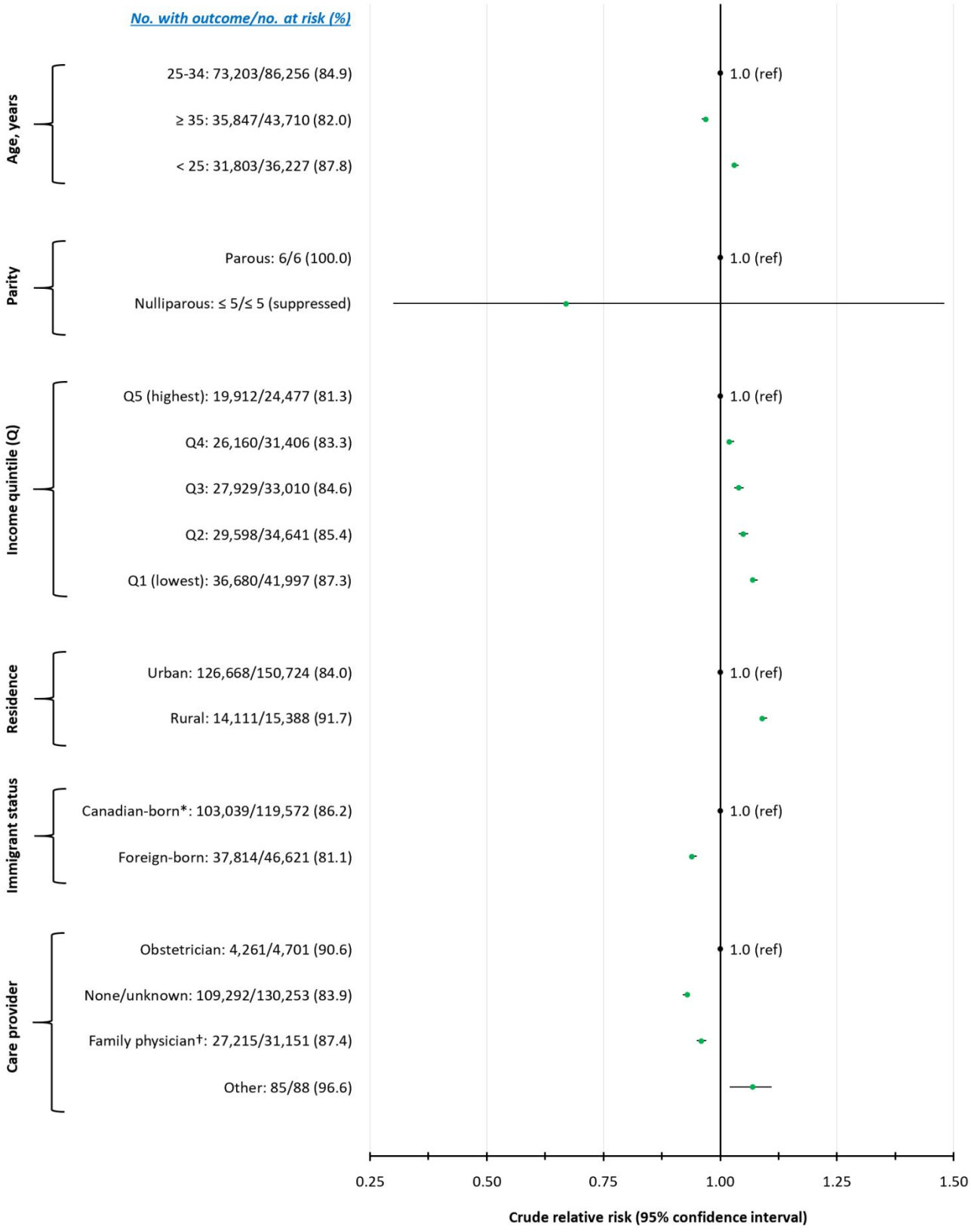
† Includes nurse practitioners.

Supplemental file 3d. Crude relative risk (green dots) of an emergency department visit in pregnancy, or up to 42 days thereafter, for patients with an induced abortion, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown).



*Includes long-term residents.
† Includes nurse practitioners.

Supplemental file 3e. Crude relative risk (green dots) of an emergency department visit in pregnancy, or up to 42 days thereafter, for patients with a threatened abortion, associated with maternal age (< 25, 25-34 [ref], ≥ 35 years); parity (parous [ref] or nulliparous); income quintile (1, 2, 3, 4, or 5 [ref]); residence (urban [ref] or rural); immigrant status (Canadian-born* [ref] or foreign-born); care provider (obstetrician [ref], family physician†, other, none/unknown).



* Includes long-term residents

† Includes nurse practitioners

Supplemental file 4. Proportion of all emergency department (ED) visits occurring in pregnancy, or up to 42 days postpartum, among livebirth deliveries