Physician procedure volume and related adverse events after surgically induced abortion: a population-based cohort study

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ABSTRACT

BACKGROUND: Induced abortion is a common procedure performed by physicians with varying degrees of clinical experience. We aimed to determine whether a physician's procedure volume influences complications after induced abortion.

METHODS: We obtained population-based retrospective data on surgically induced abortion procedures in Ontario between 2003 and 2015 from Ontario health administrative databases held at ICES. Physician procedure volume was defined as the number of surgically induced abortions performed in the 1-year period preceding the index procedure date, categorized as low (< 10th

percentile of yearly volume) or higher (≥ 10th percentile). The primary outcome was a severe adverse event (maternal end organ damage, severe maternal morbidity, intensive care unit admission or death) within 42 days after an induced abortion. The secondary outcome was any adverse event within 42 days.

RESULTS: Among 529 141 surgical abortion procedures, we found 850 severe adverse events (1.6 per 1000 procedures, 95% confidence interval [CI] 1.5–1.7), and 5664 any adverse events (10.7 per 1000 procedures, 95% CI 10.4–11.0). Severe adverse events occurred in 194 out of 52 889 procedures in the low-volume group (3.7 per 1000 procedures,

95% CI 3.2–4.2) compared with 656 out of 476 252 procedures in the higher-volume group (1.4 per 1000 procedures, 95% CI 1.3–1.5), an adjusted odds ratio (OR) of 1.91 (95% CI 1.41–2.59). The odds of any adverse event were also higher in the low-volume versus higher-volume group (adjusted OR 1.19, 95% CI 1.02–1.40).

INTERPRETATION: Low physician procedure volumes are associated with an elevated risk of a complication after surgically induced abortion. Future investigation should compare processes of care between low- and higher-volume physicians to facilitate quality improvement in abortion care.

I nduced abortion is a common procedure performed among women of reproductive age.[1] Although it is technically a simple and safe procedure, complications with different degrees of severity can occur following induced abortion.[2–6]

Physician procedure volume is known to be inversely related to the risk of complications after complex procedures, such as cancer, cardiac and pelvic surgery.[7,8] In contrast to these complex higher-risk surgeries, surgically induced abortion is a low-risk, less technically demanding procedure, performed mostly among relatively healthy women. In addition, given that most induced abortions are performed for reasons other than a maternal illness or fetal anomaly, such as a mistimed pregnancy or financial burden,[9,10] this underscores the expectation that the procedure carries little or no risk of an adverse outcome for women. To our knowledge, the influence of physician procedure volume on patient outcomes after induced abortion is not known. Accord-

ingly, we aimed to examine the relation between physicians' volume of surgically induced abortion procedures and women's risk of adverse events after surgically induced abortion.

Methods

Study setting

We conducted a population-based cohort study using administrative health data for the province of Ontario, Canada, where health care, including access to induced abortion services, is publicly funded. Induced abortions are performed in hospitals, outpatient clinics and health care centres.[11] In recent years, induced abortions have been increasingly provided at free-standing abortion clinics located almost exclusively in large urban centres.[12] Up to December 2016, at least 95% of induced abortions in the province were done as a surgical procedure.[3] An oral preparation that combines mifepristone and

misoprostol was approved for induced abortion by Health Canada in July 2015; however, it did not become available until January 2017.[13]

Sources of data

We used Ontario health administrative databases held at ICES, Toronto, as described elsewhere[14,15] and detailed in Appendix 1A, available at www.cmaj.ca/lookup/suppl/doi:10.1503/cmaj.181288/-/DC1. We linked data sets with procedure-level information using unique encoded patient identifiers and data sets with physician-level information using encoded physician billing numbers.

Study participants

We included all induced abortions performed in Ontario between Jan. 1, 2003, and Dec. 31, 2015. We defined induced abortion as a termination of pregnancy before 20 weeks' gestation by a surgical procedure or use of an abortifacient pharmaceutical agent that was identified using diagnostic codes and procedure codes (Appendix 1A) from hospital discharges, emergency department visits and physician billing. This approach had a sensitivity of 99.1% (95% confidence interval [CI] 98.3–99.6) for identifying induced abortion.[16] We excluded pharmaceutically induced abortions. We included surgical abortion procedures performed in women aged 15 to 49 years that could be linked to a physician practising in Ontario and that had no missing information for procedure- or physician-level characteristics (Appendix 1B).

Exposures and outcomes

Our primary study exposure was a physician's volume of surgically induced abortion procedures, defined as the number of surgically induced abortions a physician performed in the 1-year period preceding the index date of the induced abortion. We then ranked the induced abortions included in the analysis based on physicians' procedure volumes and categorized the low-volume group as less than the 10th percentile in volume (< 188 procedures in the previous year) and the higher-volume group as the 10th percentile or more (>/ 188 procedures in the previous year).

Our primary study outcome was a composite of any severe adverse event within 42 days after a surgical abortion, comprising any severe maternal morbidity, maternal end organ damage, admission to an intensive care unit (ICU) or death. We used a previously published algorithm to identify both maternal end organ damage and severe maternal morbidity.[17,18] Our secondary outcome was a broader composite of any adverse event within 42 days after an induced abortion, regardless of severity, and included any severe adverse event (as defined above), hemorrhage, retained products of conception, genital tract and pelvic infection, transfusion of red blood cells, damage to pelvic organs and tissues, shock, renal failure, metabolic disorders, venous complications, embolism or other unspecified complications following induced abortion.[2,3] Adverse events were identified from hospital discharge records or data from emergency department visits (Appendix 1A).

Covariates

Covariates were considered at the patient or procedure level, and the physician level. At the patient or procedure level, the first domain comprised sociodemographic characteristics of the woman, assessed at the time when the induced abortion was performed, and included her age, rural versus urban residence, neighbourhood income quintile and world region of origin.[15] The second domain reflected a woman's reproductive history, and included parity and the number of induced abortions she had before the index procedure. The third domain evaluated a woman's pre-existing health conditions in the 2 years preceding the date of the index procedure, denoted by the number of Johns Hopkins Aggregated Diagnosis Groups.[19] The fourth domain characterized the index procedure and included when the procedure was performed (early [< 15 wk gestation] or late [≥ 15 wk gestation]), location (within or outside of hospital) and the year of the procedure.

Physician-level covariates included sex, place of training, years in practice and specialty (obstetrics–gynecology, family medicine or other).

Statistical analysis

We calculated event rates (per 1000 procedures) for the primary and secondary outcomes among the entire cohort and then by deciles of physician procedure volume. The latter suggested that, in the bottom decile, the risk of severe adverse events was much higher than in the rest of the deciles (Figure 1), so we set a "low procedure volume" at less than the 10th percentile.

We reported procedure- and physician-level covariates according to whether the procedure was performed by a physician with a low (< 10th percentile) or higher (≥ 10th percentile) procedure volume. We compared means and proportions using standardized differences, with an absolute value 0.10 or more indicating meaningful difference.[20]

To assess the appropriateness of using the 10th percentile cut point to define the low and higher physician procedure volume, we used Analysis 1 (Appendix 1C) to model physician procedure volume as a continuous variable and used fractional polynomial methods to select the best-fitting transformation of this variable for describing its relation with both severe and any adverse event.[21]

In Analysis 2 (the main model), we used generalized estimating equations with binomial distribution, logit link, exchangeable correlation structure and robust standard errors, to produce odds ratios (ORs) and 95% CIs for having an adverse event within 42 days after induced abortion, comparing the low-volume group to the higher-volume group (the referent), adjusting for all covariates and further accounting for multiple procedures clustered within the same physician.[22,23]

We performed Analyses 3–8 to test the robustness of the findings from the main model (Appendix 1C).

We also conducted a sequence of multilevel logistic regression models with physician-level random effects to explore further the heterogeneity for adverse events between different physicians, and variation in rates of adverse events between physicians explained by patient- or procedure-level and physician-level characteristics[24] (Analyses 9 and 10 in Appendix 1C).

We performed the analysis using SAS version 9.4 (SAS Institute).

Ethics approval

Ethics approval was granted by the Research Ethics Board of Sunnybrook Health Sciences Centre and the Office of Research Ethics at the University of Toronto.

Results

We found that 565 631 induced abortions were performed in Ontario between 2003 and 2015. Of these, 13 286 were pharmaceutically induced abortions, 16 655 could not be linked to an Ontario physician and 5308 had missing information. Our final sample comprised 529 141 surgically induced abortion procedures (Appendix 1B).

There were 850 severe adverse events (1.6 per 1000 procedures, 95% CI 1.5–1.7) and 5664 any adverse events (10.7 per 1000, 95% CI 10.4–11.0) (Table 1). There were 28 deaths; of the 23 deaths with a known cause, most were due to intentional
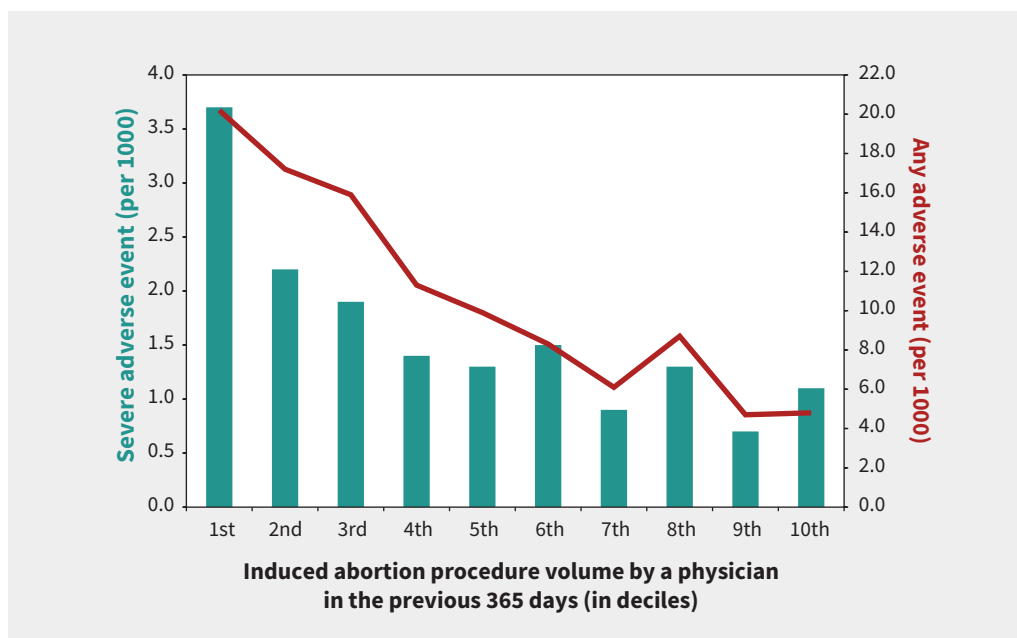

Figure 1: Incidence of an adverse event within 42 days after a surgically induced abortion procedure according to physician volume of surgically induced abortion procedures in the previous year. The green bars and the left axis show the rate of severe adverse events (Table 1). The red line and right axis show the rate of any adverse event, regardless of severity (Table 1). Procedure volume ranges from lowest (1st decile) to highest (10th decile).

Table 1: Rate of adverse events within 42 days after a surgically induced abortion, by severe and any adverse events

Type of adverse event	No. (%) of procedures with an adverse event n = 529 141	Rate of adverse events per 1000 procedures (95% CI) n = 529 141
Severe adverse event*	850 (0.2)	1.6 (1.5–1.7)
Severe maternal morbidity	550 (0.1)	1.0 (1.0–1.1)
Maternal end organ damage	221 (0.0)	0.4 (0.4–0.5)
Intensive care unit admission	165 (0.0)	0.3 (0.3–0.4)
Death	28 (0.0)	0.05 (0.03–0.07)
Any adverse event†	5664 (1.1)	10.7 (10.4–11.0)
Severe adverse event	850 (0.2)	1.6 (1.5–1.7)
Hemorrhage	2175 (0.4)	4.1 (3.9–4.3)
Retained products of conception	1583 (0.3)	3.0 (2.8–3.1)
Infection	656 (0.1)	1.2 (1.1–1.3)
Transfusion of red blood cells	256 (0.0)	0.5 (0.4–0.5)
Other‡	1059 (0.2)	2.0 (1.9–2.1)

Note: CI = confidence interval.
*Comprises any of the following: maternal end organ damage, severe maternal morbidity, admission to an intensive care unit (ICU) or death.
†Comprises any of the following: hemorrhage, infection, retained products of conception, transfusion of red cell bloods, maternal end organ damage, severe maternal morbidity, admission to an ICU, death or other.
‡Any of damage to pelvic organs and tissues, shock, renal failure, metabolic disorders, venous complications, embolism and other unspecified complications after medical abortion.

Table 2 (part 1 of 2): Characteristics of surgically induced abortion procedures, patients and physicians who performed the procedure, categorized by low (< 10th percentile) and higher (≥ 10th percentile) physician induced-abortion volume in the previous year

Characteristic	No. (%)* of physician IA procedure volume (< 10th percentile) (n = 52 889)	No. (%)* of physician IA procedure volume (≥ 10th percentile) (n = 476 252)	Standardized difference†
IA procedure			
Patient age, yr			
Mean ± SD	26.9 ± 7.2	27.1 ± 6.9	0.02
< 20	8414 (15.9)	65 033 (13.7)	0.06
20–24	15 091 (28.5)	137 104 (28.8)	0.01
25–29	11 034 (20.9)	108 945 (22.9)	0.05
30–34	8581 (16.2)	82 054 (17.2)	0.03
35–39	6639 (12.6)	58 339 (12.2)	0.01
≥ 40	3130 (5.9)	24 777 (5.2)	0.03
Rural residence	5951 (11.3)	24 514 (5.1)	0.22
Neighbourhood income quintile			
Q1 (lowest)	17 682 (33.4)	138 761 (29.1)	0.09
Q2	12 120 (22.9)	108 952 (22.9)	0.00
Q3	9180 (17.4)	92 465 (19.4)	0.05
Q4	7740 (14.6)	76 992 (16.2)	0.04
Q5 (highest)	6167 (11.7)	59 082 (12.4)	0.02
World region of origin			
Canada	40 835 (77.2)	333 373 (70.0)	0.16
Africa	1168 (2.2)	12 885 (2.7)	0.03
Caribbean	1297 (2.5)	18 075 (3.8)	0.08
East Asia	3648 (6.9)	29 436 (6.2)	0.03
Hispanic America	1080 (2.0)	13 459 (2.8)	0.05
Middle East	884 (1.7)	9465 (2.0)	0.02
South Asia	2560 (4.8)	41 743 (8.8)	0.16
Western‡	1417 (2.7)	17 816 (3.7)	0.06
Nulliparous	25 495 (48.2)	263 565 (55.3)	0.14
No. of previous IAs			
0	31 288 (59.2)	253 102 (53.1)	0.12
1	11 678 (22.1)	104 700 (22.0)	0.00
2	4982 (9.4)	51 040 (10.7)	0.04
≥ 3	4941 (9.3)	67 410 (14.2)	0.15
Total no. of adjusted ADGs¶			
Median (IQR)	5 (3–7)	4 (3–7)	0.07
0–2	11 734 (22.2)	115 461 (24.2)	0.05
3–4	13 657 (25.8)	125 702 (26.4)	0.01
5–6	12 872 (24.3)	113 941 (23.9)	0.01
≥ 7	14 626 (27.7)	121 148 (25.4)	0.05
Gestational age at IA, wk			
Early IA < 15 wk	50 853 (96.2)	463 732 (97.4)	0.07
Late IA ≥ 15 wk	2036 (3.8)	12 520 (2.6)	0.07

Table 2 (part 2 of 2): Characteristics of surgically induced abortion procedures, patients and physicians who performed the procedure, categorized by low (< 10th percentile) and higher (≥ 10th percentile) physician induced-abortion volume in the previous year

Characteristic	No. (%)* of physician IA procedure volume (< 10th percentile) (n = 52 889)	No. (%)* of physician IA procedure volume (≥ 10th percentile) (n = 476 252)	Standardized difference†
Location where IA was performed			
Within hospital	45 593 (86.2)	90 867 (19.1)	1.82
Outside of hospital	7296 (13.8)	385 385 (80.9)	1.82
Year in which the IA was performed			
2003	5446 (10.3)	36 783 (7.7)	0.09
2004	4832 (9.1)	35 363 (7.4)	0.06
2005	4588 (8.7)	36 377 (7.6)	0.04
2006	4490 (8.5)	38 693 (8.1)	0.01
2007	4585 (8.7)	38 925 (8.2)	0.02
2008	4430 (8.4)	39 197 (8.2)	0.01
2009	3950 (7.5)	39 217 (8.2)	0.03
2010	3947 (7.5)	37 597 (7.9)	0.02
2011	3867 (7.3)	37 131 (7.8)	0.02
2012	3832 (7.2)	35 626 (7.5)	0.01
2013	3157 (6.0)	34 837 (7.3)	0.05
2014	3250 (6.1)	34 305 (7.2)	0.04
2015	2515 (4.8)	32 201 (6.8)	0.09
Physician who performed the procedure			
No. of unique physicians	400	79	
Male sex	31 131 (58.9)	216 212 (45.4)	0.27
Graduated in Canada	42 584 (80.5)	326 652 (68.6)	0.28
Specialty			
Obstetrics and gynecology	39 245 (74.2)	88 343 (18.5)	1.34
Family medicine or other	13 644 (25.8)	387 909 (81.5)	1.34
Age, mean ±SD; yr	50.5 ± 13.5	55.4 ± 10.4	0.41
No. years since graduation			
Mean ± SD	24.8 ± 13.9	29.3 ± 11.0	0.36
≤ 25	27 819 (52.6)	150 978 (31.7)	0.43
≥ 26	25 070 (47.4)	325 274 (68.3)	0.43
No. of IA procedures performed in the previous year			
Mean ± SD	95.4 ± 54.7	2142.5 ± 1713.2	1.69
Median (IQR)	98 (51–145)	1609 (835–2949)	2.70

Note: ADG = Aggregated Diagnosis Group, IA = induced abortion, IQR = interquartile range, SD = standard deviation.
*Unless otherwise indicated.
†We considered a standardized difference greater than 0.10 to represent a meaninful significance.
‡Refers to all of Europe (including the United Kingdom, Wales, Scotland and Ireland), Australia, New Zealand and the United States.
§Based on the adjusted Johns Hopkins ADGs and derived from diagnostic information recorded in inpatient data for hospital admission, emergency department visits and visits to a physician.

self-harm or assault. The rate of a severe adverse event was 3.7 per 1000 procedures (95% CI 3.2–4.2) at the lowest volume decile (median number of procedures 98, interquartile range [IQR] 51–145; maximum number of procedures 188), rapidly declining by the next higher volume decile (Figure 1). For any adverse event, the rate was 20.2 per 1000 procedures (95% CI 19.0–21.4)

at the lowest decile, which gradually declined at each higher decile (Figure 1).

The probability of a woman having a severe adverse event rapidly declined with increasing physician procedure volume and started to plateau after her physician's procedure volume surpassed about 200 procedures (Analysis 1, Appendix 1D), which

Table 3: Odds of having a severe or any adverse event within 42 days after a surgically induced abortion in relation to the volume of surgically induced abortion procedures performed by that physician in the preceding year being less than the 10th versus the 10th percentile or more (Analysis 2, main model)

Outcome	Physician surgical IA procedure volume	No. (%) of women with an adverse outcome	Event rate per 1000 procedures (95% CI)	Crude OR (95% CI)*	Adjusted OR not accounting for clustering effect (95% CI)†	Adjusted OR accounting for clustering effect (95% CI)‡
Severe adverse event§	≥ 10th percentile n = 476 252	656 (0.1)	1.4 (1.3–1.5)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
	< 10th percentile n = 52 889	194 (0.4)	3.7 (3.2–4.2)	2.67 (2.27–3.13)	1.94 (1.60–2.34)	1.91 (1.41–2.59)
Any adverse event¶	≥ 10th percentile n = 476 252	4596 (1.0)	9.7 (9.4–9.9)	1.00 (Ref)	1.00 (Ref)	1.00 (Ref)
	< 10th percentile n = 52 889	1068 (2.0)	20.2 (19.0–21.4)	2.12 (1.98–2.26)	1.43 (1.32–1.54)	1.19 (1.02–1.40)

Note: ADG = Aggregated Diagnosis Group, CI = confidence interval, IA = induced abortion, ICU = intensive care unit, OR = odds ratio, Ref = referent.
*Results from univariable logistic regression models.
†Results from multivariable logistic regression models, adjusted for women's age, rural or urban residence, neighbourhood income quintile, world region of origin, nulliparous status, number of previous IAs, total number of adjusted ADGs in the 2 years before the index IA, gestational age and year when the IA was performed, sex of the physician, physician specialty and number of years since the physician graduated.
‡Results from multivariable logistic regression models, with generalized estimating equations applied to account for multiple IA procedures clustered within the same physician. Adjusted for women's age, rural or urban residence, neighbourhood income quintile, world region of origin, nulliparous status, number of previous IAs, total number of adjusted ADGs in the 2 years before the index IA, gestational age and year when the IA was performed, sex of the physician, physician specialty and number of years since the physician graduated.
§Comprises any of the following: maternal end organ damage, severe maternal morbidity, admission to ICU or death.
¶Comprises any of the following: hemorrhage, infection, retained products of conception, other, transfusion of red cell bloods, maternal end organ damage, severe maternal morbidity, admission to ICU or death.

was in alignment with the 10th percentile cut point of 188 procedures in the previous year. For any adverse event, we found a similar rapid decline after about 150 previous procedures (Analysis 1, Appendix 1E).

Four hundred unique physicians performed 52 889 procedures in the low-volume group, and 79 physicians completed 476 252 procedures in the higher-volume group. Compared with procedures in the higher-volume group, we found that procedures in the low-volume group were more likely to be performed within hospital, by a male physician, a graduate of a Canadian medical school and an obstetrician–gynecologist (Table 2).

A severe adverse event occurred in 194 out of 52 889 procedures in the low-volume group (3.7 per 1000 procedures, 95% CI 3.2–4.2) compared with 656 out of 476 252 procedures in the higher-volume group (1.4 per 1000 procedures, 95% CI 1.3–1.5) — an adjusted OR of 1.91 (95% CI 1.41–2.59) (Analysis 2, Table 3). For any adverse event, the corresponding adjusted OR was 1.19 (95% CI 1.02–1.40) (Analysis 2, Table 3). Results were similar when we restricted the analysis to 528 295 procedures performed by physicians practicing in Ontario for the 1-year period before the index procedure date (Analysis 3, Appendix 1F).

In stratified analyses, we found that the association of low volume of surgical abortions with severe adverse events observed in the main model was generally preserved and was more pronounced for late versus early induced abortion (adjusted OR 5.35, 95% CI 2.80–8.93 v. 1.64, 95% CI 1.19–2.26, respectively; p for interaction < 0.001) (Analysis 4a, Figure 2). Association of low volume of surgical abortions with any adverse event was more profound for late versus early induced abortion (adjusted OR 2.95, 95% CI 1.67–5.21 v. 1.10, 95% CI 0.93–1.31, respectively; p for interaction < 0.001) and for procedures

performed by an obstetrician–gynecologist versus a family physician or other specialist (adjusted OR 1.29, 95% CI 1.12–1.49 v. 0.94, 95% CI 0.64–1.39, respectively; p for interaction = 0.03) (Analysis 4b, Figure 3).

The adjusted OR for severe adverse events rose to 2.50 (95% CI 1.80–3.46) at less than the 5th percentile (median number of procedures 51, IQR 20–74), as did the adjusted OR for any adverse event (1.43, 95% CI 1.20–1.70) (Analysis 5, Appendix 1G). A dose–response effect was also seen at the broader thresholds of less than the 10th, or 10th to 19th, versus the 20th percentile or more, although less so for any adverse event (Analysis 6, Appendix 1H).

Women who had an induced abortion performed by a physician with a persistently low volume had the highest adjusted OR of having a severe adverse event (2.06, 95% CI 1.48–2.86) or any adverse event (1.30, 95% CI 1.09–1.56) (Analysis 7, Appendix 1I).

There were 13 778 women who had 1 abortion performed by a low-volume physician and another by a higher-volume physician. Comparing the former to the latter, the adjusted OR was 1.51 (95% CI 0.90–2.52) for a severe adverse event and 1.25 (95% CI 1.04–1.50) for any adverse event (Analysis 8, Appendix 1J).

We found that the multilevel logistic regression model that included physician-specific random effects and procedure-level characteristics explained 38.4% of the variation in rates of severe adverse events between physicians and reduced the median OR from 3.44 (95% CI 2.64–4.28) in the model considering only physician-specific random effects to 2.64 (95% CI 2.07–3.20) (Analysis 9, Appendix 1K). When we added physician-level characteristics, this accounted for another 25.0% of the variation and further reduced the median OR to 2.11 (95% 1.69–2.51) (Analysis 9, Appendix 1K).
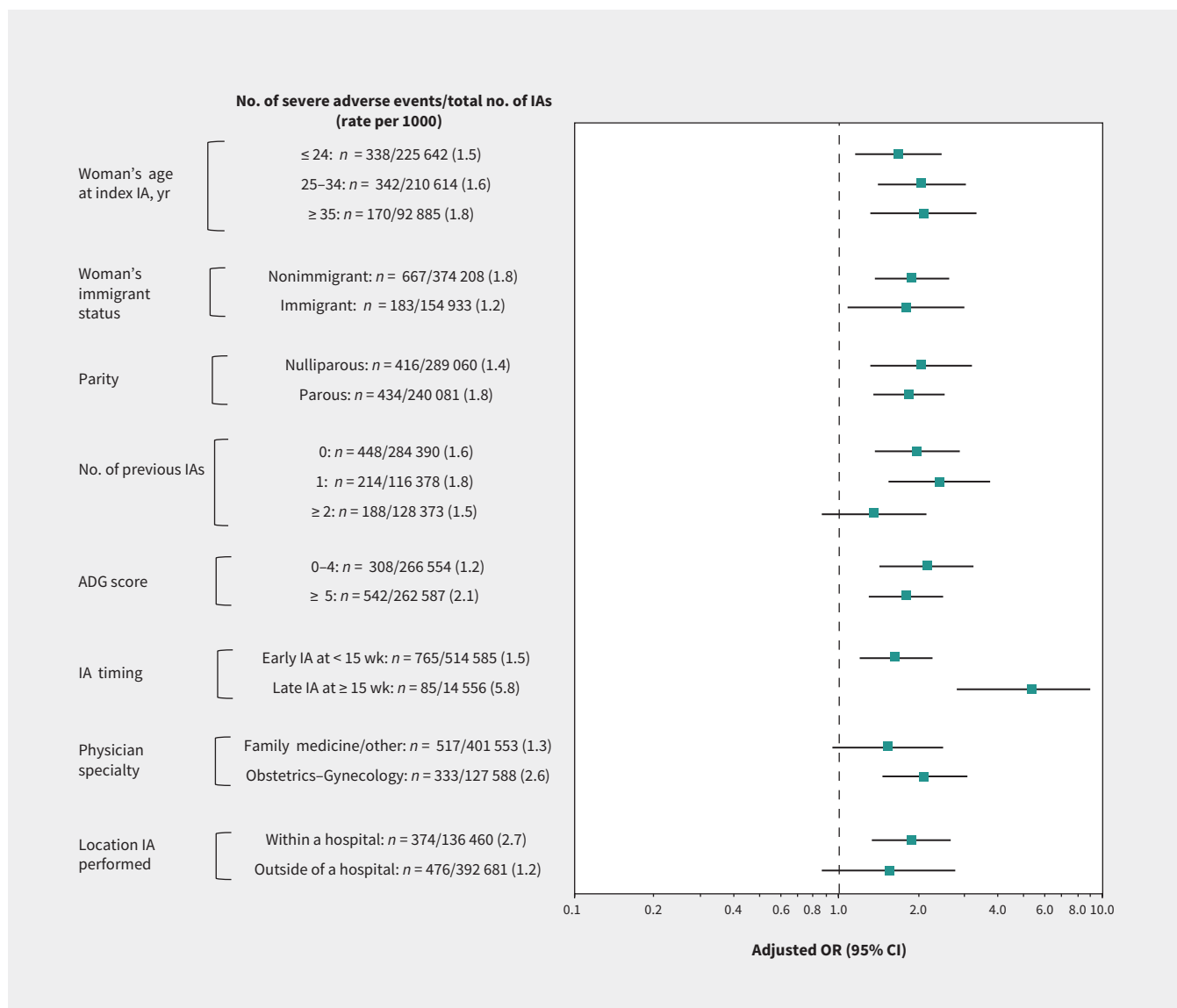
Figure 2: Stratification of the main model by age, immigrant status, parity, number of previous induced abortions (IAs), comorbidity, timing of the IA, physician specialty and location where the IA was performed, presenting the odds of having a severe adverse event (Table 1) within 42 days after a surgically IA performed by a physician whose procedure volume in the previous year was < 10th versus ≥ 10th percentile (the referent) (Analysis 4a). Odds ratios (ORs) were adjusted for age, rural or urban residence, neighbourhood income quintile, world region of origin, nulliparous status, number of previous IAs, total number of adjusted Aggregated Diagnosis Groups (ADGs) in the 2 years before the index IA, gestational age and year when the IA was performed, sex of the physician, physician specialty and number of years since the physician graduated. The interaction term between physician procedure volume and the timing of IA was statistically significant ($p < 0.001$). Note: CI = confidence interval.

For any adverse event, adjusting for both procedure-level and physician-level characteristics explained only 36.8% of the variation between physicians (Analysis 10, Appendix 1L).

Interpretation

In Ontario, we found that women who had an induced abortion performed surgically by a physician with a low procedure volume of less than the 10th percentile had almost double the odds of having a severe adverse event within 42 days of the procedure. For any adverse event, the associated odds were about 20% greater in the low-volume group.

As we expected, the rate of adverse events in this study was much lower than that observed in settings with limited access to safe abortion services[25] or in studies using a broader range of diagnoses in counting adverse events.[26] The median OR in the physician-level random-effects model, interpreted as a median relative difference of 2.11 times in the odds of having a severe adverse event when comparing an identical procedure performed by a higher-risk physician to that of a lower-risk physician, suggested large heterogeneity in rates of severe adverse events between different physicians.

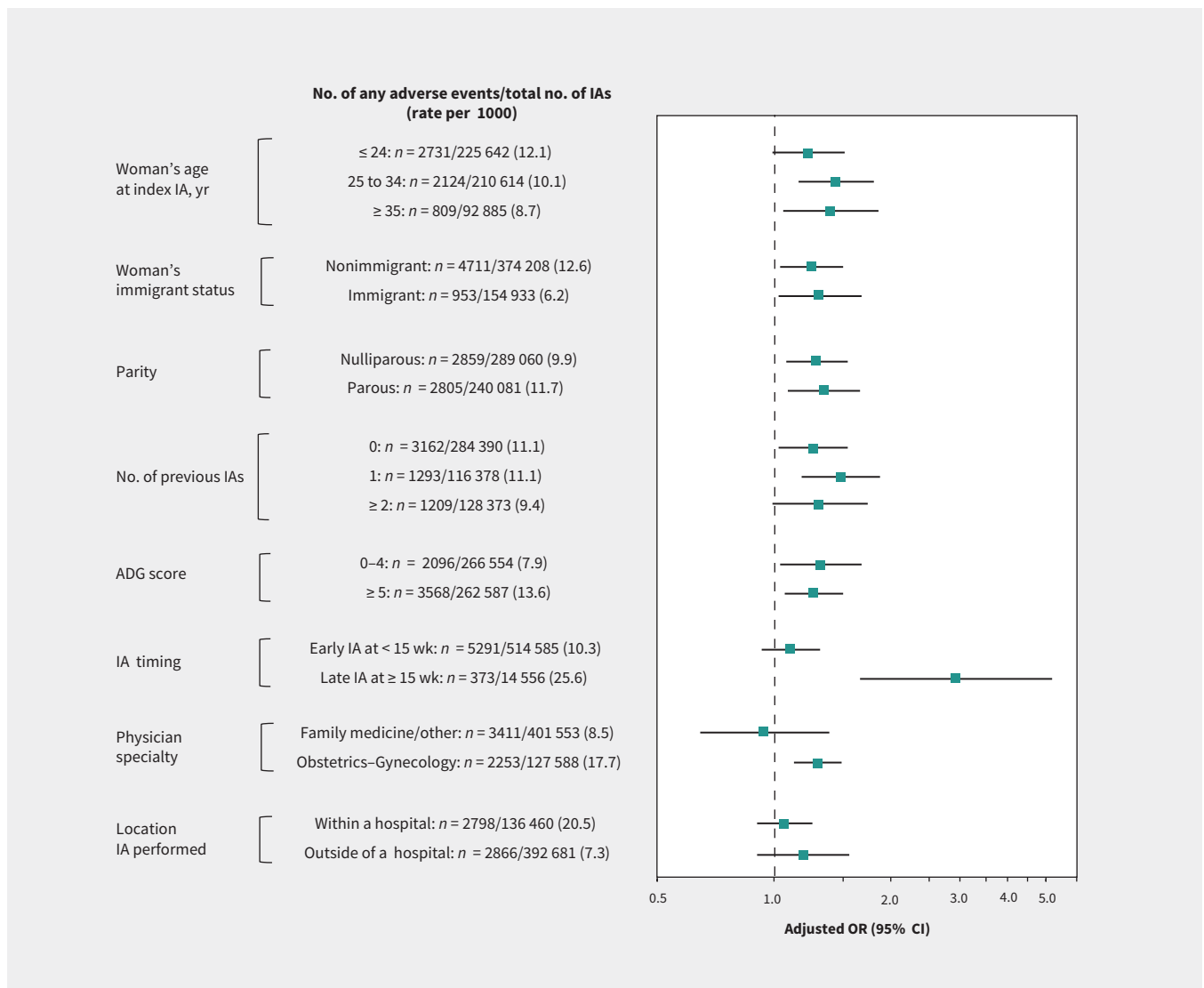We found that the effect of physician volume on adverse events was more profound for procedures done at 15 weeks

**No. of any adverse events/total no. of IAs
(rate per 1000)**

Woman's age at index IA, yr
- ≤ 24: *n* = 2731/225 642 (12.1)
- 25 to 34: *n* = 2124/210 614 (10.1)
- ≥ 35: *n* = 809/92 885 (8.7)

Woman's immigrant status
- Nonimmigrant: *n* = 4711/374 208 (12.6)
- Immigrant: *n* = 953/154 933 (6.2)

Parity
- Nulliparous: *n* = 2859/289 060 (9.9)
- Parous: *n* = 2805/240 081 (11.7)

No. of previous IAs
- 0: *n* = 3162/284 390 (11.1)
- 1: *n* = 1293/116 378 (11.1)
- ≥ 2: *n* = 1209/128 373 (9.4)

ADG score
- 0–4: *n* = 2096/266 554 (7.9)
- ≥ 5: *n* = 3568/262 587 (13.6)

IA timing
- Early IA at < 15 wk: *n* = 5291/514 585 (10.3)
- Late IA at ≥ 15 wk: *n* = 373/14 556 (25.6)

Physician specialty
- Family medicine/other: *n* = 3411/401 553 (8.5)
- Obstetrics–Gynecology: *n* = 2253/127 588 (17.7)

Location IA performed
- Within a hospital: *n* = 2798/136 460 (20.5)
- Outside of a hospital: *n* = 2866/392 681 (7.3)

Adjusted OR (95% CI)

Figure 3: Stratification of the main model by age, immigrant status, parity, number of previous induced abortion (IA), comorbidity, timing of the IA, physician specialty and location where the IA was performed, presenting the odds of having any adverse event, regardless of severity (Table 1) within 42 days after a surgically IA performed by a physician whose procedure volume in the previous year was < 10th versus ≥ 10th percentile (the referent) (Analysis 4b). Odds ratios (ORs) were adjusted for age, rural or urban residence, neighbourhood income quintile, world region of origin, nulliparous status, number of previous IAs, total number of adjusted Aggregated Diagnosis Groups (ADGs) in the 2 years before the index IA, gestational age and year when the IA was performed, sex of the physician, physician specialty and number of years since the physician graduated. The interaction terms between physician procedure volume and the timing of induced abortion (*p* < 0.001), and between physician procedure volume and physician specialty (*p* = 0.03), were both significant. Note: CI = confidence interval.

gestation or later as well as those performed by an obstetrician–gynecologist. This may be because later procedures are more complex, and the technical skills of the physician may have a larger influence on procedure outcome.

Our study lacked information on direct processes of care, including clinical decision-making, procedural techniques and the availability of allied health care, each of which may contribute to the observed relation between volume and outcome.[27] Nevertheless, a physician with greater procedure volume likely gains procedural proficiency, and an improved ability to recognize and manage periprocedural complications.[28] Higher-volume physicians may be more likely to be surrounded by a more

experienced team of other health care providers and to work in settings with procedure-specific guidelines and protocols for induced abortion.[29,30] Together, these factors may contribute to differences in rates of adverse events between low- and higher-volume physicians.

Limitations

Our study has several limitations. There was no information about the reasons why women underwent an induced abortion: maternal health status after an induced abortion for fetal anomalies might differ from that performed for social reasons.[9,10] Because we observed the volume–outcome relation in both

early and late induced abortion and early induced abortion typically precedes the gestational period of screening for structural anomalies,[31] our findings were unlikely to be materially confounded by this issue. As the relative odds for severe adverse events in the low-volume physician group was more pronounced for induced abortion done within a hospital, it is possible that administration of anesthesia was a residual confounder. We also lacked details about previous cesarean delivery or body mass index, both of which may influence outcomes after induced abortion.[32,33]

We created composite adverse event outcomes. Although previously used in other studies,[17,18] not all conditions that comprise the composite outcomes have been validated. Despite evident differences in the occurrence of the individual components of the composite outcomes, multiple models for each individual type of adverse event were not feasible. In addition, findings from our study may not be applicable to pharmaceutically induced abortions.

Conclusion

Low physician volume of surgically induced abortion procedures was associated with an increased risk of adverse events among women undergoing these procedures. These findings offer support to the current centralization of induced abortion procedures within urban abortion clinics, performed by higher-volume physicians.[11] However, centralization would be expected to limit access further to induced abortion, particularly in rural areas. Given that serious adverse events after induced abortion are uncommon, any focus on centralization should also consider geographical access to the procedure and patient wait times. Adverse events vary widely between physicians and are only partly explained by physician volumes. Therefore, quality improvement efforts should seek to identify the most influential processes of care related to adverse events after induced abortion and optimize ways to improve those processes, especially among low-volume practitioners.[34]

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