Is type of antenatal care provider, family physician, obstetrician or midwife, associated with excess or inadequate gestational weight gain? A retrospective cohort study.

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Conflict of Interest: All authors report no conflict of interest.

Funding source:

This study was funded by Canadian Institute of Health Research (CIHR) (Grant#146442; Non-communicable Diseases in Obstetrics: Improving Quality of Care and Maternal-infant Outcomes Through an Obstetrical Research Network). Matched funding was provided by the Department of Obstetrics and Gynaecology at the University of Toronto, McMaster University, Sunnybrook Research Institute, and Providence St. Joseph's and St. Michael's Healthcare. Dr. Sarah D. McDonald is supported by a Tier II Canada Research Chair. Dr. Beth Murray-Davis is supported by a Hamilton Health Sciences Early Career

Award. None of the funding agencies had any role in the idea, design, analyses, interpretation of data, writing of the manuscript or decision to submit the manuscript.

Presentation: The current study was accepted for a poster presentation at the Canadian National Perinatal Research Meeting (Banff, AB, February 2018).

ABSTRACT WORD COUNT: 250 words

TEXT WORD COUNT: 2447 words

ABSTRACT

Background

This study examined whether type of antenatal health care provider (HCP) (family physician, obstetrician, midwife, family physician + obstetrician) was associated with differing rates of excess or inadequate gestational weight gain (GWG) and associated adverse outcomes including large for gestational age (LGA), small for gestational age (SGA), cesarean section, preterm birth.

Methods

This retrospective cohort study used data from the Better Outcomes Registry & Network, 2012-2016, for singleton hospital births at 20-42 weeks in Ontario, Canada. Descriptive statistics were calculated to summarize patient characteristics and outcomes by HCP. Crude and adjusted relative risks (RR) with 95% confidence intervals (CIs) were calculated for the exposure, GWG relative to each secondary outcome by HCP. Population attributable fractions (PAFs) with 95% CIs were calculated to assess the proportion of secondary outcomes that could be prevented if GWG not meeting the recommendation were removed by antenatal HCP.

Results

Rates of GWG below, within, or above recommendations were 13.7%, 31.0% and 55.3% respectively and did not differ across HCP groups. No difference was observed in rates of secondary outcomes according to GWG across HCPs. Excess GWG was associated with a significant risk for LGA and cesarean, inadequate GWG was associated with an increased risk of SGA and PTB. The PAFs indicated a pronounced contribution of excess GWG to LGA across all HCP groups.

Interpretation

GWG and rates of secondary outcomes associated with GWG did not differ according to antenatal HCP. A significant proportion of LGA, SGA, cesarean could be prevented with appropriate GWG.

Introduction

Gestational weight gain (GWG) during pregnancy below or above the recommended guidelines significantly increases maternal, fetal and neonatal risks (1–4). The 2009 Institute of Medicine (IOM) guidelines for GWG, adopted by Health Canada, recommend that underweight women (BMI < 18.5 kg/m^2) gain 13 to 18 kg during pregnancy, normal weight women (BMI 18.5 to 24.9 kg/m^2) gain 11 to 16 kg, overweight women (BMI 25 to 29.9 kg/m^2) gain 7 to 11 kg, and obese women (BMI 30 kg/m^2 or more) gain only 5 to 9 kg (5). Excess GWG has been associated with an increased risk of gestational diabetes (1), gestational hypertension (4), augmentation of labour (3,4), cesarean section (3), birth trauma (3), neonatal macrosomia, and metabolic abnormalities (3,6), while inadequate GWG has been linked to fetal growth restriction, low birth weight and prematurity (2). Despite the robust literature in this area, GWG recommendations are often not met. Only 12% of Canadian women achieve the recommended GWG in pregnancy, and over half exceed the recommendations (6,7).

Cogswell et al (1999) found that women who received correct advice from their health care provider (HCP) about GWG were more likely to achieve appropriate GWG than women who received incorrect advice or no counseling (8). While the majority of HCPs reported counseling women on appropriate GWG, 30-40% of women reported that they did not receive counseling (7,9,10), and only about a quarter reported being informed about risks associated with inappropriate GWG (11). Yamamoto et al. (2014) found that women seen by obstetricians were significantly less likely to receive diet and exercise counseling than those seen by other types of HCPs (12). This may be because OB/GYN appointments typically last ten minutes, providing less of an opportunity to discuss GWG, compared to appointments with family physicians or midwives, which often last 15 and 30-45 minutes, respectively (13). Despite this evidence, the role of HCPs in GWG has not been fully explored.

The primary objective of this study was to examine whether type of antenatal HCP was associated with differing rates GWG. The secondary objective was to assess the association of GWG on adverse maternal and neonatal outcomes by antenatal HCP. We hypothesized that there would be differences in GWG by antenatal HCP due to variations in counselling approaches and patient populations of HCPs. We anticipated that midwifery clients would be more likely to achieve GWG within recommendations.

Methods

Study Design

We conducted a retrospective cohort study to compare the association of GWG by antenatal HCP and associated adverse maternal and neonatal outcomes for women who had a singleton hospital birth in Ontario, Canada between April 1, 2014 and March 31, 2016.

Setting

Ontario is the most populous province in Canada consisting of approximately 14 million people, which is roughly 40% of the entire Canadian population (14). Permanent residents of Ontario receive universal health coverage under the government-funded provincial health insurance plan (OHIP) and therefore have equal access to the option of receiving antenatal care from a HCP of their choice.

Study Population

Women were identified using the Better Outcomes Registry & Network Information System (BIS) (https://www.bornontario.ca/en/about-born/), a province-wide registry of mothers and their newborns with 100% capture rate. Women included had a singleton hospital birth (live or stillbirth), a plausible body mass index (BMI) and GWG (i.e., 15-70 kg/m^2 and -10 kg to 50 kg, respectively) and gestational age at delivery between 20 to 42 weeks. The BIS contains comprehensive information on maternal and newborn care including data on "maternal demographics, health behaviours, reproductive history and clinical information related to pregnancy, labour, and birth, fetal, and neonatal outcomes" (15).

Exposure and outcomes

Antenatal HCP corresponded to the HCP that provided the majority of antenatal care and included family doctor (FD), obstetrician (OB), midwife (MW) and family doctor + obstetrician (FD + OB). The FD + OB group comprises of women initially seen by an FD and then transferred to an OB. Women with a HCP corresponding to "other", "unknown" or nurse practitioner were removed from our cohort, as they comprised a small proportion of the population. In the event a woman had multiple antenatal HCPs, an algorithm (Supplementary Table 1), developed a priori, was applied.

GWG was defined as the difference in pre-pregnancy weight and final weight at delivery. The recommended weight gain in the 1st trimester is between 0.5 to 2 kg, while weight gain recommendations for gestations ≤ 40 weeks in the 2nd and 3rd trimester are specific to pre-pregnancy BMI categories defined by the World Health Organization Guidelines and include a recommended weekly weight gain (Supplementary Table 2). The weekly weight gain in the second and third trimesters was obtained by subtracting 2 kg (the upper limit for the first trimester) from the total weight gain and dividing by the number of weeks in the 2nd and 3rd trimesters (obtained by subtracting the 13 weeks of the first trimester from the total number of weeks of pregnancy). For pregnancies exceeding 40 weeks, the same upper limit of weekly recommended GWG for the 2nd and 3rd trimester up to 40 weeks was applied for beyond 40 weeks.

The primary exposure of interest was antenatal HCP and the primary outcome was

GWG below, within, or above the recommendations based on the IOM guidelines (5) after adjusting for gestational age as per above.

The secondary outcomes were small for gestational age (SGA) < 10th percentile and large for gestational age (LGA) > 90th percentile, preterm birth (PTB) (live birth or stillbirth with a gestational age at delivery < 37 weeks), caesarean section (CS). The exposure of interest was antenatal HCP, which was assessed by stratifying the association of GWG and the secondary outcomes by antenatal HCP. Published Canadian reference values were used to ascertain SGA and LGA (17).

Income and post-secondary completion quintiles were derived using postal code conversion plus (PCCF+) and the Canadian Census 2011, respectively, while remaining patient characteristic and outcome data were obtained from the BIS.

Missing Data

The level of missing in the BIS during our time period for pre-pregnancy BMI and final weight at delivery was 14.0% and 11.0% respectively. We took two steps to overcome this limitation. First, we identified pregnancies which could be linked to the Prenatal Screening Ontario (PSO) database to ascertain first trimester weight. This database contains data for approximately 70% of pregnancies in Ontario (15). Of those that successfully linked and had first trimester weight, maternal height and missing pre-pregnancy weight, the IOM first trimester upper recommended weight gain of 2 kg was subtracted from first trimester weight to estimate pre-pregnancy weight and subsequently calculate pre-pregnancy BMI (5). This reduced the level of missing for pre-pregnancy BMI from 14.0% to 10.8%.

Second, the missing at random assumption was assessed and determined to be plausibly met by analyzing the frequency, pattern and reason for missing pre-pregnancy BMI. Multiple imputation was then performed to impute missing pre-pregnancy BMI and final weight at delivery using a chained equation approach on a subset of women with available pre-pregnancy weight (18). We created 11 imputed datasets, as recommended by White et al. (2011), which were then combined across all datasets using Rubin's rule to obtain final model estimates (19). Following imputation, the level of missing was reduced from 10.8% to 4.6% and from 11.0% to 1.4% for pre-pregnancy BMI and final weight at delivery, respectively.

Analysis

Descriptive statistics were calculated to summarize patient characteristics and outcomes by antenatal HCP. Absolute risk differences with 95% confidence intervals (CIs) were calculated to compare the proportion difference for GWG within, above, or below the recommendation by the primary exposure,

antenatal HCP for all possible combinations. An absolute risk difference with a standardized difference ≥ 0.10 was assigned to indicate an importance difference (20–23).

Multivariable Poisson regression models with robust error variance were run to calculate crude and adjusted relative risks (RR) with 95% CIs for the exposure GWG below or above recommendation relative to within recommendation stratified by antenatal HCP on the following secondary outcomes by antenatal HCP: SGA and LGA, PTB, and CS (24). Multivariable models to generate adjusted RRs were adjusted for confounders specific to each secondary outcome and were chosen based on clinical expertise and evidence in the literature (25–30). Confounders included in the multivariable models for SGA and LGA were as follows: maternal age, parity, gestational age at birth, pre-pregnancy BMI, income quintile, education quintile, smoking, depression, pre-existing diabetes, pre-existing hypertension and gestational diabetes mellitus. Confounders included in the multivariable models for CS and PTB were as follows: maternal age, parity, gestational age at birth, pre-pregnancy BMI, income quintile, education quintile, smoking, pre-existing diabetes, pre-existing hypertension, gestational diabetes mellitus, drug exposure, alcohol consumption, mental illness, previous: CS, term birth, PTB, vaginal birth, stillbirth, abortion; non-vertex presentation and male newborn. Generalized estimating equations were used in the models to account for multiple pregnancies for a woman within our cohort.

Population attributable fractions (PAF) and 95% CIs, based on the adjusted RR, were calculated to assess the proportion of the adverse outcome that could be potentially prevented if GWG not meeting the recommendation were removed by antenatal HCP (31). Adjusted RRs and PAFs were visualized using forest plots.

All analyses were conducted in Statistical Analysis Software Version 9.4 (Cary, NC) and ethics approval to conduct this study was obtained from the Hamilton Integrated Research Ethics Board.

Results

Our final cohort consisted of 231,697 women of whom 26,043 (11.2%), 136,994 (59.1%), 32,262 (13.9%) and 36,298 (15.7%) had an antenatal HCP corresponding to a FD, OB, MW and FD+OB respectively (Table 1). Maternal characteristics by antenatal HCP are summarized in Table 1.

Overall, the percentages of total GWG below, within, or above recommendations were 13.7%, 31.0% and 55.3%, respectively (Figure 2). There were no significant differences in the absolute risk differences for women gaining below, within or above GWG recommendations, stratified by antenatal HCP, with the exception of excess GWG between OB vs. shared cared between OB and FD (Table 2 and Supplementary Table 3). The absolute risk difference for OB vs. shared care between OB and FD for excess GWG was -5.1% (95% CI -5.7% to 4.5%). A trend toward those in midwifery care being less

likely to gain below recommended levels than those cared for by an obstetrician was observed (Absolute risk difference -3.0%, 95% CI -3.4% to -2.6%; Absolute Difference -0.09, 95% CI -0.10 to -0.08)

The risks of adverse secondary outcomes were similar between women who gained below or above the recommended amounts, stratified by antenatal HCPs (Figures 3 and 4). Inadequate GWG was associated with a higher risk for SGA (aRR 1.37; 95% CI 1.32-1.42) and PTB (aRR 1.34; 95% CI 1.27-1.41), but was protective for LGA (aRR 0.79; 95% CI 0.75-0.83) and was not associated with an increased risk for CS (aRR 0.98; 95% CI 0.96-1.00). Excess GWG was protective for SGA (aRR 0.63; 95% CI 0.61-0.64) and was associated with a higher risk for LGA (aRR 1.88; 95% CI 1.82-1.94) as well as CS (aRR 1.10 95% CI 1.08-1.11). Excess GWG was not associated with an increased risk of PTB (aRR 1.00; 95% CI 0.96-1.04).

No differences were observed in PAFs for all outcomes between antenatal HCP when women had adequate or inadequate GWG (Figure 5 & 6). Excess GWG was associated with a negative PAF (-23.6%, 95% CI -28.4 to18.9%) for SGA, but was associated with a PAF of nearly 35% for LGA (PAF 34.3%, 95% CI 32.7 to 35.8%). The PAFs for excess GWG were not significant for PTB although they were for CS (PAF 5.5%, 95% CI 4.1 to 6.8%). Inadequate GWG was associated with a slightly positive PAF for SGA (PAF 6.0%, 95% CI 5.1 to 7.0%) as well as PTB (PAF 4.7%, 95% CI 3.5% to 5.8%) and a slightly protective PAF for LGA (PAF -2.0%, 95% CI -3.2 to 0.8%). The PAFs for inadequate GWG were not significant for CS.

Discussion

To our knowledge, this is the first study examining GWG in pregnancy by type of antenatal HCP and we did not find a clinically significant association with excess or inadequate GWG by provider type, despite our hypothesis that different counseling techniques and approaches to care would result in differing GWG. A similar proportion of women gained below, within and above the recommendations across all antenatal HCP groups. Of note, over half of all women, regardless of antenatal HCP, had excessive GWG.

Standardized differences between the HCPs highlighted two findings. First, women in midwifery care may be slightly less likely to gain below recommended levels than those cared for by an obstetrician. Second, women in the FP + OB group were more likely to have excess GWG compared to women in the other provider groups. It is possible that the lack of continuous care provider may impact counselling about nutrition and exercise during pregnancy. Consistent and on-going counselling on these topics may play a role in raising awareness about appropriate GWG. We found no difference in the rates of the secondary outcomes according to GWG across HCP groups. This is an important finding given that women in Ontario can choose which HCP they see for their pregnancy, and the great variation in access to care and care providers throughout the province.

Our research adds to the growing evidence exploring the magnitude of the association of excess GWG being a significant risk for LGA and CS, while gaining below increases the risk of SGA and PTB (26,32–35). Excess GWG contributes importantly to LGA (PAF 35%), as has been previously reported (34–38) and this was similar across all HCP groups. This finding demonstrates the critical need for promoting appropriate GWG to prevent a modifiable risk factor for maternal and neonatal morbidity.

Our study has several strengths including being the first to examine GWG according to care provider, and having a large sample size which enabled adjustment for a number of potential confounders. Our study has several limitations. Due to its retrospective nature, information on several potential confounding variables, such as history of previous LGA or SGA infant, was unavailable. Finally, we lacked data on per trimester weight gain, which could be a key factor for understanding potential time points for intervention.

Conclusion

Our study is the first to show that regardless of antenatal HCP, GWG did not differ. This suggests a similar need for improvement in counseling to support appropriate GWG across all types of care providers. Also, the rates of adverse outcomes associated with gaining above, below or within recommendations did not differ according to HCP. Among pregnant women in Ontario, a significant proportion of LGA, SGA and CS could potentially be prevented with appropriate GWG. Further research exploring counseling techniques and strategies for promoting optimal GWG would be beneficial.

References:

1. Cedergren M. Effects of gestational weight gain and body mass index on obstetric outcome in Sweden. Int J Gynaecol Obstet. 2006;93:269–74.
2. Han Z, Lutsiv O, Mulla S, Rosen A, Beyene J, McDonald SD. Low gestational weight gain and the risk of preterm birth and low birthweight: A systematic review and meta-analyses. Acta Obstetricia et Gynecologica Scandinavica. 2011;90(9): 935–54.
3. Stotland NE, Hopkins LM, Caughey AB. Gestational weight gain, macrosomia, and risk of cesarean birth in nondiabetic nulliparas. Obstet Gynecol. 2004;104(4):671–7.
4. Thorsdottir I, Torfadottir JE, Birgisdottir BE, Geirsson RT. Weight gain in women of normal weight before pregnancy: Complications in pregnancy or delivery and birth outcome. Obstetrics and Gynecology. 2002; May (99). p. 799–806.
5. Rasmussen KM, Yaktine AL. Weight gain during pregnancy: Reexamining the guidelines. National Academies Press. 2009.
6. Crane JMG, White J, Murphy P, Burrage L, Hutchens D. The effect of gestational weight gain by body mass index on maternal and neonatal outcomes. J Obstet Gynaecol Can [Internet]. 2009;31(1):28–35.
7. McDonald SD, Pullenayegum E, Taylor VH, Lutsiv O, Bracken K, Good C, Hutton E, Sword W. Despite 2009 guidelines, few women report being counseled correctly about weight gain during pregnancy. Am J Obstet Gynecol [Internet]. 2011;205(4):333.
8. Cogswell ME, Scanlon KS, Fein SB, Schieve LA. Medically advised, mother's personal target, and actual weight gain during pregnancy. Obstet Gynecol. 1999;94(4):616–22.
9. Ferrari RM, Siega-Riz AM, Evenson KR, Moos MK, Carrier KS. A qualitative study of women's perceptions of provider advice about diet and physical activity during pregnancy. Patient Educ Couns. 2013;91(3):372–7.
10. Phelan S, Phipps MG, Abrams B, Darroch F, Schaffner A, Wing RR. Practitioner Advice and Gestational Weight Gain. J Women's Health. 2011;20(4):585–91.
11. Lutsiv O, Bracken K, Pullenayegum E, Sword W, Taylor VH, McDonald SD. Little Congruence Between Health Care Provider and Patient Perceptions of Counselling on Gestational Weight Gain. J Obstet Gynaecol Canada. 2012;34(6):518–24.
12. Yamamoto A, McCormick MC, Burris HH. US provider-reported diet and physical activity counseling to pregnant and non-pregnant women of childbearing age during preventive care visits. Matern Child Health J. 2014;18(7):1610–8.
13. McDonald SD, Pullenayegum E, Bracken K, Chen AM, McDonald H, Malott A, et al. Comparison of Midwifery, Family Medicine, and Obstetric Patients' Understanding of Weight Gain During Pregnancy: A Minority of Women Report Correct Counselling. J Obstet Gynaecol Canada. 2012;34(2):129–35.
14. Statistics Canada. Table 051-0001: Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual (persons unless otherwise noted) [Internet]. International Journal of Human-Computer Studies. 2011. p. 508–24. Available from: http://www5.statcan.gc.ca/cansim/a26
15. Better Outcomes Registry & Network (BORN) Ontario Annual Report 2012–2013 and 2013–2014. Ottawa, Ontario; 2015.
16. WHO. Global Database on Body Mass Index an interactive surveillance tool for monitoring nutrition transition. 2017.
17. Kramer MS, Platt RW, Wen SW, Joseph KS, Allen A, Abrahamowicz M, et al. A New and Improved Population-Based Canadian Reference for Birth Weight for Gestational Age. Pediatrics. 2001;108(2):e35–e35.
18. Azur MJ, Stuart EA, Frangakis C, Leaf PJ. Multiple imputation by chained equations: What is it and how does it work? Int J Methods Psychiatr Res. 2011;20(1):40–9.
19. Wang C, Wei Y, Zhang X, Zhang Y, Xu Q, Sun Y, et al. A randomized clinical trial of exercise

during pregnancy to prevent gestational diabetes mellitus and improve pregnancy outcome in overweight and obese pregnant women. Am J Obstet Gynecol. 2017;216(4):340–51.
20. Yang D, Dalton J. A unified approach to measuring the effect size between two groups using SAS®. SAS Glob Forum. 2012;6. Available from: http://support.sas.com/resources/papers/proceedings12/335-2012.pdf
21. Hedges L V., Olkin I. Statistical methods for meta-analysis. Phytochemistry. 1985;72(13):369.
22. Cohen J. Statistical power analysis for the behavioral sciences. Statistical Power Analysis for the Behavioral Sciences. 1988. p. 567.
23. Mamdani M, Sykora K, Li P, Normand S-LT, Streiner DL, Austin PC, et al. Reader's guide to critical appraisal of cohort studies: 2. Assessing potential for confounding. BMJ. 2005;330(7497):960–2.
24. Zou G. A Modified Poisson Regression Approach to Prospective Studies with Binary Data. Am J Epidemiol. 2004;159(7):702–6.
25. Ehrenberg HM, Mercer BM, Catalano PM. The influence of obesity and diabetes on the prevalence of macrosomia. American Journal of Obstetrics and Gynecology. 2004. p. 964–8.
26. Hellerstedt WL, Hirnes JH, Story M, Alton IR, Edwards LE. The effects of cigarette smoking and gestational weight change on birth outcomes in obese and normal-weight women. Am J Public Health. 1997;87(4):591–6.
27. Kramer MS. Determinants of low birth weight: methodological assessment and meta-analysis. Bull World Health Organ. 1987;65(5):663–737.
28. Joseph KS, Kramer MS, Marcoux S, Ohlsson A, Wen SW, Allen A, et al. Determinants of Preterm Birth Rates in Canada from 1981 through 1983 and from 1992 through 1994. N Engl J Med. 1998;339(20):1434–9.
29. Joseph KS, Young DC, Dodds L, O'Connell CM, Allen VM, Chandra S, et al. Changes in maternal characteristics and obstetric practice and recent increases in primary cesarean delivery. Obstet Gynecol. 2003;102(4):791–800.
30. Dougherty CR, Jones AD. Th determinants of birth weight. Am J Obstet Gynecol. 1982;144(2):190–200.
31. Daly LE. Confidence limits made easy: Interval estimation using a substitution method. Am J Epidemiol. 1998;147(8):783–90.
32. Caulfield LE, Stoltzfus RJ, Witter FR. Implications of the Institute of Medicine weight gain recommendations for preventing adverse pregnancy outcomes in Black and White women. Am J Public Health. 1998;88(8):1168–74.
33. Margerison Zilko CE, Rehkopf D, Abrams B. Association of maternal gestational weight gain with short- and long-term maternal and child health outcomes. Am J Obstet Gynecol. 2010;202(6).
34. Dzakpasu S, Fahey J, Kirby RS, Tough SC, Chalmers B, Heaman MI, et al. Contribution of prepregnancy body mass index and gestational weight gain to adverse neonatal outcomes: Population attributable fractions for Canada. BMC Pregnancy Childbirth. 2015;15(1).
35. Dzakpasu S, Fahey J, Kirby RS, Tough SC, Chalmers B, Heaman MI, et al. Contribution of prepregnancy body mass index and gestational weight gain to caesarean birth in Canada. BMC Pregnancy Childbirth. 2014;14(1).
36. Oteng-Ntim E, Kopeika J, Seed P, Wandiembe S, Doyle P. Impact of Obesity on Pregnancy Outcome in Different Ethnic Groups: Calculating Population Attributable Fractions. PLoS One. 2013;8(1).
37. Djelantik AA, Kunst AE, Van Der Wal MF, Smit HA, Vrijkotte TGM. Contribution of overweight and obesity to the occurrence of adverse pregnancy outcomes in a multi-ethnic cohort: Population attributive fractions for Amsterdam. BJOG. 2012;119(3):283–90.
38. Lu GC, Rouse DJ, DuBard M, Cliver S, Kimberlin D, Hauth JC. The effect of the increasing prevalence of maternal obesity on perinatal morbidity. Am J Obstet Gynecol. 2001;185(4):845–9.

TABLE 1: Maternal characteristics by antenatal health care provider

Characteristic	Antenatal Health Care Provider				
	All (N = 231,697) N (%)	**FD (N = 26,043) N (%)**	**OB (N = 136,994) N (%)**	**MW (N = 32,362) N (%)**	**FD + OB (N = 36,298) N (%)**
Maternal Age (y), n (%)					
≤ 24	30,896 (13.3%)	5,014 (19.3%)	16,215 (11.8%)	3,663 (11.3%)	6,004 (16.5%)
25-29	64,476 (27.8%)	8,140 (31.3%)	35,950 (26.2%)	9,487 (29.3%)	10,899 (30%)
30-34	84,644 (36.5%)	8,713 (33.5%)	50,335 (36.7%)	12,995 (40.2%)	12,601 (34.7%)
≥ 35	51,681 (22.3%)	4,176 (16.0%)	34,494 (25.2%)	6,217 (19.2%)	6,794 (18.7%)
Pre-pregnancy BMI (kg/m^2)[1], n (%)					
Underweight: BMI < 18.5	14,018 (6.1%)	1,440 (5.5%)	9,086 (6.6%)	1,608 (5%)	1,884 (5.2%)
Normal weight:18.5 ≤ BMI <25	120,434 (52%)	13,337 (51.2%)	70,883 (51.7%)	18,401 (56.9%)	17,813 (49.1%)
Overweight : 25 ≤ BMI < 30	55,712 (24.0%)	6,485 (24.9%)	32,820 (24.0%)	7,551 (23.3%)	8,856 (24.4%)
Obese: BMI ≥ 30	41,533 (17.9%)	4,781 (18.4%)	24,205 (17.7%)	4,802 (14.8%)	7,745 (21.3%)
Gestational Weight Gain (kg)[2], n (%)					
GWG < recommended	31,804 (13.7%)	3,567 (13.7%)	19,936 (14.6%)	3,742 (11.6%)	4,559 (12.6%)
GWG = recommended	71,777 (31.0%)	7,768 (29.8%)	43,270 (31.6%)	10,405 (32.2%)	10,334 (28.5%)
GWG > recommended	128,116 (55.3%)	14,708 (56.5%)	73,788 (53.9%)	18,215 (56.3%)	21,405 (59%)
Pre-existing diabetes, n (%)	2,149 (0.9%)	115 (0.4%)	1,544 (1.1%)	83 (0.3%)	407 (1.1%)
Pre-existing hypertension, n (%)	1,875 (0.8%)	146 (0.6%)	1,293 (0.9%)	92 (0.3%)	344 (0.9%)
Gestational Diabetes Mellitus, n (%)	14,849 (6.4%)	1,143 (4.4%)	10,245 (7.5%)	1,270 (3.9%)	2,191 (6.0%)
Nulliparous, n (%)	100,347 (43.3%)	11,536 (44.3%)	57,781 (42.2%)	15,359 (47.5%)	15,671 (43.2%)
Gravidity, n (%)					
Primigravid	74,634 (32.2%)	8,706 (33.4%)	42,540 (31.1%)	11,708 (36.2%)	11,680 (32.2%)
Multigravid	155,619 (67.2%)	17,165 (65.9%)	93,187 (68%)	20,652 (63.8%)	24,615 (67.8%)
Income quintile[3], n (%)					
1 "lowest"	48,414 (20.9%)	5,769 (22.2%)	30,324 (22.1%)	5,560 (17.2%)	6,761 (18.6%)
2	46,243 (20.0%)	5,041 (19.4%)	28,116 (20.5%)	6,199 (19.2%)	6,887 (19.0%)
3	46,908 (20.2%)	5,255 (20.2%)	27,270 (19.9%)	6,594 (20.4%)	7,789 (21.5%)
4	48,916 (21.1%)	5,227 (20.1%)	28,128 (20.5%)	7,402 (22.9%)	8,159 (22.5%)
5 "highest"	37,207 (16.1%)	4,339 (16.7%)	20,683 (15.1%)	6,063 (18.7%)	6,122 (16.9%)
Education quintile[4], n (%)					
1 "lowest"	45,156 (19.5%)	6,479 (24.9%)	21,450 (15.7%)	6,808 (21%)	10,419 (28.7%)
2	45,027 (19.4%)	5,675 (21.8%)	23,799 (17.4%)	6,651 (20.6%)	8,902 (24.5%)
3	44,908 (19.4%)	4,794 (18.4%)	27,549 (20.1%)	6,093 (18.8%)	6,472 (17.8%)

4	44,646 (19.3%)	3,756 (14.4%)	29,796 (21.7%)	5,857 (18.1%)	5,237 (14.4%)
5 "highest"	44,294 (19.1%)	3,671 (14.1%)	30,088 (22.0%)	6,273 (19.4%)	4,262 (11.7%)
Missing	7,666 (3.3%)	1,668 (6.4%)	4,312 (3.1%)	680 (2.1%)	1,006 (2.8%)
Mental illness, n (%)	35,271 (15.2%)	4,832 (18.6%)	16,291 (11.9%)	6,867 (21.2%)	7,281 (20.1%)
Depression, n (%)	17,196 (7.4%)	2,502 (9.6%)	7,591 (5.5%)	3,246 (10.0%)	3,857 (10.6%)
Alcohol consumption during pregnancy, n (%)	5,665 (2.4%)	899 (3.5%)	2,772 (2%)	846 (2.6%)	1,148 (3.2%)
Smoking during pregnancy, n (%)					
Yes	23,342 (10.1%)	4,063 (15.6%)	12,065 (8.8%)	1,880 (5.8%)	5,334 (14.7%)
Missing	9,079 (3.9%)	979 (3.8%)	7,668 (5.6%)	202 (0.6%)	230 (0.6%)
Drug exposure during pregnancy, n (%)	4,542 (2.0%)	954 (3.7%)	2,202 (1.6%)	407 (1.3%)	979 (2.7%)
Prenatal Classes, n (%)					
Yes	51,293 (22.1%)	6,127 (23.5%)	26,951 (19.7%)	10,120 (31.3%)	8,095 (22.3%)
Missing	16,810 (7.3%)	1,943 (7.5%)	10,928 (8.0%)	2,460 (7.6%)	1,479 (4.1%)
Previous preterm birth, n (%)	12,256 (5.3%)	1,034 (4.0%)	8,075 (5.9%)	1,305 (4.0%)	1,842 (5.1%)
Previous caesarean birth, n (%)	34,652 (15.0%)	2,283 (8.8%)	23,543 (17.2%)	2,842 (8.8%)	5,984 (16.5%)
Previous abortion (A), n (%)	75,100 (32.4%)	8,134 (31.2%)	45,102 (32.9%)	9,947 (30.7%)	11,917 (32.8%)
Previous term birth, n (%)	124,036 (53.5%)	13,905 (53.4%)	74,108 (54.1%)	16,352 (50.5%)	19,671 (54.2%)
Previous vaginal birth, n (%)	96,788 (41.8%)	12,132 (46.6%)	55,108 (40.2%)	14,366 (44.4%)	15,182 (41.8%)
Previous stillbirth, n (%)	3,097 (1.3%)	226 (0.9%)	2,241 (1.6%)	280 (0.9%)	350 (1.0%)
Non-vertex presentation, n (%)	9,190 (4.0%)	707 (2.7%)	5,536 (4.0%)	1,270 (3.9%)	1,677 (4.6%)
Missing	16,179 (7.0%)	1,655 (6.4%)	13,189 (9.6%)	328 (1.0%)	1,007 (2.8%)
Male newborn, n (%)	118,794 (51.3%)	13,331 (51.2%)	70,254 (51.3%)	16,713 (51.6%)	18,496 (51.0%)

Data Sources: *BORN Ontario (2014-2016)*

Cohort definition: *Women who had a singleton birth of whom had plausible BMI and GWG available.*

Abbreviations: *FD, Family Doctor; OB, Obstetrician; MW, Midwife; HCP, Healthcare Provider*

** refers to p-value <0.05 and based on the chi-square test*

Notes:

[1] Pre-pregnancy BMI categories reflect WHO classification

[2] Total gestational weight gain recommended for singleton pregnancies based on a woman's pre-pregnancy BMI (adapted from: IOM, 2009)

[3] Income quintiles are derived from Postal Code Conversion File Plus + 2013 and are based on postal code

[4] Education quintiles reflect post-secondary completion and are derived from the Census 2011 using postal code

Missing reported for characteristics with a percentage of missing greater than 2%

TABLE 2: Absolute differences in the proportions of women gaining below, within or above gestational weight gain recommendations, stratified by antenatal health care provider

Antenatal Health Care Provider	Absolute Difference (95% Confidence Interval)		
	GWG < Recommended	GWG = Recommended	GWG > Recommended
MW vs. OB	-3.0% (-3.4% to -2.6%)	0.6% (0.0% to 1.1%)	2.4% (1.8% to 3.0%)
MW vs. FD	-2.1% (-2.7% to -1.6%)	2.3% (1.6% to 3.1%)	-0.2% (-1.0% to 0.6%)
MW vs. FD+OB	-1.0% (-1.5% to -0.5%)	3.7% (3.0% to 4.4%)	-2.7% (-3.4% to -1.9%)
FD vs. OB	-0.9% (-1.3% to -0.4%)	-1.8% (-2.4% to -1.2%)	2.6% (2.0% to 3.3%)
FD vs. FD+OB	1.1% (0.6% to 1.7%)	1.4% (0.6% to 2.1%)	-2.5% (-3.3% to -1.7%)
OB vs. FD+OB	2.0% (1.6% to 2.4%)	3.1% (2.6% to 3.6%)	-5.1% (-5.7% to -4.5%)

Abbreviations: MW, Midwife; FD, Family Doctor; OB, Obstetrician; GWG, Gestational Weight Gain

FIGURE 1. Cohort selection by antenatal health care provider

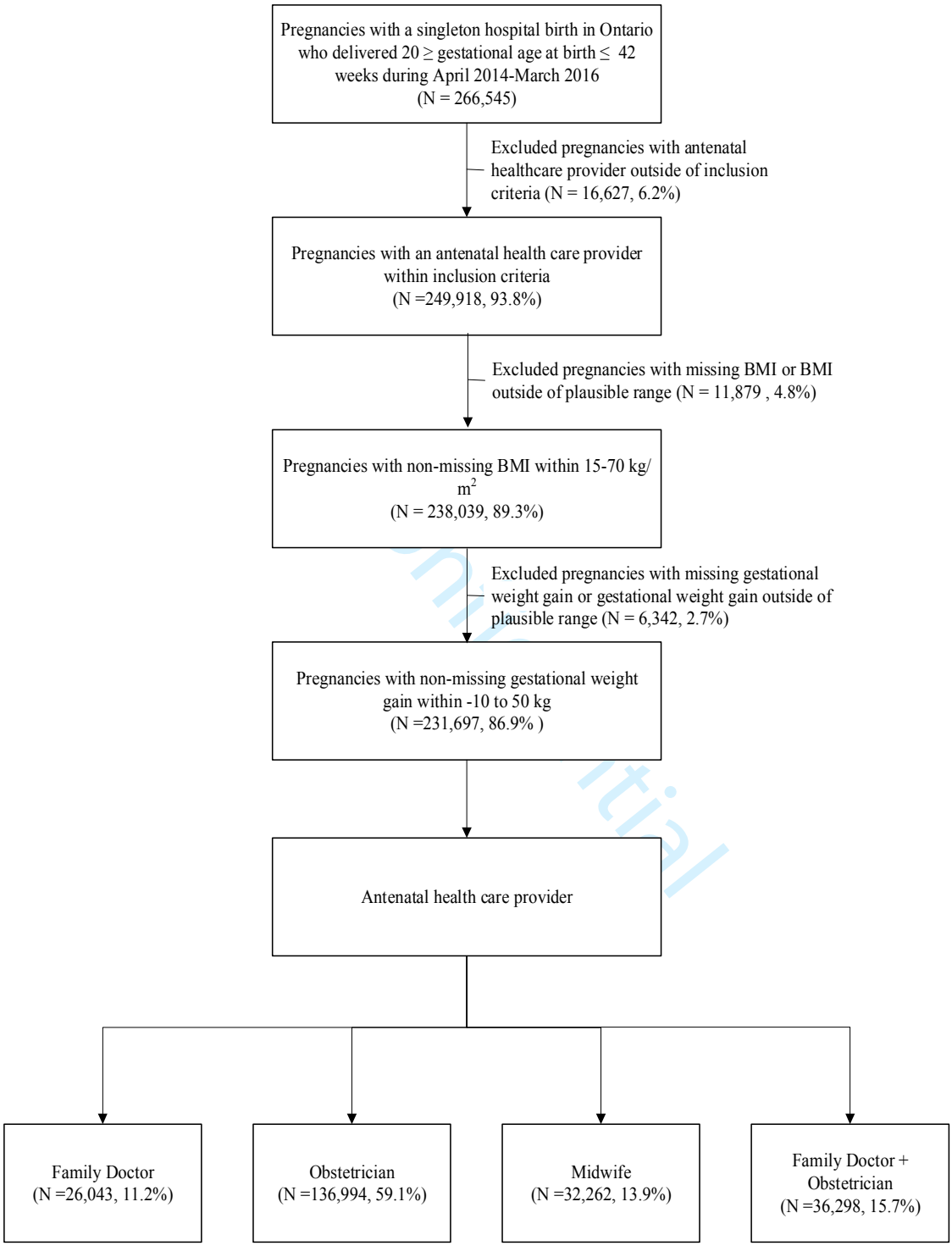


FIGURE 2. Percentages of gestational weight gain below, within and above the guidelines stratified according to antenatal health care provider

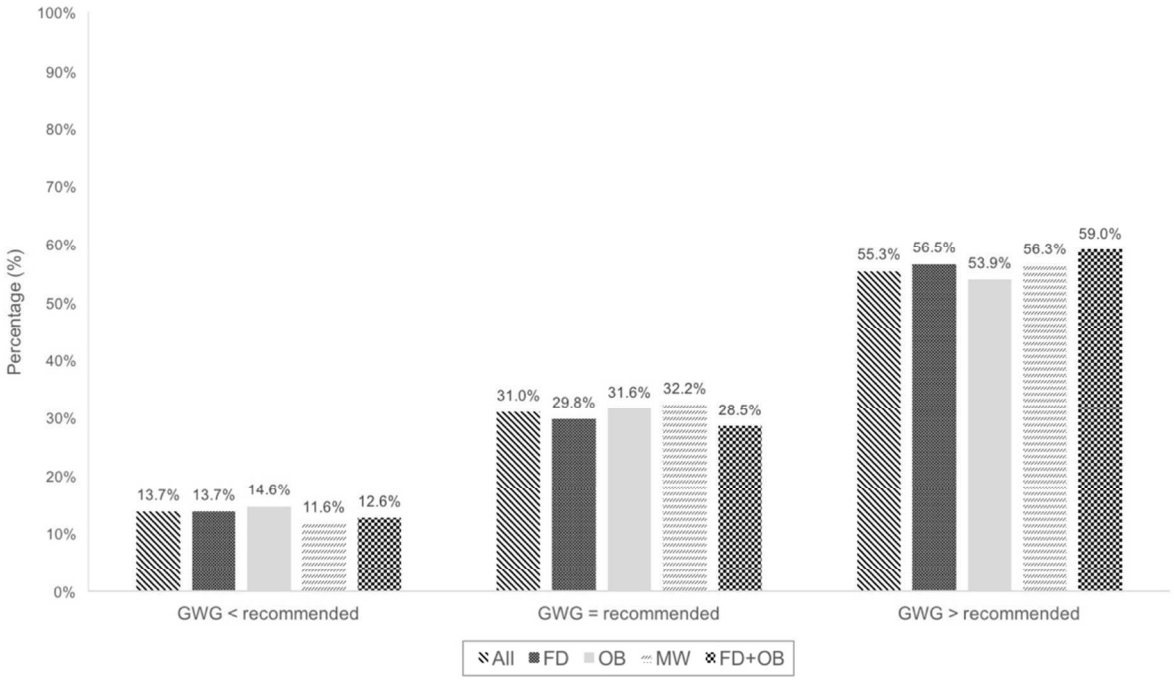
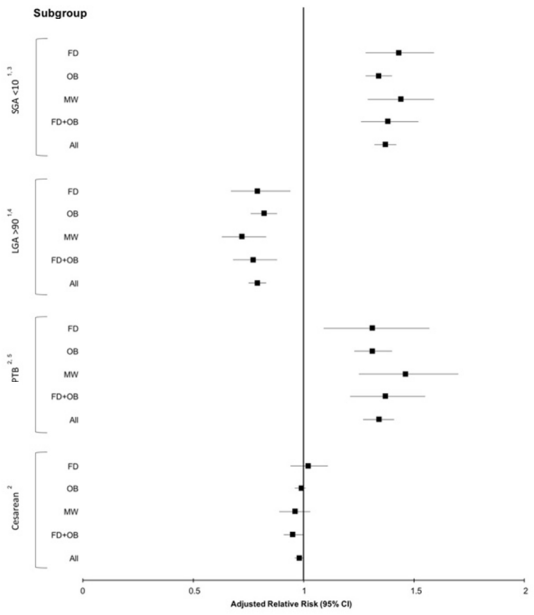


FIGURE 3. Adjusted relative risk of SGA, LGA, PTB, cesarean among pregnancies with a GWG < recommended relative to those with GWG within the guidelines, stratified according to antenatal health care provider

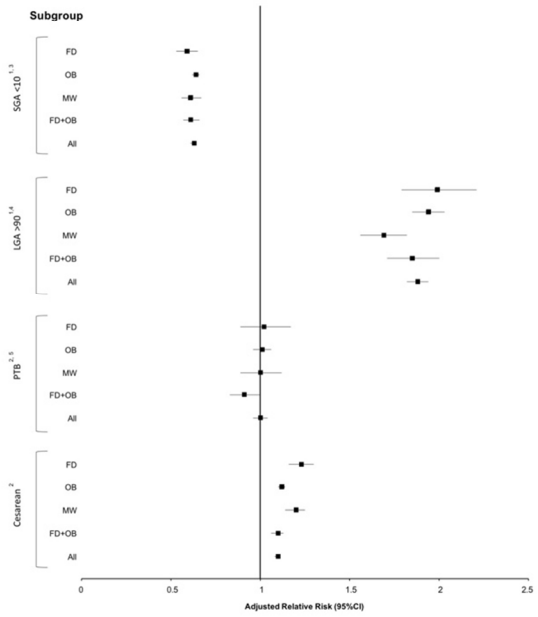


	No. of pregnancies affected/Total No. of pregnancies (Event Rate %)		Adjusted Relative Risk (95% CI)	Absolute Risk Difference (%)
	GWG < recommended	Recommended GWG		
SGA <10 [1,3]				
FD	538/3567 (15.1%)	817/7768 (10.5%)	1.43 (1.28-1.59)	4.6% (3.2% to 6.0%)
OB	3190/19,936 (16.0%)	5317/43,270 (12.3%)	1.34 (1.28-1.40)	3.7% (3.1% to 4.3%)
MW	488/3742 (13.0%)	949/10,405 (9.1%)	1.44 (1.29-1.59)	3.9% (2.8% to 5.2%)
FD+OB	656/4559 (14.4%)	1097/10,334 (10.6%)	1.38 (1.26-1.52)	3.8% (2.6% to 5.0%)
All	4872/31,804 (15.3%)	8180/71,777 (11.4%)	1.37 (1.32-1.42)	3.9% (3.5% to 4.4%)
LGA >90 [1,4]				
FD	203/3567 (5.7%)	482/7768 (6.2%)	0.79 (0.67-0.94)	-0.5% (-1.4% to 0.4%)
OB	1010/19,936 (5.1%)	2389/43,270 (5.5%)	0.82 (0.76-0.88)	-0.4% (-0.8% to -0.1%)
MW	245/3742 (6.5%)	835/10,405 (8.0%)	0.72 (0.63-0.83)	-1.5% (-2.4% to -0.5%)
FD+OB	284/4559 (6.2%)	732/10,334 (7.1%)	0.77 (0.68-0.88)	-0.9% (-1.7% to 0.0%)
All	1742/31,804 (5.5%)	4438/71,777 (6.2%)	0.79 (0.75-0.83)	-0.7% (-1.0% to -0.4%)
PTB [2,5]				
FD	224/3567 (6.3%)	331/7768 (4.3%)	1.31 (1.09-1.57)	2.0% (1.1% to 2.9%)
OB	1762/19,936 (8.8%)	2688/43,270 (6.2%)	1.31 (1.23-1.40)	2.6% (2.2% to 3.1%)
MW	250/3742 (6.7%)	463/10,405 (4.4%)	1.46 (1.25-1.70)	2.3% (1.3% to 3.1%)
FD+OB	406/4559 (8.9%)	620/10,334 (6.0%)	1.37 (1.21-1.55)	2.9% (2.0% to 3.9%)
All	2642/31,804 (8.3%)	4102/71,777 (5.7%)	1.34 (1.27-1.41)	2.6% (2.2% to 2.9%)
Cesarean [2]				
FD	585/3567 (16.4%)	1258/7768 (16.2%)	1.02 (0.94-1.11)	0.2% (-1.3% to 1.7%)
OB	5464/19,936 (27.4%)	11,848/43,270 (27.4%)	0.99 (0.96-1.01)	0.0% (-0.7% to 0.8%)
MW	592/3742 (15.8%)	1720/10,405 (16.5%)	0.96 (0.89-1.03)	-0.7% (-2.1% to 0.7%)
FD+OB	1197/4559 (26.3%)	2689/10,334 (26.0%)	0.95 (0.91-1.00)	0.3% (-1.3% to 1.8%)
All	7838/31,804 (24.6%)	17,515/71,777 (24.4%)	0.98 (0.96-1.00)	0.2% (-0.3% to 0.8%)

Data Sources: *BORN Ontario (2014-2016)*
Abbreviations: CI, confidence interval; *FD, Family Doctor; OB, Obstetrician; MW, Midwife; HCP, Healthcare Provider; GWG, Gestational Weight Gain; PTB, preterm birth; SGA, Small for gestational age; LGA, Large for gestational age*

Notes: [1]Adjusted for maternal age, parity, gestational age at birth, pre-pregnancy BMI, income quintile, education quintile, smoking, depression, pre-existing diabetes, pre-existing hypertension and gestational diabetes mellitus
[2]Adjusted for maternal age, parity, gestational age at birth, pre-pregnancy BMI, income quintile, education quintile, smoking, pre-existing diabetes, pre-existing hypertension, gestational diabetes mellitus, drug exposure, alcohol consumption, mental illness, previous: caesarean, term birth, preterm birth, vaginal birth, stillbirth, abortion; non-vertex presentation and male newborn
[3] SGA<10 defined as birth weight less than the 10th centile as per the Canadian reference population adjusted for gestational age; Kramer et al. (2001)
[4] LGA>90 defined as birth weight greater than the 90th centile as per the Canadian reference population adjusted for gestational age; Kramer et al. (2001)
[5] PTB defined as a live birth or stillbirth < 37 weeks (gestational age at birth)

FIGURE 4. Adjusted relative risk of SGA, LGA, PTB, cesarean among pregnancies with a GWG > recommended relative to those with GWG within the guidelines, stratified according to antenatal health care provider

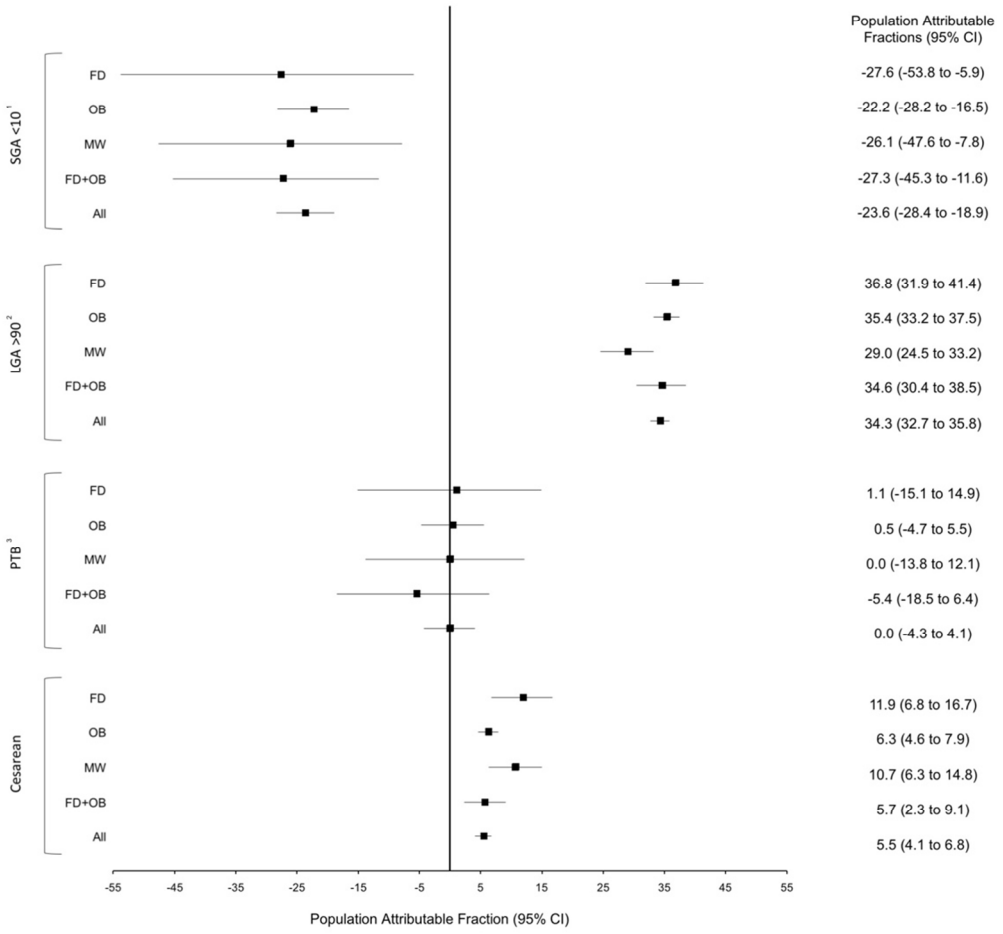


Subgroup	No. of pregnancies affected/Total No. of pregnancies (Event Rate %) GWG > recommended	Recommended GWG	Adjusted Relative Risk (95% CI)	Absolute Risk Difference (%)
SGA <10 [1,3]				
FD	895/14,708 (6.1%)	817/7768 (10.5%)	0.59 (0.53-0.65)	-4.4% (-5.2% to -3.7%)
OB	5543/73,788 (7.5%)	5317/43,270 (12.3%)	0.64 (0.62-0.66)	-4.8% (-5.2% to -4.4%)
MW	993/18,215 (5.5%)	949/10,405 (9.1%)	0.61 (0.56-0.67)	-3.6% (-4.3% to -3.0%)
FD+OB	1310/21,405 (6.1%)	1097/10,334 (10.6%)	0.61 (0.57-0.66)	-4.5% (-5.2% to -3.8%)
All	8741/128,116 (6.8%)	8180/71,777 (11.4%)	0.63 (0.61-0.64)	-4.6% (-4.9% to -4.3%)
LGA >90 [1,4]				
FD	1951/14,708 (13.3%)	482/7768 (6.2%)	1.99 (1.79-2.21)	7.1% (6.3% to 7.9%)
OB	9186/73,788 (12.4%)	2389/43,270 (5.5%)	1.94 (1.85-2.03)	6.9% (6.6% to 7.3%)
MW	2645/18,215 (14.5%)	835/10,405 (8.0%)	1.69 (1.56-1.82)	6.5% (5.8% to 7.3%)
FD+OB	3085/21,405 (14.4%)	732/10,334 (7.1%)	1.85 (1.71-2.00)	7.3% (6.7% to 8.0%)
All	16,867/128,116 (13.2%)	4438/71,777 (6.2%)	1.88 (1.82-1.94)	7.0% (6.8% to 7.3%)
PTB [2,5]				
FD	657/14,708 (4.5%)	331/7768 (4.3%)	1.02 (0.89-1.17)	0.2% (-0.4% to 0.8%)
OB	4865/73,788 (6.6%)	2688/43,270 (6.2%)	1.01 (0.96-1.06)	0.4% (0.1% to 0.7%)
MW	840/18,215 (4.6%)	463/10,405 (4.4%)	1.00 (0.89-1.12)	0.2% (-0.3% to 0.7%)
FD+OB	1214/21,405 (5.7%)	620/10,334 (6.0%)	0.91 (0.83-1.00)	-0.3% (-0.9% to 0.2%)
All	7576/128,116 (5.9%)	4102/71,777 (5.7%)	1.00 (0.96-1.04)	0.2% (-0.01% to 0.41%)
Cesarean [2]				
FD	3217/14,708 (21.9%)	1258/7768 (16.2%)	1.23 (1.16-1.30)	5.7% (4.6% to 6.7%)
OB	24,397/73,788 (33.1%)	11,848/43,270 (27.4%)	1.12 (1.10-1.14)	5.7% (5.1% to 6.2%)
MW	4101/18,215 (22.5%)	1720/10,405 (16.5%)	1.20 (1.14-1.25)	6.0% (5.1% to 6.9%)
FD+OB	6627/21,405 (31.0%)	2689/10,334 (26.0%)	1.10 (1.06-1.13)	5.0% (3.9% to 6.0%)
All	38,342/128,116 (29.9%)	17,515/71,777 (24.4%)	1.10 (1.08-1.11)	5.5% (5.1% to 5.9%)

Data Sources: *BORN Ontario (2014-2016)*
Abbreviations: CI, confidence interval; *FD, Family Doctor; OB, Obstetrician; MW, Midwife; HCP, Healthcare Provider; GWG, Gestational Weight Gain; PTB, preterm birth; SGA, Small for gestational age; LGA, Large for gestational age*

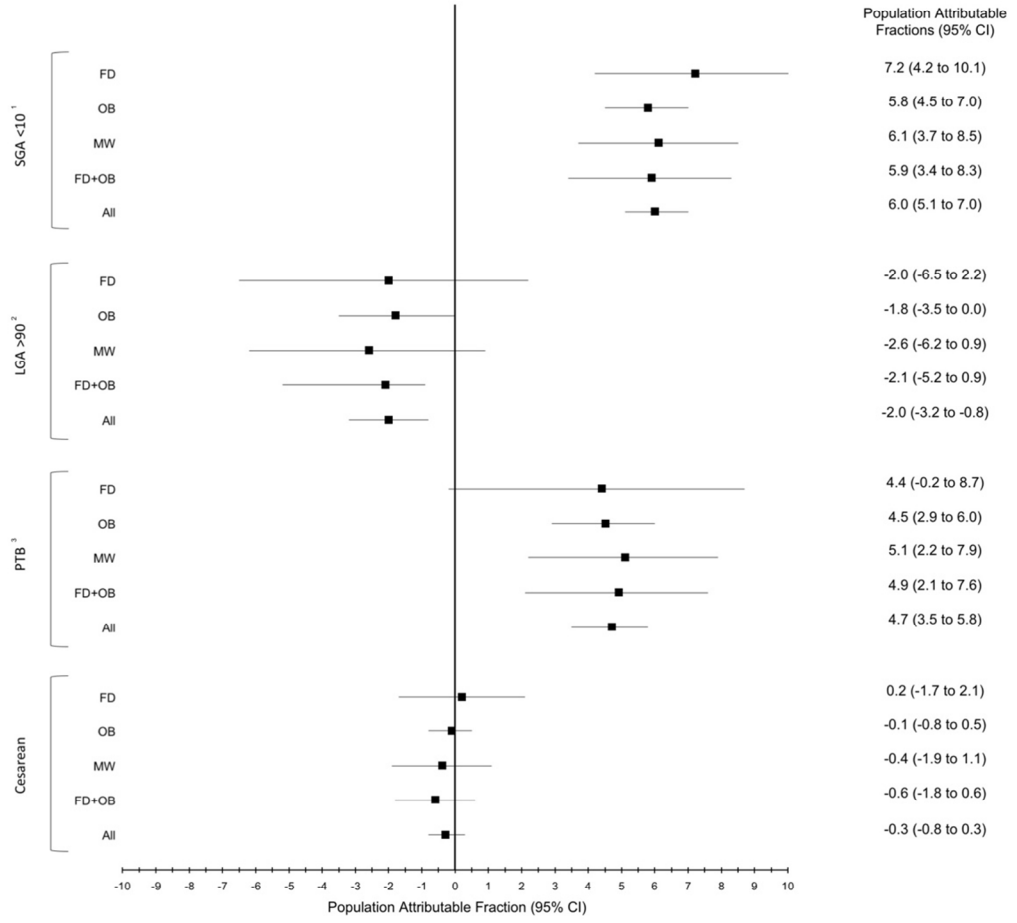
Notes: [1]Adjusted for maternal age, parity, gestational age at birth, pre-pregnancy BMI, income quintile, education quintile, smoking, depression, pre-existing diabetes, pre-existing hypertension and gestational diabetes mellitus
[2]Adjusted for maternal age, parity, gestational age at birth, pre-pregnancy BMI, income quintile, education quintile, smoking, pre-existing diabetes, pre-existing hypertension, gestational diabetes mellitus, drug exposure, alcohol consumption, mental illness, previous: caesarean, term birth, preterm birth, vaginal birth, stillbirth, abortion; non-vertex presentation and male newborn
[3] SGA<10 defined as birth weight less than the 10th centile as per the Canadian reference population adjusted for gestational age; Kramer et al. (2001)
[4] LGA>90 defined as birth weight greater than the 90th centile as per the Canadian reference population adjusted for gestational age; Kramer et al. (2001)
[5] PTB defined as a live birth or stillbirth < 37 weeks (gestational age at birth)

FIGURE 5. Population attributable fractions of SGA, LGA, PTB, and cesarean for GWG > recommended relative to those with GWG within the guidelines, stratified according to antenatal health care provider



Data Sources: BORN Ontario (2014-2016)
Abbreviations: *CI, confidence interval; FD, Family Doctor; OB, Obstetrician; MW, Midwife; HCP, Healthcare Provider; GWG, Gestational Weight Gain; PTB, preterm birth; SGA, Small for gestational age; LGA, Large for gestational age*
Notes:
[1] SGA<10 defined as birth weight less than the 10th centile as per the Canadian reference population adjusted for gestational age; Kramer et al. (2001)
[2] LGA>90 defined as birth weight greater than the 90th centile as per the Canadian reference population adjusted for gestational age; Kramer et al. (2001)
[3] PTB defined as a live birth or stillbirth < 37 weeks (gestational age at birth)

FIGURE 6. Population attributable fractions of SGA, LGA, PTB, and cesarean for GWG < recommended relative to those with GWG within the guidelines, stratified according to antenatal health care provider



Data Sources: BORN Ontario (2014-2016)
Abbreviations: *CI, confidence interval; FD, Family Doctor; OB, Obstetrician; MW, Midwife; HCP, Healthcare Provider; GWG, Gestational Weight Gain; PTB, preterm birth; SGA, Small for gestational age; LGA, Large for gestational age*
Notes:
[1] SGA<10 defined as birth weight less than the 10th centile as per the Canadian reference population adjusted for gestational age; Kramer et al. (2001)
[2] LGA>90 defined as birth weight greater than the 90th centile as per the Canadian reference population adjusted for gestational age; Kramer et al. (2001)
[3] PTB defined as a live birth or stillbirth < 37 weeks (gestational age at birth)

SUPPLEMENTARY TABLE 1: Multiple health care provider assignment algorithm

The following algorithm was applied to assign antenatal HCP in cases where a woman had multiple HCPs.

Midwife + Obstetrician:	A woman would be assigned to the midwife group, with the assumption that she started her pregnancy with a midwife and was transferred to an obstetrician, where shared care was followed. The assumption will be the majority of antenatal care would be provided by the midwife.
Family Physician + Obstetrician:	It is not uncommon for women to see their family physician until 32 weeks and then have their care transferred to an obstetrician. An assumption cannot be applied reliably for this scenario and thus Family Physician + Obstetrician will comprise a category in itself.
Family Physician + Midwife	A woman would be assigned to the midwife group as this generally represents the scenario where a woman was seen by a family physician once and transferred to a midwife for the remainder of their care.
Family Physician + Midwife + Obstetrician	A woman would be assigned to the midwife group for this scenario. This generally represents a scenario where a woman was initially seen by a family physician and was subsequently transferred to a midwife and is then later transferred to an obstetrician. The midwife and the obstetrician will follow a shared care model, where the midwife will provide the majority of antenatal care.

SUPPLEMENTARY TABLE 2: Total gestational weight gain recommended for singleton pregnancies based on a woman's pre-pregnancy BMI (adapted from: IOM, 2009).

Pre-pregnancy BMI (kg/m^2)	Recommended Total GWG (kg)	Weekly Recommended gain in 2nd and 3rd Trimester (kg/week)
Underweight: BMI < 18.5	12.5 - 18.0	0.44-0.58
Normal weight: 18.5 ≤ BMI <25	11.5 - 16.0	0.35-0.50
Overweight: 25 ≤ BMI < 30	7.0 - 11.5	0.23-0.33
Obese: BMI ≥ 30	5.0 - 9.0	0.17-0.27

Institute of Medicine, National Research Council Committee to Reexamine. The National Academies Collection: Reports funded by National Institutes of Health. In: Rasmussen KM, Yaktine AL, eds. Weight Gain During Pregnancy: Reexamining the Guidelines. Washington (DC): National Academies Press (US)
National Academy of Sciences, 2009.

SUPPLEMENTARY TABLE 3: Standardized differences of total gestational weight gain stratified by antenatal health care provider

Antenatal Health Care Provider	Standardized Difference (95% Confidence Interval)		
	GWG < Recommended	GWG = Recommended	GWG > Recommended
MW vs. OB	-0.09 (-0.10 to -0.08)	0.01 (0.00 to 0.02)	0.05 (0.04 to 0.06)
MW vs. FD	-0.06 (-0.08 to -0.04)	0.05 (0.03 to 0.07)	0.00 (-0.02 to 0.02)
MW vs. FD+OB	-0.03 (-0.04 to -0.02)	0.08 (0.07 to 0.09)	-0.05 (-0.06 to -0.04)
FD vs. OB	-0.02 (-0.03 to -0.01)	-0.04 (-0.05 to -0.03)	0.05 (0.04 to 0.06)
FD vs. FD+OB	0.03 (0.01 to 0.05)	0.03 (0.01 to 0.05)	-0.05 (-0.07 to -0.03)
OB vs. FD+OB	0.06 (0.05 to 0.07)	0.07 (0.06 to 0.08)	-0.10 (-0.11 to -0.09)*

*A standardized difference greater than 0.10 indicates an important difference
Abbreviations: MW, Midwife; FD, Family Doctor; OB, Obstetrician; GWG, Gestational Weight Gain

SUPLEMENTARY TABLE 4: Rate (%) and adjusted relative risk of adverse maternal and neonatal outcomes with gestational weight gain

Outcome	Antenatal HCP	GWG < recommended (n, %)	GWG = recommended (n, %)	GWG > recommended (n,%)	GWG < recommended		GWG > recommended	
					Crude RR (95% CI)	Adjusted RR (95% CI)	Crude RR (95% CI)	Adjusted RR (95% CI)
SGA <10[1]	*FD*	538 (15.1%)	817 (10.5%)	895 (6.1%)	1.42 (1.29-1.58)	1.43 (1.28-1.59)	0.58 (0.53-0.63)	0.59 (0.53-0.65)
	OB	3,190 (16%)	5,317 (12.3%)	5,543 (7.5%)	1.30 (1.25-1.36)	1.34 (1.28-1.4)	0.61 (0.59-0.63)	0.64 (0.62-0.66)
	MW	488 (13%)	949 (9.1%)	993 (5.5%)	1.44 (1.3-1.59)	1.44 (1.29-1.59)	0.60 (0.55-0.65)	0.61 (0.56-0.67)
	FD + OB	656 (14.4%)	1,097 (10.6%)	1,310 (6.1%)	1.35 (1.24-1.48)	1.38 (1.26-1.52)	0.58 (0.53-0.62)	0.61 (0.57-0.66)
	All	4,872 (15.3%)	8,180 (11.4)	8,741 (6.8%)	1.34 (1.3-1.39)	1.37 (1.32-1.42)	0.60 (0.58-0.62)	0.63 (0.61-0.64)
LGA>90[2]	*FD*	203 (5.7%)	482 (6.2%)	1,951 (13.3%)	0.92 (0.79-1.08)	0.79 (0.67-0.94)	2.13 (1.94-2.35)	1.99 (1.79-2.21)
	OB	1,010 (5.1%)	2,389 (5.5%)	9,186 (12.4%)	0.92 (0.86-0.99)	0.82 (0.76-0.88)	2.25 (2.15-2.35)	1.94 (1.85-2.03)
	MW	245 (6.5%)	835 (8%)	2,645 (14.5%)	0.81 (0.71-0.93)	0.72 (0.63-0.83)	1.80 (1.67-1.94)	1.69 (1.56-1.82)
	FD + OB	284 (6.2%)	732 (7.1%)	3,085 (14.4%)	0.88 (0.77-1.00)	0.77 (0.68-0.88)	2.03 (1.88-2.19)	1.85 (1.71-2.00)
	All	1,742 (5.5%)	4,438 (6.2%)	16,867 (13.2%)	0.89 (0.84-0.94)	0.79 (0.75-0.83)	2.12 (2.05-2.19)	1.88 (1.82-1.94)
PTB[3]	*FD*	201 (5.6%)	314 (4%)	625 (4.2%)	1.39 (1.17-1.65)	1.31 (1.09-1.57)	1.05 (0.92-1.2)	1.02 (0.88-1.17)
	OB	1,666 (8.4%)	2,573 (5.9%)	4,714 (6.4%)	1.41 (1.32-1.49)	1.29 (1.22-1.38)	1.07 (1.03-1.13)	1.03 (0.98-1.08)
	MW	235 (6.3%)	430 (4.1%)	805 (4.4%)	1.52 (1.3-1.77)	1.48 (1.26-1.73)	1.07 (0.95-1.2)	1.02 (0.91-1.15)
	FD + OB	387 (8.5%)	596 (5.8%)	1,176 (5.5%)	1.46 (1.29-1.65)	1.37 (1.21-1.55)	0.95 (0.86-1.04)	0.91 (0.83-1.01)
	All	2,489 (7.8%)	3,913 (5.5%)	7,320 (5.7%)	1.43 (1.37-1.51)	1.33 (1.26-1.4)	1.05 (1.01-1.09)	1.01 (0.97-1.05)
Cesarean [3]	*FD*	585 (16.4%)	1,258 (16.2%)	3,217 (21.9%)	1.01 (0.92-1.1)	1.02 (0.94-1.11)	1.34 (1.27-1.42)	1.23 (1.16-1.30)
	OB	5,464 (27.4%)	11,848 (27.4%)	24,397 (33.1%)	1.00 (0.97-1.03)	0.99 (0.96-1.01)	1.20 (1.18-1.22)	1.12 (1.1-1.14)
	MW	592 (15.8%)	1,720 (16.5%)	4,101 (22.5%)	0.96 (0.88-1.04)	0.96 (0.89-1.03)	1.36 (1.29-1.43)	1.20 (1.14-1.25)
	FD + OB	1,197 (26.3%)	2,689 (26%)	6,627 (31%)	1.00 (0.95-1.06)	0.95 (0.91-1.00)	1.18 (1.14-1.23)	1.10 (1.06-1.13)
	All	7,838 (24.6%)	17,515 (24.4%)	38,342 (29.9%)	1.01 (0.99-1.03)	0.98 (0.96-1.00)	1.21 (1.2-1.23)	1.10 (1.08-1.11)

Data Sources: *BORN Ontario (2014-2016)*
Abbreviations: *FD, Family Doctor; OB, Obstetrician; MW, Midwife; HCP, Healthcare Provider; GWG, Gestational Weight Gain; RR, Relative Risk; PTB, preterm birth; SGA, Small for gestational age; LGA, Large for gestational age*

Notes: [1]Adjusted for maternal age, parity, gestational age at birth, pre-pregnancy BMI, income quintile, education quintile, smoking, depression, pre-existing diabetes, pre-existing hypertension
[2]Adjusted for maternal age, parity, gestational age at birth, pre-pregnancy BMI, income quintile, education quintile, smoking, depression, pre-existing diabetes, pre-existing hypertension, gestational diabetes mellitus
[3]Adjusted for maternal age, parity, gestational age at birth, pre-pregnancy BMI, income quintile, education quintile, smoking, pre-existing diabetes, pre-existing hypertension, gestational diabetes mellitus, drug exposure, alcohol consumption, mental illness, previous: caesarean, term birth, preterm birth, vaginal birth, stillbirth, abortion; non-vertex presentation, male newborn

[4] SGA<10 defined as birth weight less than the 10th centile as per the Canadian reference population adjusted for gestational age and sex;

Kramer et al. (2001)

[5] LGA>90 defined as birth weight greater than the 90th centile as per the Canadian reference population adjusted for gestational age and sex; Kramer et al. (2001)

[6] PTB defined as a live birth or stillbirth < 37 weeks (gestational age at birth)