Distribution and association of interpregnancy weight change with subsequent pregnancy outcomes: a cohort study using electronic medical records

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Abstract

Objective To examine the change in maternal body mass index (BMI) between the first two deliveries and outcomes in the second delivery. Design Cohort study using electronic medical records. Setting and population Medical records of women with their first two consecutive deliveries between 2015 and 2020 at KK Women's and Children's Hospital, Singapore were retrieved. Methods Analysis was limited to women with BMI available for both pregnancies, which was standardised/adjusted to 12 weeks gestation. The difference between gestational-age-adjusted BMI in both pregnancies was calculated as the change in interpregnancy BMI. The risk ratios (RR) of pregnancy outcomes were estimated using modified Poisson regression models with confounder adjustment. Main outcome measures Low birthweight (<2.5 kg), high birthweight ([?]4 kg), small-for-gestational-age, large-for-gestational-age, preterm delivery, gestational diabetes, elective and emergency caesarean deliveries. Results Of 6264 included women with a median interpregnancy interval of 1.44 years, 40.7% had a stable BMI change within +1 kg/m2, 10.3% lost >1 kg/m2, 34.3% gained 1-3 kg/m2 and 14.8% gained [?]3 kg/m2. Compared to women with stable BMI change, those with >1 kg/m2 loss had a higher risk of low birthweight delivery (RR 1.36; 95% confidence interval 1.02, 1.80), while those with 1-3 kg/m2 gain had higher risks of large-for-gestational-age birth (1.16; 1.03, 1.31), gestational diabetes (1.25; 1.06, 1.49) and emergency caesarean delivery (1.16; 1.03, 1.31); these risks were higher in those with [?]3 kg/m2 gain. Conclusion Our study demonstrated the importance of returning to pre-pregnancy weight and maintaining a stable interpregnancy BMI, to achieve better pregnancy outcomes.

Introduction

The rates of overweight and obesity continue to increase worldwide.[1] In women, pregnancy is a life stage that can alter their weight trajectory due to the risk of weight gain during or between pregnancies.[2, 3] Higher parity has been associated with higher pre-pregnancy body mass index (BMI) and subsequent development of obesity.[4, 5] On average, women gain approximately 1 kg/m^2 of BMI unit between consecutive pregnancies, with greater interpregnancy weight gain observed in those with a higher weight before pregnancy.[6]

In women who are overweight or obese, or underweight, the risks of adverse perinatal outcomes are well documented.[7, 8]However, the extent to which interpregnancy weight change influences the risks of subsequent maternal and neonatal outcomes remain poorly understood,[9] and most studies have been focused on Western populations.[10] Given that Asians have increased health risks at different BMI thresholds to Caucasians,[11] and that unique sociocultural factors may influence weight management behaviours before, during, and after pregnancy,[10] it is essential to personalize weight management planning for Asian women.

The interpregnancy period represents a unique phase of the reproductive life-course. A recent systematic review and meta-analysis pooling 61 studies investigating outcomes of interpregnancy weight changes from 11 Western countries highlighted the gaps and clinical needs.[10] Data from this meta-analysis showed that women with interpregnancy weight gain had increased risks of gestational diabetes, hypertensive disorders, large-for-gestational-age birth and caesarean delivery, while those with interpregnancy weight loss had increased risks for preterm delivery and small-for-gestational-age birth. In the present study, our aims were to (i) describe the distribution of weight changes in BMI between first and second pregnancies among Singaporean women and (ii) examine whether similar associations between interpregnancy BMI changes and pregnancy outcomes would be observed in Asian women, compared to those reported in the aforementioned meta-analysis among Caucasians.[10]

Methods

Secondary routine healthcare data was retrieved from women with their first two consecutive deliveries from January 2015 to September 2020 at the KK Women's and Children's Hospital (KKH), Singapore. KKH houses the largest public maternity unit in Singapore and manages one-third of all live births in this country with approximately 12,000 deliveries every year, across a wide sociodemographic spectrum. We retrospectively extracted electronic medical records of women who had singleton births at 24 weeks gestation or more in the first and second pregnancies. Only women who were 21 years or older and conceived naturally in the first and second pregnancies were included. Women with missing information about BMI (at first and/ or second pregnancies) and interpregnancy interval were excluded. Ethical approval was obtained from the Centralised Institutional Review Board of SingHealth (reference 2020/2018).

Interpregnancy BMI change and interval

Maternal weight in kilograms and height in centimetres were routinely measured at the first antenatal appointment of the first and second deliveries. BMI, calculated as weight (in kilograms) divided by height (in metres) squared, at the first antenatal visit during the first and second pregnancies, was used to determine the interpregnancy BMI change. Given that gestational age at the first antenatal visit varied, the BMI measures were standardised separately in the first and second deliveries, by using linear regression with BMI at the first antenatal visit as dependent variable and gestational age centred at 12 weeks (i.e. the mean gestational age at the first antenatal visits) as the independent variable, calculating the residuals, and adding the residual values to the regression predicted mean BMI at 12 weeks. The difference between gestational-age-adjusted BMI at both visits was then calculated as the change in BMI from the first to second deliveries and further categorized as BMI stable -1 to <1 kg/m^2, BMI loss >1 kg/m^2, moderate BMI gain 1 to <3 kg/m^2 and excess BMI gain [?]3 kg/m^2. The gestational-age-adjusted BMI at 12 weeks was used to represent the pre-pregnancy BMI in both pregnancies and was categorized using cut-offs for Asian populations: underweight (<18.5 kg/m^2), normal weight (18.5-22.9 kg/m^2), overweight (23-27.49 kg/m^2) and obese ([?]27.5 kg/m^2).[11] The interpregnancy interval was calculated based on the period between the first delivery date and the second delivery conception date, which was derived by subtracting gestational age at delivery for the second birth from the duration between delivery dates of two consecutive births.[12]

Pregnancy outcomes

Neonatal outcomes included preterm delivery (<37 completed weeks of gestation), low birthweight (<2.5 kg), high birthweight ([?]4 kg), small-for-gestational-age (SGA) and large-for-gestational-age (LGA). SGA and LGA were defined as birthweight for sex and gestational age below the 10th centile and above the 90th centile,[13]respectively, based on a reference sample of healthy livebirths from the Growing Up in Singapore Towards healthy Outcomes (GUSTO) cohort, which is the largest pregnancy cohort study involving approximately 1000 mother-child pairs in Singapore.[14] Maternal outcomes included gestational diabetes mellitus (GDM) as diagnosed by a risk-based, 2-point oral glucose tolerance test (OGTT) between 2015-2017,[15] and a universal 3-point OGTT between 2018-2020,[16] elective and emergency caesarean deliveries. Gestational hypertensive disorders were not included in the analysis due to incomplete information recorded in the electronic medical database.

Statistical analysis

The differences in characteristics between excluded and included women were compared using chi-square tests for categorical variables and independent t-tests for continuous variables. The associations of the change in interpregnancy BMI with subsequent pregnancy outcomes in the second pregnancy were examined using modified Poisson regression models to estimate relative risks (RR) and 95% confidence intervals (CI).[17] The change in interpregnancy BMI was included as a categorical exposure (BMI stable, loss, moderate gain, and excess gain), with stable BMI used as the reference group, as conventionally used by other studies.[10] The models were adjusted for maternal age (continuous), ethnicity (categorical), gestational-age-adjusted BMI at 12 weeks in the first pregnancy (continuous), interpregnancy interval (continuous) and pregnancy outcomes in the first pregnancy (categorical).

As the effect of interpregnancy change may differ by maternal BMI at the beginning of the first pregnancy, we performed post-hoc analysis to examine whether there was any effect modification by weight status <23 vs [?]23 kg/m^2 at 12 weeks during the first pregnancy on any observed association. These models included categorical interpregnancy BMI change, weight status (effect modifier), the interaction terms between categorical interpregnancy BMI change weight status (3 degrees of freedom), and potential confounders as the independent variables. The results were stratified by weight status.

Sensitivity analyses were performed using a similar modified Poisson regression to analyse the associations of the crude (unstandardised for gestational age) change in interpregnancy BMI with pregnancy outcomes, with confounder adjustment. These analyses were restricted to those with measures before or at 12 weeks gestation for both pregnancies. Statistical analyses were performed using Stata 16 (Stata, College Station, TX, USA).

Results

Women's characteristics

This study initially enrolled 7095 women with singleton first and second pregnancies. Of these, we excluded 831 women without BMI measured in one of the pregnancies (n=772) or in both pregnancies (n=59), leaving 6264 women in the final sample. Compared to excluded women, the included women tend to be older by only 0.5 years on average (28.4 vs 27.9 years, p=0.015). **(Table S1)** . All other background variables were similar between the women included and excluded from the analysis (each p>0.05)

The characteristics of participants are displayed in **Table 1** . Of the 6264 women included, most were of Chinese ethnicity (41.5%), followed by Malay (30.4%) and Indian (10.6%), and other ethnicities that included mixed Asians or Caucasians. These women had a mean age of 28.4 years. They had a mean BMI of 23.8 kg/m^2 at 12 weeks during the first pregnancy, which increased to 24.9 kg/m^2 at 12 weeks during the second pregnancy. The interpregnancy BMI change had a median gain of 0.97 kg/m^2, while the median interval between the first and second pregnancies was 1.44 years. Overall, 40.7% of women had a stable interpregnancy BMI (-1 to <1 kg/m^2), 10.3% had BMI loss (>1 kg/m^2), 34.3% had moderate BMI gain (1 to <3 kg/m^2) and 14.8% had excess BMI gain ([?]3 kg/m^2). Women of younger age, Malay ethnicity and with higher BMI in the first pregnancy tended to experience excess BMI gain between their first two pregnancies.

Distribution of interpregnancy BMI change

Figure 1 shows the cross-sectional trends of BMI change over the interpregnancy interval by weight status at 12 weeks of gestation in the first pregnancy. Overall, BMI tended to change (increase or decrease) among women who had the second delivery in the first two years after the first, and was stable at that level among women who delivered later, regardless of the initial weight status. **Figure 2A** shows the comparisons of interpregnancy BMI change and weight status at 12 weeks gestation in the first pregnancy. Women who were overweight and obese in their first pregnancy tended to have interpregnancy BMI loss or gain as compared to those who were underweight and normal weight, who tended to be BMI stable ($p<0.001$).

In total, 24.5% of women gained weight between pregnancies and progressed to a higher BMI category; while 5.4% of women lost weight and dropped to a lower BMI category. Although at least 90% of women who were overweight or obese in the first pregnancy remained at least overweight in the second pregnancy, nearly two-thirds of women with normal weight and half of women who were underweight remained in the same weight status in the first and second pregnancies (**Figure 2B**). Similar distributions of interpregnancy BMI change status and weight status in the second pregnancy were observed across weight status in the first pregnancy based on the WHO conventional cut-offs**(Table S2)** .

Interpregnancy BMI change and subsequent pregnancy outcomes

Table 2 shows the adjusted associations of interpregnancy BMI change status with maternal and neonatal outcomes in the second pregnancy. Compared to women with a stable BMI from the first to the second pregnancy, those with BMI loss had a higher risk of low birthweight delivery (RR 1.36; 95% CI 1.02, 1.80). Women with moderate BMI gain had higher risks of LGA birth (1.16; 1.03, 1.31), GDM (1.25; 1.06, 1.49) and emergency caesarean delivery (1.16; 1.03, 1.31) in the second pregnancy; these risks were higher in those with excess BMI gain. Similar findings were obtained in a sensitivity analysis using crude interpregnancy BMI change (**Table S3**).

Table 3 shows the adjusted associations of interpregnancy BMI change status with maternal and neonatal outcomes in the second pregnancy, stratified by weight status in the first pregnancy. In women with BMI [?]23 kg/m^2, BMI loss was associated with increased risk of low birthweight (1.64; 1.09, 2.47) and SGA deliveries (1.54; 1.02, 2.34). In women with BMI <23 kg/m^2, moderate (1.31; 1.07, 1.59) and excess BMI gains (1.35; 1.04, 1.77) were associated with an increased risk of emergency caesarean.

Discussion

Main findings

In this cohort that included 6264 Singaporean women, 25% of them increased their BMI category, while 5% of them lowered their BMI category between their first and second pregnancies. Approximately half of the women gained [?]1 kg/m^2, of which one-third had excess gain of [?]3 kg/m^2; only 10% lost >1 kg/m^2 between pregnancies. Overall, BMI tended to change among women who had the second delivery in the first two years after the first, and was stable at that level among women who delivered later, regardless of the initial weight status. Interpregnancy BMI gain was associated with increased risks of LGA, GDM and emergency caesarean delivery in the second pregnancy. Greater risks of these adverse outcomes were seen in women with excess interpregnancy BMI gain of [?]3 kg/m^2. Conversely, an increased risk of low birthweight was observed in women with BMI loss between their first two pregnancies. The findings remained similar in sensitivity analyses restricted to women with BMI measured [?]12 weeks gestation for both pregnancies. When the results were further stratified by BMI in the first pregnancy (<23 or [?]23 kg/m^2), a higher risk of emergency caesarean delivery was evident in women with a BMI <23 kg/m^2 experiencing interpregnancy BMI gain, while higher risks of low birthweight and SGA were evident in women with a BMI [?]23 kg/m^2 experiencing interpregnancy BMI loss. We believe that this is the first study to investigate the distribution and outcomes of interpregnancy weight change in Asian women between the first and second delivery.

Interpretation

The interpregnancy period is a valuable opportunity to address complications that have developed during pregnancy and optimise their health for the next pregnancy and for the rest of the life-course. Despite recommendations to return to pre-pregnancy weight between 6 and 12 months postpartum, with the goal to achieve a normal BMI,[18] about half of the women in our study had an increase in BMI during the first two years after delivery instead. Almost 30% of women who were of normal weight subsequently became overweight or obese in their next pregnancy, while more than 90% who were overweight or obese remained the same. Indeed, three-quarters of women with an initial BMI of 27.5-29.9 kg/m^2 had increased BMI to [?]30 kg/m^2 in their second pregnancy (data not shown). A study conducted among Caucasians also showed similar findings, in which almost 20% of women of normal weight became overweight or obese in their next pregnancy, whereas more than 90% of overweight or obese women maintained their status in the next pregnancy.[19] These alarming numbers highlight the urgent need to implement intervention strategies including targeted lifestyle modifications to prevent an increase in BMI during the interpregnancy period.

The results on interpregnancy BMI gain and the increased risks of subsequent LGA, GDM and emergency caesarean delivery are consistent with previous studies.[9, 10, 20] These adverse complications could be due to reduced insulin sensitivity due to interpregnancy weight gain accompanied by body fat rather than muscle gain, which is common among Asians.[19, 21-24] The heightened risk of emergency caesarean delivery in women with an initial BMI <23 kg/m^2 is consistent with a systematic review and meta-analysis by Oteng-Ntim et al.[21], suggesting that lean women could be more susceptible to subsequent delivery complications in response to weight gain between pregnancies. However, the indications for emergency caesarean delivery were not clear in our data and should be further examined in future studies. Similarly, interpregnancy BMI gain has also been associated with an increased risk of hypertensive disorders[9, 25] and stillbirth[10], but we could not analyse these outcomes due to our limited sample size or incomplete outcome data. In view of multiple adverse pregnancy outcomes, long-term obesity, and related health risks in women and their offspring, our study, together with many others,[12, 26-31] calls for a nationwide effort to break the vicious cycle of interpregnancy weight gain and poor metabolic health.

We found that offspring of women with BMI loss between their first two pregnancies were at a higher risk of low birthweight. This is supported by a study on interpregnancy weight change among women in three consecutive pregnancies, showing that weight loss was associated with an increased risk of low placental weight and SGA births.[32] Another study also showed that a decrease in BMI >1 kg/m^2 was associated with low birthweight (<2500 g).[33] This phenomenon could be explained by insulin sensitivity induced by weight loss, resulting in less glucose crossing the placenta, which contributed to an increased risk of small fetal size.[21] A meta-analysis showed that interpregnancy weight loss and SGA was only apparent in women with initial BMI <25 kg/m^2, but not among those with BMI [?]25 kg/m^2.[10] In contrast, we observed that women with BMI [?]23 kg/m^{2}who lost weight during the interpregnancy interval were at a higher risk of low birthweight and SGA, compared to those with BMI <23 kg/m^2 in the first pregnancy. This may be attributed to the greater weight loss among women who were overweight or obese within the interpregnancy interval of 1-2 years, compared with women who were lean (BMI loss 1.9 vs 1.5 kg/m^2, p<0.001). In addition, unlike other studies which showed a reduction in the risk of adverse pregnancy outcomes among overweight and obese women who lost weight,[10, 19-21] our study did not find any significant risk reduction among women with BMI [?]23 kg/m^2 who lost weight. Despite the current emphasis on BMI, it represents a crude measure of adiposity and an imperfect assessment of metabolic health.[34] This was highlighted by a recent study that showed that metabolic health status, rather than BMI, played a greater role in fecundability.[35]Therefore, interpregnancy BMI loss may not truly reflect the metabolic health status of those in our study, which may possibly confound the positive effects of weight loss in overweight and obese women. Furthermore, changes in body composition and fat distribution between pregnancies in these women who were overweight or obese may impact on subsequent pregnancy outcomes. This points to the need to investigate the metabolic profile and body composition of women in future studies of interpregnancy weight change and associated outcomes.

Taken together, maintaining a stable interpregnancy BMI is recommended, instead of losing weight between pregnancies. Based on the trend of interpregnancy BMI change, the first two years after delivery likely represents the best window of opportunity to intervene to return to pre-pregnancy BMI, regardless of initial weight status. Effective lifestyle interventions aimed at limiting postpartum weight retention and maintaining a stable interpregnancy BMI during this window are crucial to improve perinatal outcomes. Such interventions should ideally be engaging, grounded by behaviour change theories, and integrate components of both diet and physical activity.[36]Recently, Bijlholt et al.[37] adopted an electronic health approach for postpartum women with excessive GWG, resulting in restrained eating as well as decreased uncontrolled eating and energy intake. However, there was no change in other behaviours such as emotional eating, physical activity, and sedentary time.[37] To improve the success of lifestyle interventions, it is essential to identify additional enablers and barriers faced by these women. Although Ku et al. [38] identified potential enablers and barriers among overweight and obese women trying to conceive, it remains unclear whether such findings are applicable to women of normal weight.

Strengths and limitations

The main strength of the study is the substantial sample size of women from the three largest ethnicities in Singapore (Chinese, Malay and Indian), and the results are likely generalizable to the Asian population. In addition, the study used gestational-age-adjusted BMI, allowing a more accurate comparison of interpregnancy BMI change. However, since BMI is an imperfect measurement of metabolic health,[34] more needs to be done to investigate how other markers of metabolic health, such as insulin resistance, lipid profile and body composition, are associated with adverse perinatal outcomes beyond a change in BMI. The GDM screening policy underwent a transition during the study period, from a risk-based 2-point OGTT between 2015-2017 to a universal 3-point OGTT from 2018-2020, thus, the incidence of GDM may be underestimated in the earlier years.[39, 40] We did not account for the socioeconomic status and lifestyle habits of the women in the analysis due to the lack of data from medical records. Finally, long-term outcomes of these women and their offspring were not available to provide insights on their long-term health.

Conclusion

This study has shown that a large proportion of women increase their BMI, and a small proportion decrease their BMI between their first two pregnancies. Both increase and decrease in BMI between pregnancies were associated with higher risks of adverse outcomes in the second pregnancy. These findings highlight the importance of returning to pre-pregnancy weight and maintaining a stable interpregnancy BMI thereafter, to achieve better pregnancy outcomes subsequently. However, the recommended magnitude of weight loss beyond their pre-pregnancy weight remains unclear, especially for those who are overweight or obese, where a loss >1 kg/m^2 was associated with SGA and low birthweight. Future studies should examine the role of interpregnancy lifestyle interventions in maintaining a stable interpregnancy BMI among Asian women, and more importantly, the role of metabolic health in adverse pregnancy outcomes with the measurement of body composition and metabolic biomarkers. This will shed light on possible aetiologies of low birthweight/SGA and weight loss and guide personalized interventions and BMI targets for women with lean BMI and those who are overweight or obese.

Disclosure of interests

KMG has received reimbursement to speak at conferences sponsored by companies that sell nutritional products. KMG is part of an academic consortium who has received research funding from Abbott, Nutrition, Nestle and Danone. Other authors declare that they have no competing interests.

Contribution to authorship

SLL designed the study. SLL and TSC performed data analysis. SLL, TSC, CWK, COK, and KXZ drafted the manuscript. SLL, TSC and CWK interpreted the findings. CWK, YBC, KMG, WMH, FY and JKYC revised the manuscript critically. All authors reviewed, read, and approved the final manuscript.

Details of ethics approval

Ethical approval was obtained from the Centralised Institutional Review Board of SingHealth (reference 2020/2018).

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Table 1 Characteristics of participants according to their interpregnancy BMI change status (n=6264)

		BMI change status between first t
Characteristics	**Total**	**Stable** (-1 to <1 kg/m^2)
	n=6264	n=2548; 40.7%
Maternal age in the first pregnancy, years	28.36 + 4.31	28.58 + 4.32
Ethnicity		
Chinese	2600 (41.5)	1192 (46.8)
Malay	1902 (30.4)	704 (27.6)
Indian	666 (10.6)	231 (9.1)
Others	1096 (17.5)	421 (16.5)
BMI at 12-week gestation in the first pregnancy, kg/m^2	23.76 + 4.97	23.19 + 5.04
BMI categories at 12-week gestation in the first pregnancy		
Underweight (<18.5 kg/m^2)	585 (9.3)	319 (12.6)
Normal weight (18.5-22.9 kg/m^2)	2719 (43.4)	1209 (47.4)
Overweight (23-27.4 kg/m^2)	1785 (28.5)	607 (23.8)
Obesity ([?]27.5kg/m^2)	1175 (18.8)	413 (16.2)
BMI at 12-week gestation in the second pregnancy, kg/m^2	24.92 + 5.40	23.33 + 5.03
BMI categories at 12-week gestation in the second pregnancy		
Underweight (<18.5 kg/m^2)	416 (6.6)	286 (11.2)
Normal weight (18.5-22.9 kg/m^2)	2262 (36.1)	1210 (47.5)
Overweight (23-27.4 kg/m^2)	1972 (31.5)	626 (24.6)
Obesity ([?]27.5kg/m^2)	1614 (25.8)	426 (16.7)
Interpregnancy BMI change, kg/m^2	0.97 (-0.04 – 2.21)	0.19 (-0.25 – 0.59)
Interpregnancy interval, years	1.44 (0.89 – 2.19)	1.39 (0.88 – 2.04)

Data are presented as number (percentage) for categorical variables, and as mean + standard deviation or median (25th – 75th percentiles) for continuous variables. BMI, body mass index.

Table 2 Association between interpregnancy body mass index (BMI) change status and outcomes of second pregnancy

	BMI change status between first two pregnancies	**BMI change status bet**
Outcomes of second pregnancy	**Stable** (-1 to <1 kg/m^2) n (%)	
Offspring birth weight		

	BMI change status between first two pregnancies	BMI change status bet
Normal 2.5 to <4 kg	2341 (92.2)	
Low <2.5 kg	163 (6.4)	
High [?]4 kg	35 (1.4)	
Offspring birth size		
AGA 10 - 90 percentile	1932 (76.2)	
SGA <10 percentile	206 (8.1)	
LGA >90 percentile	399 (15.7)	
Preterm delivery <37 weeks		
No	2385 (93.6)	
Yes	163 (6.4)	
Gestational diabetes		
No	2352 (92.3)	
Yes	196 (7.7)	
Mode of delivery		
Vaginal delivery	1892 (76.7)	
Elective caesarean	345 (14.0)	
Emergency caesarean	229 (9.3)	

Risk ratios are adjusted for maternal age and BMI at 12-week gestation in the first pregnancy, ethnicity, interpregnancy interval and respective pregnancy outcomes in the first pregnancy. BMI stable (-1 to < 1 kg/m^2) serves as the reference group. RR, risk ratio; CI, confidence interval; AGA, appropriate for gestational age; SGA, small for gestational age; LGA, large for gestational age.

Table 3 Association between interpregnancy body mass index (BMI) change status and outcomes of second pregnancy, by weight status at 12-week gestation in the first pregnancy

		BMI <23 kg/m²			**BMI [**
Outcomes of second pregnancy	**Loss** (>1 kg/m^2) RR (95% CI)	**Moderate gain** (1 to <3 kg/m^2) RR (95% CI)	**Excess gain** ([?]3 kg/m^2) RR (95% CI)	**Loss** (>1 kg/m^2) RR (95% CI)	**Moder** (1 to < RR (95
Offspring birth weight					
Normal 2.5 to <4 kg					
Low <2.5 kg	1.22 (0.79, 1.90)	0.84 (0.63, 1.11)	1.07 (0.72, 1.59)	1.64 (1.09, 2.47)	1.43 (0.
High [?]4 kg	0.52 (0.07, 4.04)	1.30 (0.56, 3.02)	3.00 (1.17, 7.68)	0.93 (0.46, 1.86)	1.01 (0.
Offspring birth size					
AGA 10 - 90 percentile					
SGA <10 percentile	0.96 (0.63, 1.45)	0.84 (0.67, 1.06)	0.88 (0.62, 1.25)	1.54 (1.02, 2.34)	1.29 (0.
LGA >90 percentile	0.73 (0.49, 1.09)	1.16 (0.96, 1.40)	1.67 (1.30, 2.15)	0.88 (0.71, 1.10)	1.13 (0.
Preterm delivery <37 weeks					
No					
Yes	1.03 (0.65, 1.65)	0.82 (0.60, 1.12)	1.24 (0.81, 1.88)	1.09 (0.74, 1.61)	1.13 (0.
Gestational diabetes					
No					
Yes	1.22 (0.76, 1.95)	1.11 (0.83, 1.48)	1.77 (1.20, 2.61)	0.99 (0.74, 1.31)	1.27 (1.
Mode of delivery					
Vaginal delivery					
Elective caesarean	1.10 (0.89, 1.36)	1.09 (0.97, 1.22)	1.09 (0.92, 1.28)	0.97 (0.84, 1.13)	0.97 (0.
Emergency caesarean	1.34 (0.96, 1.88)	1.31 (1.07, 1.59)	1.35 (1.04, 1.77)	0.98 (0.82, 1.17)	1.06 (0.

Risk ratios are adjusted for maternal age and BMI at 12-week gestation in the first pregnancy, ethnicity, interpregnancy interval and respective pregnancy outcomes in the first pregnancy. BMI stable (-1 to < 1 kg/m^2) serves as the reference group. RR, risk ratio; CI, confidence interval; AGA, appropriate for gestational age; SGA, small for gestational age; LGA, large for gestational age.

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