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Gestational diabetes and fetal macrosomia: a dissenting opinion

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Abstract

Objectives: To examine the effect of interaction between parity, overweight/obesity, gestational weight gain, and gestational diabetes mellitus (GDM) on the incidence of fetal macrosomia.

Methods: We used a population-based dataset to establish the incidence of macrosomia (birth weight >4,000 g) in singleton births at ≥38 weeks' gestation. The cohort included women who were (1) overweight/obese or had normal body mass index (BMI) before pregnancy, (2) nulliparous or multiparous, (3) with appropriate or excessive weight gain, and (4) without GDM, with GDM controlled by non-pharmacological treatment (GDM0), or with GDM requiring insulin treatment (GDM1).

Results: We examined 129,686 births at ≥38 weeks. The mean gestational age at birth for all subgroup was similar. When compared with a reference incidence for nulliparas with normal pregravid BMI, appropriate weight gain, and without GDM, all variables, except GDM, independently and significantly increased the incidence of neonates weighing >4,000 g. The logistic regression analysis found that excessive weight gain, pregravid BMI >25, and parity were the only independent factors associate with birth weight >4,000 g.

Conclusions: Well-managed GDM is not significantly associated with macrosomia, whereas pre-pregnancy obesity, excessive gestational weight gain, and parity appear to be significant risk factors. These results emphasize the need for effective weight management before and during pregnancy to reduce the risk of fetal overgrowth.

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Keywords: macrosomia; gestational diabetes; parity; obesity; weight gain

Introduction

Macrosomia, gestational diabetes mellitus and obesity

Fetal macrosomia, usually defined as birth weight >4,000 g regardless of gestational age, is associated with an increased rate of birth anomalies, and consequently higher perinatal morbidity and mortality. The threshold for birth weight of >4,000 g corresponds to a value above the 90th percentile at term. The management of pregnancies with a suspected macrosomic fetus is often challenging [1].

Maternal obesity before pregnancy is widely recognized as a significant risk factor for the development of macrosomic infants, and is a major contributor to several adverse pregnancy outcomes, including GDM and hypertensive disorders [2, 3]. Obesity increases the likelihood of developing GDM, which, in combination with the complex interaction of insulin resistance and other metabolic factors, significantly impairs fetal growth and often leads to macrosomia [2, 3]. Furthermore, maternal obesity increases the risk of complications in labor and delivery, cesarean section, and postpartum disorders and complications such as infection and delayed recovery. In addition, infants born to obese mothers are at increased risk of long-term health problems, including obesity and metabolic syndrome later in life [4–6].

The analysis by Sweeting et al. [7] clearly shows that as maternal BMI increases, particularly in overweight and obese women, there is a corresponding increase in the risk of conditions such as GDM, hypertensive disorders and cesarean delivery. Crucially, the risk of fetal macrosomia is more closely associated with maternal obesity than with GDM alone, emphasizing the importance of effective maternal weight management before and during pregnancy to mitigate these risks [8]. Key factors such as elevated glucose and triglyceride levels, which are common in obese women and those with GDM, further increase the risk of macrosomia [7]. The biological link between hyperglycemia in GDM and macrosomia is based on the

Pedersen hypothesis that maternal hyperglycemia leads to excessive fetal insulin production, which promotes abnormal fetal growth and increases the likelihood of cesarean delivery, birth injuries and neonatal hypoglycemia [7, 8]. Elevated triglycerides contribute to increased fat deposition in the fetus, which increases the risk of preeclampsia and other hypertensive disorders.

Sweeting et al. advocate for comprehensive preconception and prenatal care strategies that focus on risk factors to ensure better health outcomes for both mothers and their newborns [3, 4].

There is controversy about the extent to which each of these variables contributes to macrosomia. Schaefer-Graf et al. [9] found that maternal obesity appears to be a strong risk factor for macrosomia in GDM pregnancies. They also found that maternal euglycemia did not normalize the incidence of macrosomia.

In the meta-analysis conducted by Gaudet et al. [10], the authors found that maternal obesity (pregravid or at the first prenatal visit) was significantly associated with a fetal birth weight ≥4,000 g. Another frequently cited risk factor is hyperglycemia during pregnancy. In fact, the Hyperglycemia and Adverse Pregnancy Outcomes (HAPO) study showed a modest but significantly increased risk of birth weight >90th percentile with maternal hyperglycemia [8].

Several studies have highlighted the critical role of maternal obesity and gestational weight gain (GWG) in the risk of fetal macrosomia, which often outweighs the impact of GDM. Nakashine et al. [11] demonstrated that both GDM and elevated triglyceride levels modestly mediate the relationship between pre-pregnancy obesity and macrosomia, emphasizing the importance of managing these factors. Maternal obesity, rather than GDM, is the strongest predictor of macrosomia and adverse pregnancy outcomes, with studies [12–17] consistently highlighting pre-pregnancy BMI and excessive gestational weight gain (EGWG) as important independent risk factors that often overshadow the impact of GDM. Zheng et al. [18] emphasized that management of GWG after a GDM diagnosis is crucial, as even moderate weight gain can increase the risk of LGA. Overall, these findings suggest that effective pre-pregnancy weight management and control of GWG may reduce the incidence of macrosomia more than focusing solely on the management of GDM.

Trojner et al. [19] showed that women with pre-gravid class III obesity (BMI>40 kg/m^2) had significantly more GDM and macrosomic infants as compared with class I obesity (BMI 30.1–35 kg/m^2), suggesting a quasi dose-response relationship between severity of obesity and the incidence of GDM and macrosomia. Our group also observed [20] that obesity (without diabetes) is more frequently associated with macrosomia than GDM with obesity ("diabesity") or GDM in non-obese mothers.

Although these and other associations with macrosomia have been reported previously, the studies have often been confounded. Two important confounding factors are parity and GWG. In the common context, the incidence of GDM and obesity increases with parity, so the potential direct association between parity, *per se*, and macrosomia remains uncertain or not properly assessed. In addition, excessive weight gain during pregnancy has been associated with increased birth weight and fetal growth (LGA) [21, 22].

To our knowledge, these four variables, namely GDM, obesity, excessive weight gain, and parity, have not been compared before. The aim of our study was to examine the effect of the interaction between these variables on the incidence of fetal macrosomia by examining a large series of singleton pregnancies from a well-validated population database.

Materials and methods

Study population

We used data from the Slovenian National Perinatal Information System (PIS RS), in which registers all deliveries from 22 weeks gestation or birth weight over 500 g. Registration is mandatory by law and more than 140 variables are entered into the computerized database immediately after birth. Our study population included live singleton births at ≥38 weeks in the period 2016 to 2023. In Slovenia, guidelines based on the recommendations of the International Association of Diabetes and Pregnancy Study Groups (IADPSG) were introduced and adopted in 2011.

As the analysis was based on individual deliveries, women who gave birth more than once during the study period were included multiple times, with each delivery counted separately.

The dependent variable of our study was birth weight >4,000 g. The following dichotomous independent variables were analyzed: overweight and obesity or normal weight before pregnancy, being primiparous or multiparous, gaining weight according to the Institute of Medicine weight gain recommendations in pregnancy [23], and being without GDM, with GDM0 (GDM under control by nonpharmacologic treatment), or GDM1 (GDM requiring insulin treatment)

(see below). We excluded patients with chronic arterial hypertension, smoking, and pre-gestational diabetes mellitus.

Clinical definitions and practices in Slovenia

Overweight and obesity were defined according to the pregravid BMI ≥25 kg/m^2 (defined as the individual's body mass divided by the square of body height, kg/m^2, [24]). The PIS RS method of registering maternal pre-pregnancy weight is particularly accurate and presumably without recall error, as pre-pregnancy weight was measured and recorded at the first visit to the doctor at the beginning of pregnancy.

GDM has been defined according to the national guidelines for screening and diagnosing GDM. We follow a two-step screening approach. The first step is at the first visit to the doctor at the beginning of pregnancy, where the fasting serum glucose is measured. The limit value is 5.1 mmol/L. If blood sugar is below this, we perform 75 g oral glucose tolerance test (OGTT) between the 24th and 28th week of pregnancy according to the consensus of the International Association of Diabetes and Pregnancy Study Groups in 2010 [25]. GDM1 was defined as GDM requiring insulin treatment, while GDM0 was defined as when dietary changes and a healthy lifestyle were adequate to control glucose levels. GDM per se was not an indication for induction of labor or elective cesarean section before 40 weeks' gestation.

As standard of care [26], women with GDM were referred to a multidisciplinary team of obstetrician, endocrinologist, and nutritionist to receive diabetic education, nutritional counseling, and encouragement to adopt a healthy lifestyle. The goal was to maintain fasting blood glucose below 5.3 mmol/L, achieved with both diet and lifestyle changes or together with insulin treatment. Glycemic control was assessed by traditional four times daily capillary blood sampling using calibrated glucose meters. The results were checked at regular intervals. Weight gain was defined by the difference between maternal weight at birth and pre-pregnancy weight. Mothers were considered to have a normal GWG or to be over-gainers, according to the Institute of Medicine standards endorsed by the American College of Obstetricians and Gynecologists (ACOG) [24].

In Slovenia, pregnant women with GDM have additional ultrasound examinations to assess the growth and well-being of the fetus. If accelerated fetal growth or an increased amount of amniotic fluid (polyhydramnios) is detected, the patient is referred to a secondary or tertiary level. Patients with other diagnoses that could complicate pregnancy or birth are also referred to the tertiary level [27].

Statistical analysis

IBM *SPSS*® Statistics *software* was used for statistical analysis of the data. Chi-square tests were used to compare categorical variables and to calculate odds ratio (OR) and the 95% confidence interval (CI). A logistic regression analysis was also performed to explain the relationship between one dependent binary variable (birth weight >4,000 g) and several nominal and ordinal variables. The level of significance used in the statistical analysis of the data was set at $p < 0.05$.

This retrospective study of anonymous entries was exempt of approval by the Ethics Committee. This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Results

We examined 87,862 women with a normal BMI before pregnancy and 41,824 women who were overweight or obese before pregnancy, for a total of 129,686 singleton births at ≥ 38 weeks' gestation. Among mothers with a normal BMI, 44,870 (51.1%) were multiparous and 42,992 (48.9%) nulliparous. In this group with normal BMI before pregnancy, there were 63,658 women with normal GWG, 33,456 multiparous (52.6%) and 30,202 nulliparous (47.4%) while 24,204 women had EGWG, 11,426 multiparous (47.2%) and 12,778 nulliparous (52.8%). The mean gestational age at delivery was similar in both nulliparous and multiparous without GDM, GDM0, or GDM1 (39.1 ± 0.9 to 39.6 ± 1.0 weeks' gestation).

Table 1 shows the incidence of neonates >4,000 g by parity, weight gain, BMI before pregnancy, and GDM status in comparison: nulliparous women with a normal BMI before pregnancy, with appropriate weight gain during pregnancy, and without GDM.

Nulliparous women with a normal pre-pregnancy BMI who gained more weight than recommended had a higher risk of macrosomia, compared to the control group. In nulliparous women who were overweight or obese before pregnancy, the risk increased even further, with an OR of 3.31 (95% CI: 3.04, 3.59). Multiparous women had a higher risk of macrosomia than their nulliparous counterparts regardless of BMI before pregnancy. For example, multiparous women with a normal BMI had an OR of 2.87 (95% CI: 2.65, 3.11), while those who were overweight or obese had an OR of 5.26 (95% CI: 4.88, 5.67). These findings indicate that both pre-pregnancy obesity and EGWG significantly increase the risk of delivering a macrosomic infant, with the effect being more pronounced in multiparous women.

Table 1: Incidence of neonates > 4,000 g by parity, weight gain, pregravid BMI, and GDM status in Slovenia (2016 – 2023).

	Pregravid BMI 15.5–24.9				Pregravid BMI ≥ 25			
	Normal GWG		EGWG		Normal GWG		EGWG	
	Normal neonate weight	>4,000 g (%)	Normal neonate weight	>4,000 g (%)	Normal neonate weight	>4,000 g (%)	Normal neonate weight	>4,000 g (%)
Nulliparas								
No	24,918	[a]1,360 (5.2)	10,192	[b]1,372	4,754	[c]452 (8.7)	6,473	[d]1,168
GDM				(11.9)				(15.3)
	Reference		OR 1.74 (1.56 – 1.95)		OR 2.47 (2.28 – 2.67)		OR 3.31 (3.04 – 3.59)	
GDM0	3,501	[a]212 (5.7)	995	[b]151 (13.2)	1,836	[c]201 (9.9)	1,364	[d]247 (15.3)
	OR 1.11 (0.95, 1.29)		OR 2.01 (1.71 - 2.35)		OR 2.78 (2.31 - 3.33)		OR 3.32 (2.85 – 3.84)	
GDM1	201	[a]15 (6.9)	64	[b]11 (14.7)	345	[c]30 (8.0)	170	[d]39 (18.7)
	OR 1.37 (0.75, 2.32)		OR 1.59 (1.05 – 2.33)		OR 3.15 (1.49 – 6.04)		OR 4.20 (2.88 - 6.01)	
Multiparas								
No	26,122	[e]2,583 (9.0)	8,562	[f]1,804	8,124	[g]1,273	6,602	[h]1,895
GDM				(17.4)		(13.6)		(22.3)
	OR 1.81 (1.69 – 1.94)		OR 2.87 (2.65 - 3.11)		OR 3.86 (3.58 – 4.16)		OR 5.26 (4.88 - 5.67)	
GDM0	3,960	[e]406 (9.3)	763	[f]188 (19.8)	3,303	[g]618 (15.8)	1,395	[h]436 (23.8)
	OR 1.88 (1.67 – 2.11)		OR 3.43 (3.09 – 3.80)		OR 4.51 (3.79 – 5.35)		OR 5.26 (4.88 – 5.67)	
GDM1	357	[e]28 (7.3)	87	[f]20 (18.7)	674	[g]119 (15.0)	216	[h]90 (29.4)
	OR 1.44 (0.94 – 2.12)		OR 3.23 (2.62 – 3.97)		OR 4.21 (2.45 – 6.93)		OR 7.63 (5.86 – 9.87)	

Data are shown as n (%); statistics are shown as OR (95% CI) as compared to the reference incidence. BMI, body mass index; GWG, gestational weight gain; EGWG, excessive gestational weight gain; GDM, gestational diabetes mellitus; GDM0, GDM controlled by nonpharmacological treatment; GDM1, GDM requiring insulin treatment; OR, odds ratio.

Considering the role of GDM, nulliparous women with normal pre-pregnancy BMI had an OR of 2.01 (95% CI: 1.71, 2.35) for women with GDM0 and EGWG, similar to the OR for EGWG without GDM. This trend persisted across other GDM categories, suggesting that well-treated GDM did not independently raise the risk of macrosomia when weight gain was controlled. Among multiparous women a similar pattern emerged. For example, those who were overweight or obese, also had EGWG, and had GDM0 had an OR of 5.26 (95% CI: 4.88, 5.67), which was comparable to multiparous women with EGWG without GDM.

Across all BMI and weight gain categories, multiparous women were consistently more likely to deliver a macrosomic infant than nulliparous women. For example, multiparous women with normal BMI and normal weight gain had an OR of 1.81 (95% CI: 1.69, 1.94), and this risk increased for women with EGWG or a higher pre-pregnancy BMI.

Maternal obesity before pregnancy, EGWG, and multiparity with the exception of GDM, independently and significantly increase the incidence of neonates weighing more than 4,000 g. In contrast, GDM alone does not increase the incidence of newborns weighing more than 4,000 g when compared with no GDM within the parity, pregravid BMI and weight gain categories (all not significant).

The highest risk of macrosomia was in multiparous women, who were also overweight/obese, had EGWG, and GDM. In women with GDM, controlled with non pharmacologic treatment, the risk of macrosomia was increased almost 6-fold (OR 5.73, 95% CI 5.06, 6.47); in women with GDM, controlled with insulin, the risk was increased 7.5-fold (OR 7.63, 95% CI 5.86, 9.87).

Illustrations of the relationship between pre-pregnancy BMI and the incidence of fetal macrosomia in different groups, particularly in deliveries categorized by parity (primiparous and multiparous) and GDM status are shown in Figures 1–3. The analysis used restricted cubic splines with three knots to model this relationship, taking in to account the age of the patients for its potential confounding factor (Figure 4).

The graphs illustrate the relationship between pre-pregnancy BMI and the risk of fetal macrosomia and show a clear positive trend: as BMI increases, so does the likelihood of macrosomia. This correlation applies to all deliveries and underlines the fact that higher BMI before pregnancy is a significant risk factor.

For primiparous women (Figure 2), the risk increases with higher BMI, but the trend is more pronounced in multiparous women (Figure 3), where the slope is steeper. Even after adjusting for maternal age (Figure 4), the

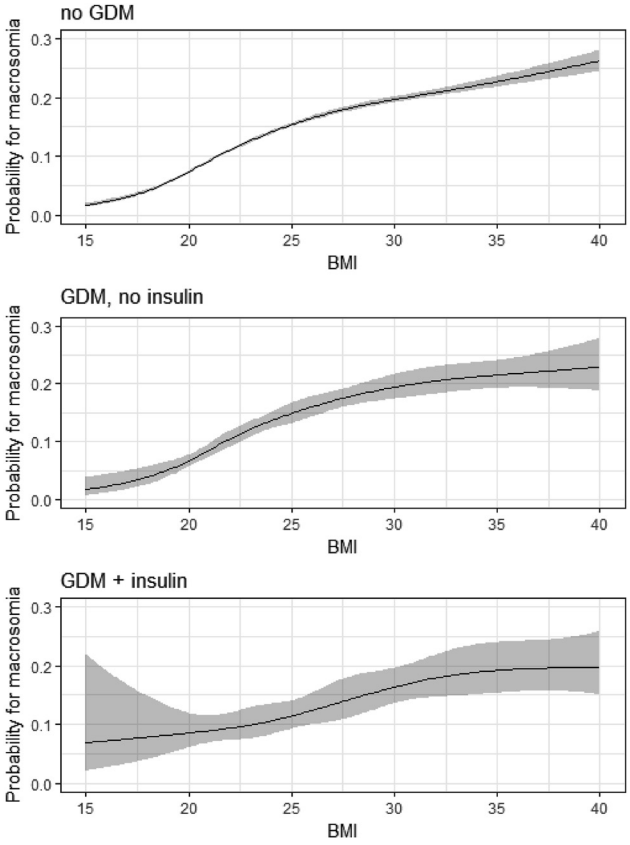

Figure 1: Association between pre-pregnancy BMI and incidence of macrosomia across all deliveries.

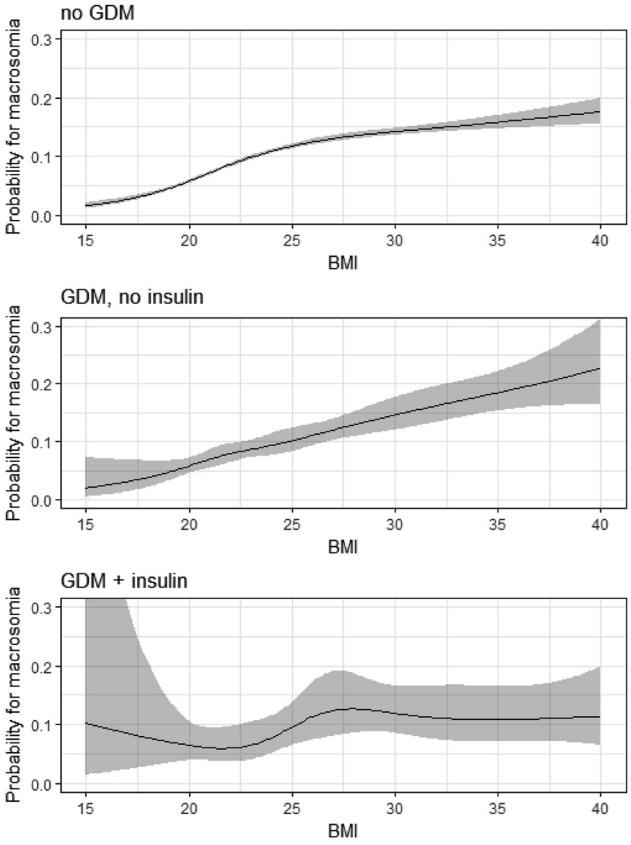

Figure 2: Impact of pre-pregnancy BMI on macrosomia in primiparous women.

association between pre-pregnancy BMI and the risk of macrosomia remained robust. This confirms that higher maternal BMI is an independent predictor of macrosomia and that maternal age did not significantly confound this relationship.

Building on these findings, it is important to consider the broader trends in pre-pregnancy BMI over time. Our data (Table 2) show a steady increase in the proportion of primiparous women with a BMI over 25 in singleton pregnancies between 2013 and 2023. Specifically, the proportion increased from 24.1% in 2013 to 32.2% in 2023. Comparing the two periods of 2013–2015 and 2016–2023, the average percentage increased significantly, from 24.3% to 28.7%. This steady increase underlines the growing prevalence of overweight and obesity among pregnant women in Slovenia and highlights the urgent need for targeted interventions to address this trend and mitigate its impact on maternal and neonatal outcomes.

During the study period, the proportion of deliveries affected by GDM more than doubled, rising steadily from 11.3 % in 2016 to 22.3 % in 2023 (Table 3). The most pronounced year-on-year increase occurred after 2018, with the rate exceeding 20 % from 2021 onward. A concurrent gradual increase in maternal pre-pregnancy BMI was also observed during this period. By contrast, the distribution of parity remained remarkably stable: the share of primiparous deliveries fluctuated only slightly between 51 % and 53 % across all eight years.

Discussion

Principal findings

Our data suggest that well-treated GDM, whether treated nonpharmacologically by diet and exercise (GDM0) or with insulin (GDM1), is not significantly associated with the development of macrosomia in our population. Instead, factors such as pre-pregnancy BMI, weight gain during pregnancy, and parity have a grater impact on this risk. This suggests that effective management of GDM may mitigate its influence on macrosomia, with the observed risk being primarily due to other maternal characteristics rather than GDM itself.

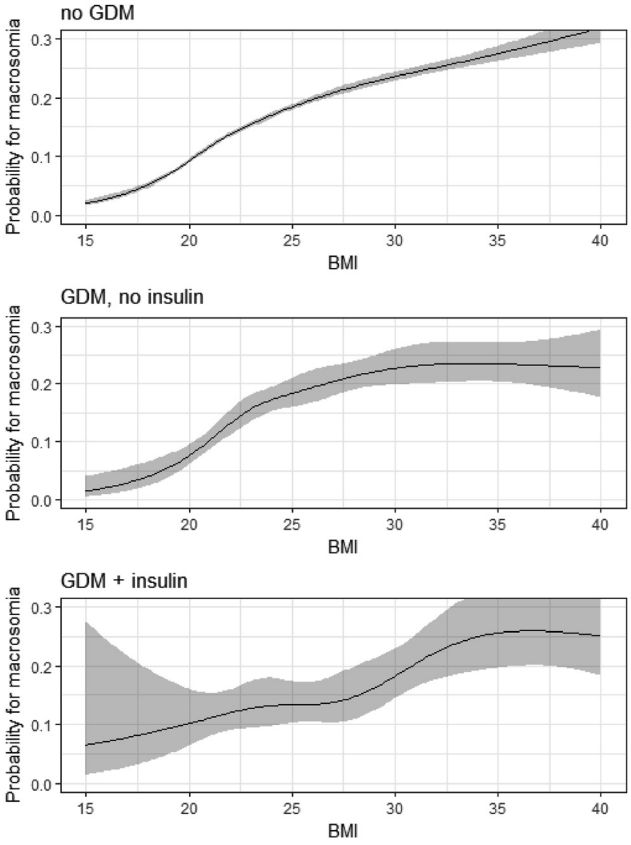

Figure 3: Association between pre-pregnancy BMI and macrosomia in multiparous women.

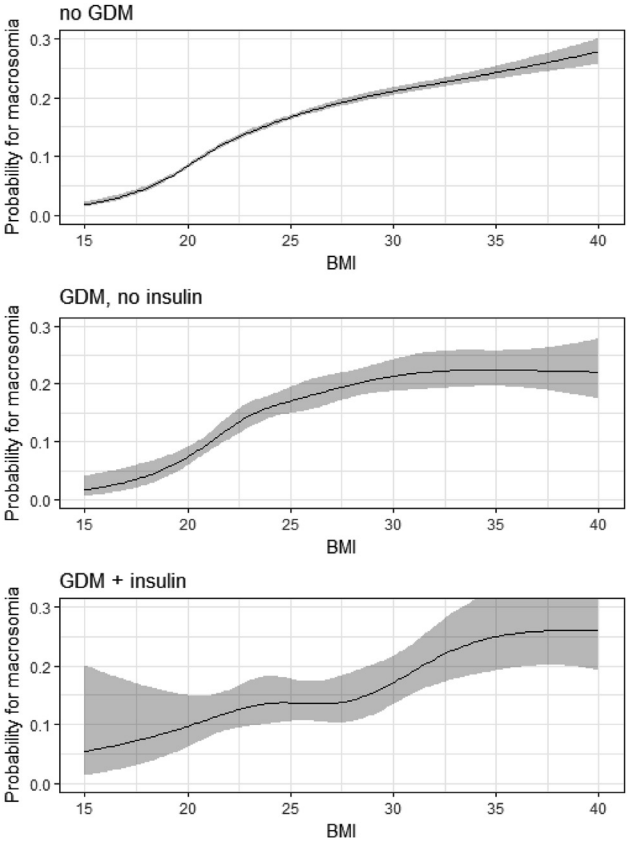

Figure 4: Adjusted impact of pre-pregnancy BMI on macrosomia in multiparous women, controlling for age.

Overall, the graphs confirm our earlier statement that pre-pregnancy obesity and EGWG are of the main factors for macrosomia, especially in multiparous women. Effective weight management before and during pregnancy remains essential in reducing the risk of fetal overgrowth, as the consistent patterns in the different groups make clear.

Clinical implications

A proportion of the pregnant women may have been misclassified as having GDM due to the implementation of the two step approach. A study by Huhn and coworkers [28] suggests that the introduction of the new criteria has led to a significant increase in GDM diagnoses. The incidence of GDM in Slovenia in 2023 was 21%. It was therefore plausible that some women diagnosed with GDM did not have high insulin resistance and the association between GDM and macrosomia was not significant. However, since these misclassified women probably belong to the GDM0 group, our data suggest that there was no difference between GDM0 and GDM1, implying that misclassification cannot explain our observation.

Table 2: Yearly proportion of primiparas with BMI > 25 in singleton pregnancies in Slovenia (2013–2023).

Year	BMI, %
2013	24.1
2014	23.7
2015	25.1
2016	26.1
2017	26.5
2018	26.6
2019	28.5
2020	29.8
2021	29.8
2022	31.0
2023	32.2

BMI, body mass index

GDM care in Slovenia includes physical activity education, nutrition education, management of gestational diabetes and regular screening for gestational diabetes in all pregnant women [26]. Thus, the data may indicate that, in

Table 3: Yearly incidence rates of gestational diabetes mellitus (GDM) in Slovenia, 2016 to 2023.

Year	GDM incidence, %
2016	11.3
2017	13
2018	15
2019	16.6
2020	18.6
2021	21
2022	20.8
2023	22.3

terms of macrosomia, appropriate GDM care, and reaching euglycemia eliminates the potential increase in macrosomia caused by GDM.

The increase in the incidence of GDM reflects the increasing prevalence of overweight and obesity among pregnant women in Slovenia, which is consistent with global trends related to lifestyle changes and reduced physical activity. This increase is of critical implications, as higher maternal BMI is associated with adverse pregnancy outcomes, including gestational diabetes, hypertensive disorders, and macrosomia. Preventive measures to promote healthy weight before and during pregnancy are crucial to address these challenges [29, 30].

Catalano and Hauguel-De Mouzon [31] criticized the Pedersen's hypothesis on which the link between GDM and macrosomia is based. They underlined the different pathophysiology of diabetes mellitus type 1 (DM1), which is primarily a disorder of beta cell failure and GDM/type 2 diabetes mellitus (DM2), in which the pathophysiological mechanisms include both insulin resistance and beta cell dysfunction. Since Pedersen was concerned with type 1 diabetics, the authors suggest that his hypothesis may not apply for GDM/DM2 and claim that the metabolic milieu in which the fetus develops is quite different in the two settings. This points to the importance of maternal obesity and lipid metabolism on fetal adiposity. This study also addresses the potential issue that women with GDM are more aware of the importance of dietary interventions because they participate in diabetic education, which includes dietary education and self-measurement of blood glucose levels. As these women are more likely to follow dietary guidelines, their weight gain behavior may differ from that of less well-informed women.

The data indicate that regardless of the weight gain pattern, GDM does not affect the incidence of birth weight >4,000 g. In a study examining actual weight gain during pregnancy compared with the weight gain recommendations issued by the American Institute of Medicine, our group showed an increased incidence of those who gained less than recommended ("undergainers") in pregnancies with GDM in all pre-gravid BMI categories, [32, 33] which most likely is a result of better glycemic control in our country. Similarly, Alberico et al. [34] reported that among the subgroup of patients with GDM, the incidence of macrosomia was significantly higher in those who had an excessive weight gain during pregnancy compared with the recommended weight gain, suggesting that controlled weight gain, which is likely to be associated with controlled GDM, reduces the risk of macrosomia. In contrast, we, found that weight gain above the recommended level was associated with macrosomia in all pregravid BMI categories [32, 33].

A third explanation for the results we obtained could be the practice of induction of labor for suspected LGA fetuses is guided by international standards, including those set by ACOG and the National Institute for Health and Care Excellence (NICE). According to the ACOG guidelines [1], induction of labor for suspected macrosomia at 39 weeks of gestation may be considered to reduce the risk of complications, particularly if the estimated fetal weight is above the 95th percentile [35]. Thus, the induction of labor for suspected LGA in our population could potentially affect study outcomes by reducing the recorded incidence of macrosomia. This intervention could prevent some fetuses from reaching the weight threshold for macrosomia (over 4,000 g), which could lead to an underestimation of the true impact of factors such as maternal obesity and GDM on fetal growth.

Research implications

The research highlights several important avenues for future investigation. Namely, the interaction between obesity, GWG, and glycemic control calls for deeper examination, with future studies needed to determine how these factors together influence fetal growth and outcomes. Longitudinal studies tracking women from pre-conception through postpartum could offer insights into the long-term effects of pre-pregnancy weight management on the incidence of GDM and macrosomia. Additionally, the potential influence of genetic and epigenetic factors in the context of maternal obesity and GDM remains underexplored, suggesting a need for research into specific biomarkers or genetic profiles that may predispose to macrosomia. Furthermore, randomized controlled trials could evaluate the effectiveness of specific lifestyle and dietary interventions in managing weight gain and preventing macrosomia across various populations. Lastly, broader public health research could assess the impact of early

intervention strategies and public health policies aimed at reducing obesity rates among women of reproductive age, with a focus on their cost-effectiveness in mitigating the healthcare burden associated with macrosomia.

Strengths and limitations

One of the biggest strengths of this study is the large sample size. The study utilizes a large dataset comprising nearly 200,000 singleton births, which strengthens the statistical power and generalizability of the findings. Furthermore, a well-validated population database was used, which adds credibility to the findings since the PIS RS in Slovenia is a legally mandated registry that ensures comprehensive, complete and accurate data collection. Another strength is that the entire population of pregnant women in Slovenia is covered by centrally regulated clinical guidelines that ensure standardized diagnosis and treatment practises. This consistency in care improves the comparability of results and supports the generalisability of our findings. The statistical in-depth analysis of the independent and combined effects of key variables — GDM, obesity, parity, and GWG — on the incidence of fetal macrosomia is certainly one of the biggest strengths of the study. This comprehensive approach allows for a nuanced understanding of how these factors interact and influence outcomes, addressing gaps in previous research that often considered these variables in isolation.

The study not only identifies significant associations but also explores the potential clinical implications of these findings. For instance, the discussion on the role of appropriate GDM care in potentially mitigating the risk of macrosomia highlights the importance of tailored clinical interventions based on individual patient profiles. Additionally, by challenging the traditional understanding of the relationship between GDM and macrosomia and emphasizing the stronger impact of obesity and weight gain, this study adds valuable insights to the existing knowledge. The findings suggest that interventions targeting obesity and weight management might be more effective in reducing the incidence of macrosomia than focusing solely on GDM management.

The study's findings are directly relevant to public health and clinical practice, particularly in the context of designing interventions to reduce the incidence of macrosomia. The emphasis on pre-pregnancy obesity and weight management during pregnancy offers actionable insights for healthcare providers.

The main limitation of our study is the lack of information about glycemic control. This seems to be of importance as Langer et al. [35] concluded that targeted levels of glycemic control enhanced outcome only in cases with GDMA2 in obese women. This preferential effect of insulin is not supported by our study because GDMA2 mothers had no advantage in overweight/obese women as well as in women with pregravid normal BMI.

While the study's findings are robust and relevant within the Slovenian population, generalizing them to other populations should be done cautiously, considering the differences in healthcare practices, population demographics, and the prevalence of the key variables studied. We acknowledge that the incidence of maternal obesity in our population is apparently lower as compared to other countries. Devlieger et al. [36] ranked our population (roughly 9% obese women) among the European countries with the lowest incidence of obese mothers (range 7 to 25%). Our incidence of pregravid obesity is certainly much lower than that reported in the USA [23]. Despite these variations, the robust conclusions of our study appear applicable to every population that includes obese gravidas. Further research in diverse settings would be beneficial to confirm the broader applicability of our conclusions.

Finally, we used the 4,000 g cutoff to define macrosomia. Regardless of its statistical merit, clinician might be more comfortable with conclusions related to 4,500 g as a cutoff. Regrettably, despite the dataset of nearly 200,000 patients, the small number of infants weighing over 4,500 g at birth did not permit meaningful conclusions.

Conclusions

The study concludes that, contrary to conventional wisdom, GDM alone is not significantly associated with the development of macrosomia when factors such as obesity, parity, and weight gain during pregnancy are considered. Instead, obesity and excessive weight gain during pregnancy, together with higher parity, are the main contributors to macrosomia risk. The results suggest that while significant efforts are being made to diagnose and treat GDM to reduce macrosomia risk, more emphasis should be placed on treating obesity before pregnancy and controlling weight gain during pregnancy. The study also highlights the need for individualized care to address these modifiable risk factors, which could more effectively prevent macrosomia and improve perinatal outcomes.

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