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Offspring birthweight and placental weight—does the type of maternal diabetes matter? A population-based study of 319 076 pregnancies

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Abstract

Introduction—Our aim was to estimate the difference in birthweight and in placental weight in pregnancies with type 1 diabetes, type 2 diabetes, and gestational diabetes compared with pregnancies without diabetes.

Material and methods—By using data from the Medical Birth Registry of Norway during the years 2009–2017, we included 319 076 singleton pregnancies with delivery after the 21st week of pregnancy. We used linear regression analyses to estimate the difference in birthweight and in placental weight in grams (g) in pregnancies with type 1 diabetes, type 2 diabetes, and gestational diabetes, using pregnancies without diabetes as the reference. Adjustments were made for pregnancy duration and pre-pregnancy body mass index.

Results—In pregnancies without diabetes, mean crude birthweight was 3527 g (SD 552 g). The adjusted mean birthweight was 525 g (95% CI 502–548 g) higher in pregnancies with type 1 diabetes compared with pregnancies without diabetes. In pregnancies with type 2 diabetes, and pregnancies with gestational diabetes, birthweights were 192 g (95% CI 160–223 g) and 102 g (95% CI 93–110 g) higher, respectively. Mean crude placental weight was 664 g (SD 147 g) in pregnancies without diabetes. Compared with pregnancies without diabetes, the adjusted mean placental weight was 109 g (95% CI 101–116 g) higher in pregnancies with type 1 diabetes, 50 g (95% CI 39–60 g) higher in pregnancies with type 2 diabetes, and 31 g (95% CI 28–34 g) higher in pregnancies with gestational diabetes.

Conclusions—The increase in birthweight and in placental weight associated with maternal diabetes was most pronounced for type 1 diabetes, followed by type 2 diabetes, and gestational diabetes.

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AUTHOR CONTRIBUTION

EMS-R and AE had the original idea for this study. EMS-R performed the data analyses, and made the tables and figures. All authors wrote the manuscript, and contributed to the interpretation of the results. AE is the guarantor of the study.

CONFLICT OF INTEREST

None.

1 INTRODUCTION

The prevalence of diabetes among pregnant women has increased over the past 20 years in many countries of the world.¹ In particular, the prevalence of gestational diabetes has increased. However, pregnant women may also have type 1 diabetes or type 2 diabetes, and all types of diabetes are characterized by increased glucose concentrations in the blood.

Any type of diabetes during pregnancy has been associated with increased birthweight of the offspring.^{2,3} High birthweight increases the risk of delivery complications, both for the mother and the child.⁴⁻⁶ Furthermore, babies that are heavy at birth are also more likely to be obese or have diabetes as adults.⁷

Placental weight is increased in diabetic pregnancies.⁸ High placental weight or high placental weight relative to birthweight, has been associated with several adverse outcomes such as low Apgar score,⁹ respiratory distress in the newborn,¹⁰ perinatal death, and cardiovascular death in adulthood.¹¹⁻¹³

High body mass index (BMI) increases the risk of high birthweight and high placental weight, independent of maternal diabetes,^{14, 15} and BMI may differ between women with type 1 diabetes, women with type 2 diabetes, and those with gestational diabetes.

The duration of pregnancy is another factor that is positively associated with offspring birthweight. However, women with diabetes may have a shorter duration of pregnancy as they are more likely to suffer from complications that necessitate early delivery of the offspring.¹⁶ Thus, the observed birthweights and placental weights from diabetic pregnancies are lower than they would have been if the pregnancy had continued. If duration of pregnancy at delivery is not accounted for in the data analyses, comparisons between diabetic and non-diabetic pregnancies will be biased, and the true differences will be underestimated.

To our knowledge, no previous study has compared offspring birthweight in pregnancies with type 1 diabetes, type 2 diabetes, and gestational diabetes within the same study sample, and at the same time made adjustments for maternal BMI and pregnancy duration. Such comparisons may improve our understanding of the impact of the different types of maternal diabetes on fetal growth. Also, such comparisons may provide important information about the magnitude of the health problem associated with increased birthweight in pregnancies with maternal diabetes.

We included 319 076 singleton pregnancies in Norway, and we estimated differences in birthweight and placental weight between pregnancies with type 1 diabetes, type 2 diabetes, and gestational diabetes, using pregnancies without diabetes as the references. Differences in weight at birth were studied with and without adjustment for maternal BMI and pregnancy duration. Additionally, we studied the risk for giving birth to a large- or a small-for-gestational-age offspring according to maternal diabetes type.

2 MATERIAL AND METHODS

2.1 Study population

We used data from the Medical Birth Registry of Norway. All births in Norway after 16 weeks of pregnancy are compulsorily reported to this registry by the midwife or doctor who attended the delivery.¹⁷ Placental weight has been reported since 1999, maternal height and pre-pregnancy weight since 2009. We aimed to include all singleton pregnancies with delivery after the 21st week of pregnancy during the years 2009–2017, a total of 525 478 pregnancies (Figure 1). Of these, we excluded 200 774 pregnancies without information on maternal height and/or weight (Figure 1). We also excluded two pregnancies with reported delivery after 45 weeks of pregnancy, as we considered such delay in delivery improbable. Additionally, 35 pregnancies were excluded due to missing ($n = 21$) or outlying ($n = 14$) values on birthweight (birthweight <250 grams (g) or >6500 g), and 5591 pregnancies were excluded because of missing ($n = 1077$) or outlying ($n = 4514$) values on placental weight (placental weight <25 or >2500 g), leaving a total of 319 076 pregnancies for our data analyses.

Birthweight and placental weight were measured in grams, and grams were used as a continuous variable in the data analyses. According to obstetric guidelines in Norway, the newborn infant and the placenta are weighed routinely shortly after birth. The placenta is placed in a bowl and weighed fresh with membranes and umbilical cord attached. The weight of the bowl is subtracted from the total weight.

Maternal diabetes is reported to the Medical Birth Registry as type 1 diabetes, type 2 diabetes, or gestational diabetes. Type 1 and type 2 diabetes are, in almost all cases, present before the pregnancy. Women with gestational diabetes were identified by testing for presence of glucose in the urine (with dipstick) at every antenatal clinical examination. Such testing is as part of the public antenatal health-care program in Norway.¹⁸ During our study period, an oral glucose tolerance test was offered to all patients with glucosuria, and/or previous gestational diabetes, and/or hereditary risk of diabetes, and/or immigrants from the Indian subcontinent, and/or maternal age >35 years, and/or pre-pregnancy BMI >27 kg/m². Gestational diabetes was diagnosed if the fasting blood glucose concentration was <7.0 mmol/L, and if the blood glucose concentration was between 7.8 and <11.1 mmol/L 2 hours after intake of 75 g oral glucose in fasting (12 h) women without pre-gestational diabetes.¹⁹ These criteria are in line with the 2006 WHO criteria for impaired glucose tolerance.²⁰

Antenatal care is offered free of charge in Norway. Almost 100% of pregnant women follow the public antenatal care program, which includes at least eight examinations by a doctor (usually a general practitioner) and/or a midwife. The frequency of the examinations increases towards the estimated date of delivery.¹⁸ Women with any type of diabetes in pregnancy are referred to clinical follow up at the hospital where the delivery is scheduled to take place. Women with diabetes type 1 and women with diabetes type 2 are most often treated with insulin in pregnancy. In the last part of our study period, some women with diabetes type 2 or gestational diabetes were treated with metformin. Women with gestational

diabetes are offered dietary advice. If dietary changes do not lower the blood glucose concentrations sufficiently, insulin or metformin treatment is initiated.

Information about maternal height and pre-pregnancy weight was obtained by interview at the first antenatal clinical examination, typically at pregnancy week 8–10. BMI was calculated as weight (kg)/height (m)² and used as a continuous variable in the data analyses.

Duration of pregnancy at delivery (in weeks) was estimated on the basis of fetal size at routine ultrasound examination 17–19 weeks after the last menstrual period. If such an examination was not performed, duration of pregnancy was based on the date of the last menstrual period (for 2.2% of the women).

2.2 Statistical analyses

2.2.1 Increase in birthweight and placental weight—We calculated crude mean offspring birthweight and mean placental weight according to maternal diabetes status (type 1 diabetes, type 2 diabetes, gestational diabetes or no diabetes). Differences in crude mean weight between groups were tested with a one-way analysis of variance with Bonferroni correction. Furthermore, we used linear regression analyses to estimate the mean difference in birthweight and in placental weight (in grams) for pregnancies with type 1 diabetes, pregnancies with type 2 diabetes, and pregnancies with gestational diabetes, compared with pregnancies without diabetes. The difference was estimated as crude and adjusted regression coefficients (B) with 95% CI. The adjusted model included duration of pregnancy at delivery and pre-pregnancy maternal BMI. In supplementary analyses, we also made adjustment for maternal age and parity. To explore the consistency of our finding, we studied separately the women with normal pre-pregnancy BMI (BMI 18.5 to <25 kg/m²). Additionally, we included in the analyses the women with missing BMI (Figure 1), and in these analyses, we made adjustment for duration of pregnancy at delivery.

2.3 Risk of delivering a large- or a small-for-gestational-age offspring or placenta

In separate analyses, we estimated the associations of diabetes type with delivery of a large-for-gestational-age (LGA) or a small-for-gestational-age (SGA) infant. We defined LGA as birthweight above the 90th centile, and SGA as birthweight less than the 10th centile. The definitions of LGA and SGA were based on the distribution of birthweight z-scores in the study sample as a whole.²¹ z-scores were calculated separately for male and female offspring. We estimated the associations of diabetes type with giving birth to an SGA (yes/no) or LGA (yes/no) infant as odds ratios (OR) with 95% CI by applying logistic regression analyses. Non-diabetic pregnancies constituted the reference group. We present crude ORs and ORs after adjustment for maternal BMI. In supplementary analyses, we also made adjustments for maternal age and parity.

Finally, we calculated z-scores of placental weight by using the same principles as for birthweight. Hence, LGA placentas had weights in the >90th centiles, and SGA placentas had weights in the <10th centiles of placental weights. We repeated the above analyses while using LGA and SGA placental weight as the outcomes.

All statistical analyses were performed by using the statistical package IBM SPSS Statistics for Windows, Version 21.0.

2.4 Ethical approval

The Norwegian Data Inspectorate has approved the use of the Medical Birth Registry of Norway for research. The data in our study are anonymous. Hence, no ethical approval was required for this specific study. We ordered the data at <https://helsedata.no/>, and the data were received on January 4, 2021. The Medical Birth Registry of Norway is not responsible for the data analyses or the interpretation of the results.

3 RESULTS

Of the 319 076 women in our study sample, 13 904 (4,4%) women had diabetes in pregnancy. Among the women with diabetes, 9.8% (n = 1360) had type 1 diabetes, 5.1% (n = 704) had type 2 diabetes and 85.1% (n = 11 840) had gestational diabetes (Table 1). In the study sample as a whole, mean birthweight was 3529 g (SD 555 g), and mean placental weight was 666 g (SD 148 g) (Table 1).

In pregnancies without diabetes, mean crude birthweight was 3527 g (SD 552 g). Mean birthweight was highest in pregnancies with type 1 diabetes (3672 g; SD 725 g), followed by pregnancies with gestational diabetes (3575 g; SD 590 g) and pregnancies with type 2 diabetes (3523 g; SD 687 g) (Table 1).

Mean crude placental weight in pregnancies without diabetes was 664 g (SD 147 g). As for birthweight, mean placental weight was highest in pregnancies with type 1 diabetes (730 g; SD 186 g) (Table 1). Pregnancies with type 2 diabetes and pregnancies with gestational diabetes had similar mean placental weights: 703 g (SD 200 g) and 698 g (SD 161 g), respectively.

The duration of pregnancy was 2 weeks shorter in pregnancies with type 1 diabetes compared with pregnancies without diabetes (Table 1). Mean maternal BMI was highest in pregnancies with type 2 diabetes followed by pregnancies with gestational diabetes (Table 1).

After adjustments for differences between women in duration of pregnancy and maternal BMI (Table 2 Model 3), we estimated mean birthweight to be 525 g (95% CI 502–548 g) higher in pregnancies with type 1 diabetes compared with pregnancies without diabetes (Table 2 model 3). Birthweight was 192 g (95% CI 160–223 g) higher in pregnancies with type 2 diabetes, and 102 g (95% CI 93–110 g) higher in pregnancies with treated gestational diabetes compared with pregnancies without diabetes. Table 2 presents three different models for estimation of the change in birthweight in pregnancies with different diabetes subtypes compared with pregnancies without diabetes. In model 1, crude estimates are presented. In model 2, adjustment is made for duration of pregnancy, and in model 3 adjustments are made for duration of pregnancy and maternal BMI. In all models, the increase in birthweight and in placental weight was highest in pregnancies with type 1

diabetes. The highest birthweight increase associated with type 1 diabetes was estimated after adjustment for duration of pregnancy only (model 2).

The associations of diabetes types with placental weight showed similar patterns as for birthweight. Hence, after adjustment for duration of pregnancy and maternal BMI, mean placental weight was 109 g (95% CI 101–116 g) higher in pregnancies with type 1 diabetes compared with pregnancies without diabetes. The placental weight was 50 g (95% CI 39–60 g) higher in pregnancies with type 2 diabetes, and 31 g (95% CI 28–34 g) higher in pregnancies with gestational diabetes (Table 2).

In separate analyses of women with BMI >18.5 to <25 kg/m², we estimated similar differences in birthweight and in placental weight associated with diabetes type as in the study sample as a whole (Supporting Information Table S1). We also found similar results when we included in the data analysis the pregnancies without information about maternal BMI; and in this analysis, we made adjustments for pregnancy duration (Table S2).

Women with type 1 diabetes had the highest risk of giving birth to an LGA infant (adjusted OR 6.9; 95% CI 6.2–7.8). Adjustment was made for maternal BMI, and women without diabetes were used as the reference group. For women with type 2 diabetes, the adjusted OR of giving birth to an LGA infant was 2.1 (95% CI 1.8–2.5), and for women with gestational diabetes the adjusted OR was 1.6 (95% CI 1.5–1.6) (Tables 3 and 4). All types of diabetes reduced the risk of giving birth to an SGA infant. However, only for pregnancies with type 1 diabetes was the risk significantly lower than for women without diabetes (adjusted OR 0.4; 95% CI 0.3–0.5) (Tables 3 and 4).

The adjusted ORs for delivering an LGA or SGA placenta according to diabetes type showed similar patterns as for birthweight (Tables 3 and 4). Hence, women with type 1 diabetes had the highest odds ratio of delivering an LGA placenta, and the lowest odds ratio of delivering an SGA placenta.

Additional adjustment for maternal age and parity did not notably alter any of the above associations (Table S3).

4 DISCUSSION

In this population-based study of 319 076 singleton pregnancies, we found that birthweight and placental weight were highest in pregnancies with type 1 diabetes, followed by pregnancies with type 2 diabetes and pregnancies with gestational diabetes.

It is well known that any type of diabetes in pregnancy increases the risk of delivering an LGA infant,^{2, 22, 23} and an LGA placenta.⁸ To our knowledge, no previous study has compared birthweight and placental weight between women with type 1 diabetes, type 2 diabetes, and gestational diabetes and at the same time made adjustment for pregnancy duration and maternal BMI.

Previously, a study from France found that LGA infants (birthweight above the 90th centile) were most common in pregnancies with type 1 diabetes (OR 7.7; 95% CI 6.8–8.6) followed

by type 2 diabetes (OR 3.8; 95% CI 3.4–4.2) and gestational diabetes (OR 1.8; 95% CI 1.7–1.8).³ Pregnancies without diabetes were used as the reference. Also, an Australian study found that the risk of delivering an LGA infant was highest in pregnancies with pre-gestational diabetes (type 1 and type 2 diabetes combined) (OR 4.91; 95% CI 4.28–5.63), followed by pregnancies with gestational diabetes (OR 1.65; 95% CI 1.57–1.72), using pregnancies without diabetes as the reference.²⁴ The results from these studies support our results. However, adjustment for maternal BMI was not performed in these studies, and differences in absolute birthweight and placental weight according to diabetes type were not estimated.

Other studies did not include three different types of diabetes within the same study, but their results support that women with diabetes type 1 have the highest risk of delivering an LGA infant.^{23, 25} One study suggested that women with type 1 diabetes have a 12-fold increase in risk of delivering an LGA infant (OR 12.2; 95% CI 11.4–13.1) compared with women without diabetes.²³ Another study reported higher risk in women with diabetes type 1 than in women with diabetes type 2.²⁵ Women with gestational diabetes are reported to have a two-fold increase in risk of delivering an LGA infant (OR 2.19; 95% CI 1.93–2.47) compared with women without diabetes.²⁶

All types of diabetes in pregnancy are characterized by increased maternal serum glucose concentrations. Increased maternal glucose concentrations leads to increased glucose concentrations in the fetal-placental circulation. This in turn stimulates fetal synthesis of insulin. Insulin facilitates glucose uptake into cells. It is assumed that increased glucose and insulin concentrations in the fetal-placental circulation partly explain the increased fetal growth and possibly also the increased placental growth in diabetic pregnancies.²⁷

The relation of maternal blood glucose concentrations with giving birth to an LGA infant (>90 centile) may be dose-dependent.²⁸ Thus, our findings may suggest that the maternal glucose concentrations in pregnancies with type 1 diabetes are higher than in pregnancies with other types of diabetes. In pregnancies with type 1 diabetes, in particular, fluctuation of maternal glucose concentrations or high glucose concentrations in early pregnancy may enhance fetal growth.^{24, 25, 27, 29}

Insulin is a growth hormone, and pregnant women with type 1 diabetes are likely to receive higher doses and/or longer duration of insulin treatment than women with other types of diabetes in pregnancy. According to present knowledge, insulin in the mother is not transferred to the fetal-placental unit. However, our findings are compatible with enhanced fetal and placental growth as a consequence of maternal insulin treatment. Possible biological mechanisms of insulin in the maternal circulation on the placenta are being explored.³⁰ Additionally, insulin treatment may increase the risk of maternal hypoglycemia, and hypoglycemia may trigger weight gain.³¹ Maternal weight gain in pregnancy is associated with increased offspring birthweight.

Other factors may enhance offspring growth and be more prevalent in pregnancies with type 1 diabetes. Vascular dysfunctions are more prevalent in type 1 diabetes than in other types of diabetes, and maternal vascular dysfunctions may cause suboptimal oxygen supply

to the fetal-placental unit.³² Increased angiogenesis is a known response to hypoxia,³³ and angiogenic responses are more prominent among individuals with type 1 diabetes than among individuals with other types of diabetes.³⁴ It is conceivable that increased placental angiogenesis and vasculogenesis lead to a larger placenta and possibly also a larger fetus.

It has been suggested that the risk of delivering an LGA infant may be increased also within the upper ranges of normal blood glucose concentrations.²⁸ The World Health Organization recommended therefore in 2013 the following diagnostic criteria for gestational diabetes; fasting maternal blood glucose concentrations between 5.1 and 6.9 mmol/L or maternal blood glucose concentration between 8.5 and 11.0 mmol/L 2 hours after oral intake of 75 g glucose.³⁵ These WHO criteria, as well as the screening strategy for gestational diabetes, are being debated.³⁶ Still, we lack knowledge about the effects of interventions in women diagnosed with gestational diabetes according to the 2013 WHO definition.³⁷ The 2013 WHO criteria for gestational diabetes,³⁵ and the International Association of Diabetes in pregnancy Study Group (IADPSG) criteria,³⁶ include lower blood glucose concentrations than the diagnostic criteria used in our study. Hence, women with gestational diabetes in our study may, on average, have higher concentrations of blood glucose than women diagnosed according to the 2013 WHO criteria. We may therefore, have estimated a higher birthweight increase in our study than if the 2013 WHO criteria had been used to define gestational diabetes. Nevertheless, we found that the mean adjusted infant birthweight in pregnancies with treated gestational diabetes was 102 g higher than in pregnancies without diabetes. The consequences of the increase in infant birthweight associated with gestational diabetes should be further studied, and if possible separated from the effect of maternal BMI. Previously, it has been reported that infants with birthweight between the 80th and 84th centiles have the lowest perinatal mortality.³⁸ Also, adult cardiovascular and metabolic health risks are lowest for persons with birthweight around the 90th centile.³⁹ The magnitude of the health problem associated with gestational diabetes may vary across different parts of the world. Hence, the magnitude of the health problem and the effects of intervention should determine whether new guidelines for identification and treatment of women with gestational diabetes should replace existing guidelines.

Our large study sample allowed us to compare offspring weight and placental weight between pregnancies with different types of diabetes. Although a large proportion of the eligible pregnancies lacked information about maternal BMI (44.3%), and were excluded, we do not believe that skewed selection to the study sample has caused biased estimates. The included and the excluded pregnancies were similar in the prevalence of diabetes types, mean birthweight, placental weight, duration of pregnancy, maternal age, and parity (data not shown). Also, our results were not altered when pregnancies with missing maternal BMI information were included in the analyses.

The diagnosis of diabetes in the Medical Birth Registry of Norway has been validated.⁴⁰ The specificity for diabetes (all types) was high (99%), and the specificity for type 1 diabetes was close to 100%. However, misclassification of type 2 diabetes and gestational diabetes may have occurred. Any misclassification of diabetes type may have caused underestimation rather than overestimation of the differences in offspring weight according to diabetes type.

We made adjustment for duration of pregnancy, maternal BMI, maternal age, and parity. Maternal socio-economic factors, ethnicity and weight gain in pregnancy have been associated with diabetes and offspring birthweight.^{41, 42} Unfortunately, we had no information about these factors.

Women with diabetes are delivered by cesarean section more often than women without diabetes. Mode of delivery could possibly influence placental weight, since the placenta is delivered quickly by cesarean section, whereas during a vaginal birth, the delivery of the placenta may be delayed. A delayed placental delivery may influence placental blood volume and thereby weight. However, in both vaginal and cesarean deliveries we found the highest adjusted mean birthweight and placental weight in pregnancies with type 1 diabetes, followed by type 2 diabetes and gestational diabetes (data not shown).

Our data hold no information about individual blood glucose concentrations or treatment during pregnancy. Women with diabetes in pregnancy were diagnosed and treated according to the Norwegian guidelines on diabetes in pregnancy (see Material and methods).⁴³ Possible effects of the Norwegian guidelines on offspring birthweight cannot be estimated in our study.

5 CONCLUSION

In this population-based study of 319 076 singleton pregnancies, we found that offspring birthweight and placental weight were highest in pregnancies with type 1 diabetes, followed by pregnancies with type 2 diabetes and pregnancies with gestational diabetes.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Key message

Offspring birthweight and placental weight were highest in pregnancies with type 1 diabetes, followed by pregnancies with type 2 diabetes, and pregnancies with gestational diabetes.

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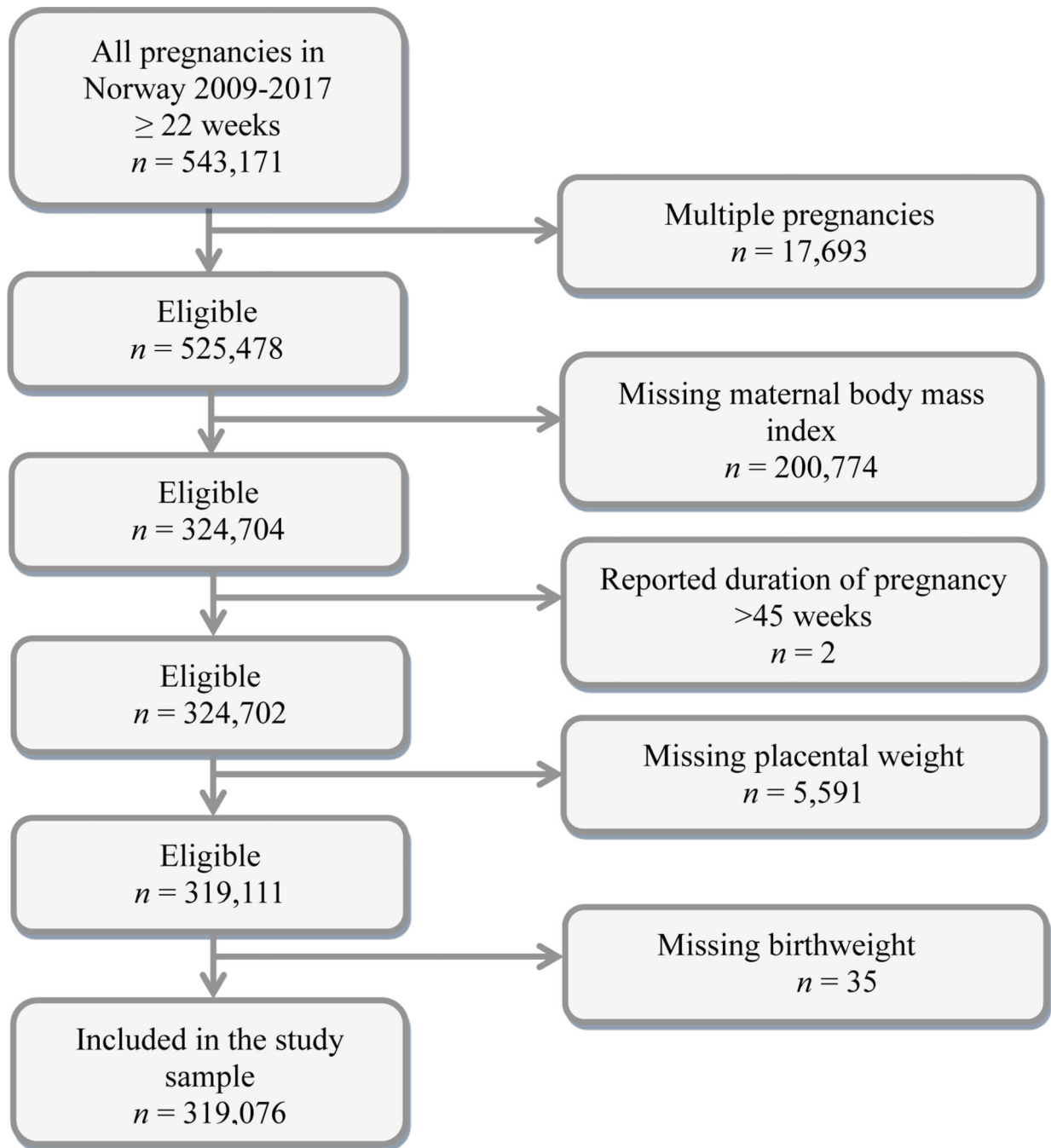


Figure 1.
Flow chart of study sample

Table 1.

Number of pregnancies and means of study factors according to maternal diabetes status. Singleton pregnancies in Norway during the years 2009–2017.

Diabetes status	<i>n</i> (%)	Pre-pregnancy BMI (kg/m ²) (SD)	Duration of pregnancy (wk) (SD)	Birthweight ^a (g) (SD)	Placental weight ^a (g) (SD)
No diabetes	304,758 (95.5)	24.1 (4.6)	39.4 (1.8)	3527 (552)	664 (147)
Type 1 diabetes	1360 (0.4)	25.8 (4.9)	37.3 (2.2)	3672 (725)	730 (186)
Type 2 diabetes	704 (0.2)	30.5 (6.4)	37.9 (2.2)	3523 (687)	703 (200)
Gestational diabetes	11 840 (3.7)	28.2 (6.1)	38.9 (1.8)	3575 (590)	698 (161)
Total	319 076 (100.0)	24.3 (4.8)	39.4 (1.8)	3529 (555)	666 (148)

Abbreviations: BMI, maternal body mass index (kg/m²); SD, standard deviation.

^aThe differences in means between groups of BMI, duration of pregnancy, birthweight, and placental weight are statistically significant ($p < 0.05$, Student's *t* test).

Table 2.

Crude and adjusted increase in birthweight and in placental weight in grams with 95% CI in pregnancies with type 1 diabetes, type 2 diabetes, or gestational diabetes using pregnancies without diabetes as the reference. ^a

	n	Crude B Model 1 ^b	95% CI	Adjusted B Model 2 ^b	95% CI	Adjusted B Model 3 ^b	95% CI
Increase in birthweight (grams)							
Diabetes status							
No diabetes (reference)	304,758	0		0		0	
Type 1 diabetes	1360	146 ^{***}	116–175	549 ^{***}	526–572	525 ^{***}	502–548
Type 2 diabetes	704	–5	–46–36	282 ^{***}	249–314	192 ^{***}	160–223
Gestational diabetes	11,840	49 ^{***}	39–59	159 ^{***}	151–167	102 ^{***}	93–110
Duration of pregnancy (weeks)	319,076	188 ^{***}	187–189	191 ^{***}	190–192	190 ^{***}	190–191
Maternal BMI (kg/m ²)	319,076	15 ^{***}	14–15			14 ^{***}	13–14
Increase in placental weight (grams)							
Diabetes status							
No diabetes (reference)	304,758	0		0		0	
Type 1 diabetes	1360	66 ^{***}	58–74	116 ^{***}	108–123	109 ^{***}	101–116
Type 2 diabetes	704	39 ^{***}	28–50	74 ^{***}	64–85	50 ^{***}	39–60
Gestational diabetes	11,840	33 ^{***}	31–36	48 ^{***}	44–50	31 ^{***}	28–34
Duration of pregnancy (weeks)	319,076	23 ^{***}	22–23	23 ^{***}	23–24	23 ^{***}	23–24
Maternal BMI (kg/m ²)	319,076	4 ^{***}	4–4			4 ^{***}	4–4

^a Adjustments are made for pregnancy duration at delivery (in weeks) and pre-pregnancy maternal body mass index (BMI) (in units). The increase in grams was estimated as unstandardized B-coefficients by applying linear regression analyses.

^b Model 1 Crude estimates. Model 2 The variables included in the analyses were maternal diabetes status and duration of pregnancy at delivery. Model 3 The variables included in the analyses were maternal diabetes status, duration of pregnancy at delivery, and maternal BMI.

Abbreviations: BMI, body mass index (kg/m²); SD, standard deviations.

* $p < 0.05$.

** $p < 0.005$.

*** $p < 0.001$.

Table 3.

Crude and adjusted odds ratios (OR) for giving birth to a large-for-gestational-age (LGA) offspring and a small-for-gestational-age (SGA) offspring according to maternal diabetes status ^a

Diabetes status	Number with LGA	Odds ratio LGA				Number with SGA	Odds ratio SGA				
		Crude OR	95% CI	OR ^b	95% CI		Crude OR	95% CI	OR ^b	95% CI	
Without diabetes	28 955					30 732	Ref				
Diabetes type 1	601	7.5	6.8–8.4	6.9	6.2–7.8	55	0.4	0.3–0.5	0.4	0.3–0.5	
Diabetes type 2	175	3.2	2.7–3.7	2.1	1.8–2.5	55	0.8	0.6–1.0	0.9	0.7–1.2	
Gestational diabetes	2085	2.0	1.9–2.1	1.6	1.5–1.6	1008	0.8	0.8–0.9	0.9	0.9–1.0	

^a Pregnancies without diabetes were used as reference group. Included were 319 076 singleton pregnancies in Norway during the period 2009–2017.

^b Adjustment was made for pre-pregnancy maternal body mass index.

Table 4.

Crude and adjusted odds ratios (OR) for giving birth to a large-for-gestational-age (LGA) placenta and a small-for-gestational-age (SGA) placenta according to maternal diabetes status ^a

Diabetes status	Number with LGA	Odds ratio LGA				Number with SGA	Odds ratio SGA				
		Crude OR	95% CI	OR ^b	95% CI		Crude OR	95% CI	OR ^b	95% CI	
Without diabetes	29 164					31 008	Ref				
Diabetes type 1	440	4.5	4.0–5.1	4.2	3.7–4.7	65	0.4	0.4–0.6	0.5	0.4–0.6	
Diabetes type 2	166	2.9	2.5–3.4	2.1	1.8–2.5	51	0.7	0.5–0.9	0.8	0.6–1.1	
Gestational diabetes	2013	1.9	1.8–2.0	1.6	1.5–1.6	829	0.7	0.6–0.7	0.8	0.7–0.8	

^a Pregnancies without diabetes were used as the reference group. Included were 319 076 singleton pregnancies in Norway during the period 2009–2017.

^b Adjustment was made for pre-pregnancy maternal body mass index.