

Original Article

Pregnancy Complications in Women With Pregestational and Gestational Diabetes Mellitus

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Summary

Background: Diabetes mellitus (DM) is a major risk factor for complications of pregnancy. Based on information for all inpatient births in Germany, we assessed the risks for selected pregnancy complications in women with pregestational diabetes mellitus (preDM) or gestational diabetes mellitus (GDM).

Method: The underlying data comprised all singleton births contained in the inpatient perinatal medicine quality assurance statistics for the years 2013–2019. The frequencies of premature birth, elevated birth weight (large for gestational age, LGA), cesarean section, transfer of the newborn to the perinatal unit, and stillbirth were stratified by maternal age and diabetes status (preDM, GDM, no DM). Poisson regression was used to calculate the relative risks (RR) with 95% confidence intervals (95% CI) for the whole period and for each individual year in women with preDM or GDM relative to women without DM.

Results: Among the 4 991 275 singleton births included, GDM was documented in 283 210 (5.7%) and preDM in 46 605 (0.93%) cases. GDM was associated with higher RR for premature birth (1.13 [1.12; 1.15]), LGA (1.57 [1.55; 1.58]), cesarean section (1.26 [1.25; 1.27]), and transfer of the newborn (1.54 [1.52; 1.55]). These associations were even stronger in women with preDM: premature birth (2.13 [2.08; 2.18]), LGA (2.72 [2.67; 2.77]), cesarean section (1.62 [1.60; 1.64]), transfer of the newborn (2.61 [2.56; 2.66]). PreDM increased the risk of stillbirth (RR: 2.34 [2.11; 2.59]); GDM was associated with a lower risk (RR: 0.67 [0.62; 0.72]). For women with preDM, the risk of pregnancy complications increased over the study period.

Conclusion: GDM and preDM are still associated with elevated risks of pregnancy complications. In the case of preDM, the risks may be attributable to the fact that the hyperglycemia is more severe and is already present before conception. Continuous monitoring should include risk factors in pregnant women and care-relevant aspects.

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Diabetes mellitus (DM) is a major risk factor for complications of pregnancy and childbirth. Two types of diabetes are distinguished: gestational diabetes mellitus (GDM), which first occurs during pregnancy, and type 1 or type 2 diabetes pregestational DM (preDM), which already existed before pregnancy (1). In Germany, the prevalence of GDM has increased in recent years, with an estimated 5–15% of all pregnant women now affected (2–5). In contrast, preDM is less common and its prevalence has consistently been around 1% over the last few years (3, 6).

DM during pregnancy is associated with risks for mother and child. For instance, newborns of mothers with preDM are more likely to have an increased birth weight (large for gestational age, LGA) and more congenital malformations compared to newborns of mothers without diabetes. In addition, the risks of premature birth, cesarean section and birth injuries are also significantly increased (7–9).

International studies and a regional analysis in Germany have shown that GDM is also associated with an elevated risk for birth complications, albeit to a

lesser extent (8–10). The risk of complications can be significantly reduced by appropriate GDM management (11). Furthermore, preDM also increases the risk of perinatal mortality and the frequency of stillbirth, whereas such increases have not been conclusively demonstrated for GDM (8, 9, 12, 13).

Both the St. Vincent Declaration and the Maternity Directives of the German Federal Joint Committee (G-BA, Gemeinsamer Bundesausschuss) aim to prevent pregnancy complications associated with diabetes (14, 15). Within the framework of the National Diabetes Surveillance at the Robert Koch Institute, an indicator for diabetes-associated pregnancy complications (premature birth, cesarean section, LGA, stillbirth, and perinatal mortality) was established in addition to GDM prevalence and screening rate (16). This study is the first to analyze diabetes-associated pregnancy complications in Germany based on nationwide inpatient perinatal medicine quality assurance data. The findings are meant to form the basis for regular reporting within the Diabetes Surveillance framework.

Methods

Data basis

This analysis is based on data from quality assurance procedures pursuant to Section 136 of the German Social Code (SGB, Sozialgesetzbuch) V of the Federal Joint Committee (G-BA). The German Institute for Quality Assurance and Transparency in Health Care (IQTIG, Institut für Qualitätssicherung und Transparenz im Gesundheitswesen) uses the Perinatal Medicine quality assurance system to record all inpatient births in Germany (6). From the maternity hospital, information about the pregnancy obtained from the maternity records (“Mutterpass”, literally “mother’s passport”) as well as the childbirth and inpatient stay is communicated (*eFigure 1*). The dataset contains information about the mothers (dataset: 16/1 : M) and the newborns (dataset: 16/1 : N). After application for secondary data use, the results are provided in aggregated form. This study is based on all births from 2013–2019, after GDM screening was introduced in 2012. As in previous analyses (8, 10), the primary analysis only included singleton births, since the inclusion of multiple births which are frequently associated with premature birth, cesarean section and transfer of the newborn to a children’s hospital, could distort the results (*eFigure 2*).

Definition of diabetes mellitus

As in the preceding study (5), preDM was assumed if at the first screening the diagnosis diabetes was documented in the maternity record (catalog A: “History and general findings/first screening”); no distinction is made between type 1 and type 2 diabetes. GDM was assumed if it was coded in catalog B under ‘Special findings during pregnancy’ or as a discharge diagnosis according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revi-

sion, German Modification (ICD-10-GM: O24.4). If both preDM and GDM were documented, women were assigned to preDM on the assumption that diabetes was already known at the first screening and not first diagnosed during pregnancy.

Definition of pregnancy complications

Premature birth was defined as a birth of a child before 37 weeks of pregnancy are completed; the gestational age was determined according to the IQTIG calculation rules (17). LGA was defined as a weight exceeding the 90th reference percentile based on the 2007–2011 perinatal survey according to Voigt et al. in relation to gestational age and sex (18). A cesarean section was assumed if any of the codes of the German Operation and Procedure Classification System (OPS, Operationen- und Prozedurenschlüssel) 5–74 was documented as the mode of delivery. Whether the newborn was transferred to a children’s hospital is documented by the maternity hospital. A stillbirth was defined as a premature fetal loss after 24 weeks of gestation or a baby born dead with a birth weight ≤500 g. Perinatal mortality additionally included all newborns who died within 7 days after birth. Given the large amount of missing data on perinatal mortality (*eTable 1*), analyses were limited to stillbirths.

Statistical analyses

Data on pregnancy complications were provided by IQTIG and were stratified by diabetes status (preDM, GDM, no diabetes), reporting year, and maternal age at birth which was aggregated in 5-year age groups. The ratio of the number of births with a certain complication to the number of all births in the respective age and diabetes groups yielded the incidence of this complication. Multiple pregnancies were excluded from the primary analysis. The relative risks (RR) and 95% confidence intervals (95% CI) for the incidence of a pregnancy complication in women with preDM or GDM compared to no diabetes were estimated using Poisson regression models overall and stratified by age group and reporting year. In a sensitivity analysis, the effect of including multiple pregnancies as well as the effect of excluding mothers with a double diagnosis of GDM and preDM were evaluated. For the analyses, the statistical software package R (version 4.0.5) was used.

Results

Study population

After exclusion of all multiple pregnancies (N = 97 434), almost 5 million singleton births recorded during the years from 2013 to 2019 were included (*eFigure 2*). Altogether, 5.7% of mothers had been diagnosed with GDM and 0.93% with preDM. Cesarean section, transfer of the newborn to a children’s hospital and premature birth were documented for 30.4%, 9.6% and 6.7% of all inpatient births, respectively. LGA was documented for 9.7% of the births and fell thus within the expected range of about 10%. The proportion of stillbirths was 0.33%.

TABLE 1

Description of the included study population – Inpatient singleton births in Germany during the years 2013–2019 (n = 4 991 275)

	Pregestational diabetes mellitus		Gestational diabetes mellitus		No diabetes mellitus	
	n	%	n	%	n	%
Number of inpatient births	46 605	100,0	283 210	100.0	4 661 460	100.0
Maternal age						
< 25 years	3586	7.7	20 902	7.4	619 695	13.3
25–29 years	11 046	23.7	65 238	23.0	1 311 916	28.1
30–34 years	16 817	36.1	102 598	36.2	1 654 964	35.5
35–39 years	11 785	25.3	73 376	25.9	890 226	19.1
≥ 40 years	3371	7.2	21 096	7.4	184 659	4.0
Complications						
Premature birth	6516	14.0	21 072	7.4	305 814	6.6
Large for gestational age* *1,*2	11 668	25.0	40 897	14.4	429 530	9.2
Cesarean section	22 544	48.4	106 444	37.6	1 390 595	29.8
Transfer of the newborn*1	11 194	24.0	40 033	14.1	428 401	9,2
Stillbirth*1	366	0.79	635	0.22	15 638	0.34

*1 The denominator is the number of children and is equal to the number of births, since multiples were excluded.

*2 Data are missing (n = 4814) due to incomplete information.

Women with GDM or preDM were older compared to women without diabetes (Table 1). All complications of pregnancy were more common among women with preDM compared to women without diabetes. With the exception of stillbirth, this was also true for women with GDM. Stillbirth was less frequent in women with GDM compared to women without diabetes, as reflected in the unadjusted RR estimate (Table 2). For all studied complications of pregnancy, RR was higher for women with preDM compared to women with GDM. In each case, the highest RRs were found for LGA.

Pregnancy complications in relation to maternal age

Age-stratified evaluation of the relative frequencies of pregnancy complications showed that the previously observed differences between women with GDM or preDM compared to women without diabetes were present in almost all age groups, but differed in degree (Figure, eTable 2). In the younger age groups, all studied complications of pregnancy were significantly more common among women with preDM compared to women of the same age group without diabetes. This effect decreased with increasing age. Differences in the relative risks for LGA were particularly striking (<25 years: 4.28; 95% CI: [4.02; 4.55] versus ≥ 40 years: 2.15; 95%-KI: [2,00; 2,31]) and stillbirth (<25 years: 4.38; 95% CI: [3,38; 5,67] versus ≥ 40 years: 1.24; 95% CI: [0.82; 1.88]). The differences between women with GDM and women of the same age group without diabetes were less pronounced.

TABLE 2

Unadjusted relative risk for pregnancy complications in women with pregestational diabetes mellitus or gestational diabetes mellitus compared to women without diabetes

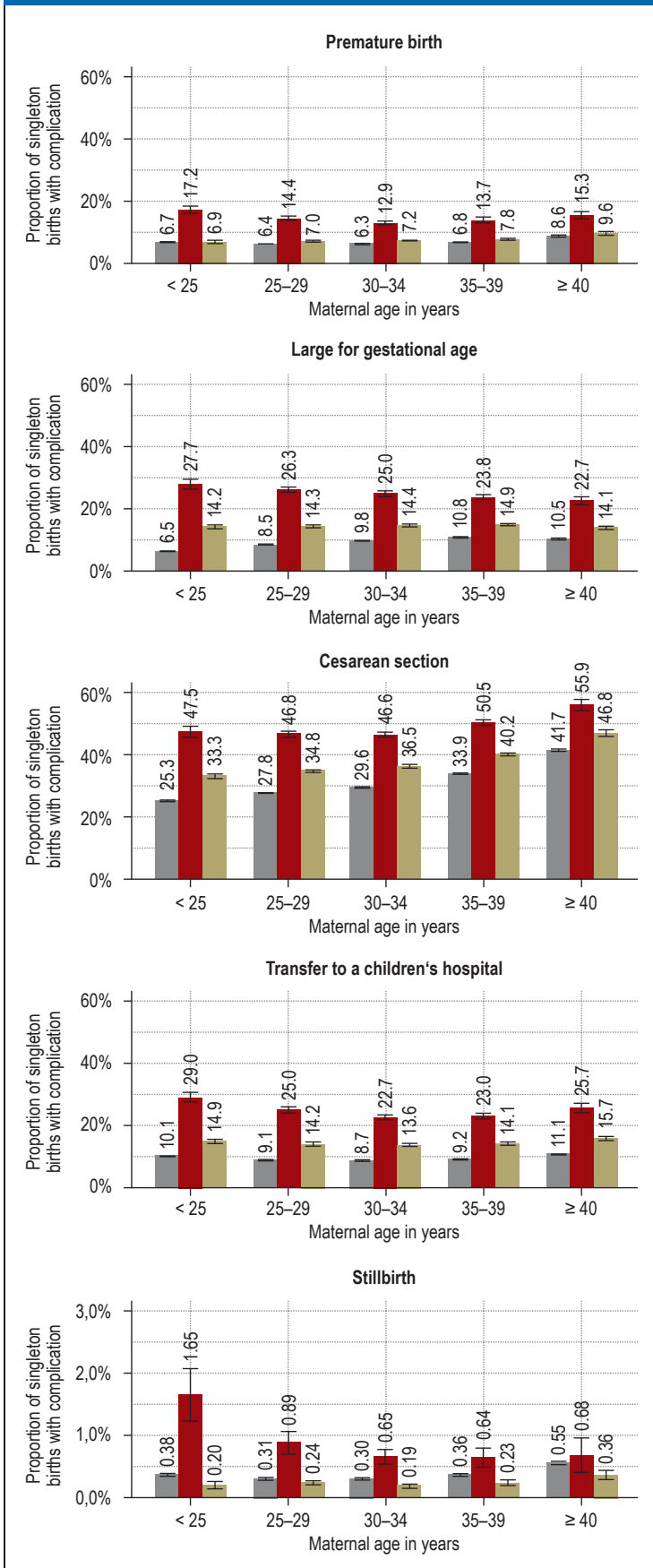
Complication	Pregestational diabetes mellitus		Gestational diabetes mellitus	
	RR	[95% CI]	RR	[95% CI]
Premature birth	2.13	[2.08; 2.18]	1.13	[1.12; 1.15]
Large for gestational age	2.72	[2.67; 2.77]	1.57	[1.55; 1.58]
Cesarean section	1.62	[1.60; 1.64]	1.26	[1.25; 1.27]
Transfer of the newborn	2.61	[2.56; 2.66]	1.54	[1.52; 1.55]
Stillbirth	2.34	[2.11; 2.59]	0.67	[0.62; 0.72]

The reference category is women without diabetes mellitus. CI, confidence interval; RR, relative risk

Trend in pregnancy complications over time

Over time, the percentage of complications overall remained largely stable (eTable 3). Stratification by type of diabetes yielded a differentiated picture. While the proportions of complications in women without diabetes and with GDM were relatively constant over the years, it was noted that the proportions of premature births, LGA and, in particular, stillbirths increased in women with preDM over time. This was also reflected in the resulting RR for stillbirth, which increased between 2013 and 2019 for women with preDM compared to women without diabetes (eTable 4).

FIGURE



Proportions (in percent with 95% confidence intervals) of inpatient singleton births with pregnancy complications of all inpatient singleton births in Germany in the years 2013–2019 stratified by maternal age and type of diabetes

No diabetes mellitus
 Pregestational diabetes mellitus
 Gestational diabetes mellitus

Sensitivity analyses

After excluding pregnant women with double diagnoses (GDM and preDM), the RRs for pregnancy complications overall increased in women with preDM compared to the primary analysis. The greatest difference was seen for LGA (sensitivity analysis: 3.00; 95% CI: [2.94; 3.06] versus primary analysis: 2.72; 95% CI: [2.67; 2.77]). Conversely, inclusion of multiple births resulted in slightly lower complication risks both in women with GDM and preDM compared to women without diabetes.

Discussion

Summary of the results

In this study, major complications of pregnancy in women with GDM or preDM were assessed based on all inpatient births in Germany for the first time. During the 2013–2019 observation period, the prevalence of GDM was 5.7% as compared to 0.93% for preDM. Both GDM and preDM were associated with increased risks for premature birth, cesarean section, transfer of the newborn to a children’s hospital, and LGA. Compared with mothers without diabetes, RRs for all complications were more elevated in mothers with preDM than with GDM. The RR of stillbirth was increased more than twofold in women with preDM, but reduced in women with GDM.

Comparison with the available literature

Compared with analyses of statutory health insurance billing data (3, 4, 19), the prevalence of GDM was lower in our study. This finding may be attributable to different study populations, possible overestimation in billing data, and/or underestimation in the maternity record documentation (5). For the prevalence of preDM, there were no differences between analyses based on different data sources and the value that could be expected among women in the age group irrespective of pregnancy (20). Over time, the prevalence of GDM increased which could be attributable to the fact that the screening rate has risen (5) and high-risk pregnancies have become more frequent, e.g. in obese women (6). No definite trend over time was seen for the prevalence of preDM. Against the backdrop of increasing incidence rates of type 2 diabetes (21) and type 1 diabetes (22) in the general population, it is advisable to further monitor the prevalence rates of GDM and preDM.

With regard to GDM-associated complications of pregnancy, studies have consistently shown that

women with GDM are at an increased risk of premature birth (odds ratio [OR] 1.1–1.8), LGA (OR: 1.4–3.3), and cesarean section (OR: 1.1–1.7) (4, 7, 9, 10, 23, 24). Regarding the transfer of the newborn to a children's hospital, an elevated risk is reported by most studies (OR: 1.0–1.6) (4, 8, 23). One study showed an inconsistent picture depending on the GDM definition used (24). In comparison to the literature, the RRs found in our study were in the lower range. This may be attributable to differences in study population composition, GDM definitions, or GDM care. Furthermore, the OR used in the cited studies overestimates the RR especially for common complications.

Consistent with previous studies, our analysis showed a lower risk of stillbirth in women with GDM compared to women without diabetes. However, it is a matter of debate whether the risk is actually lower, for example because of more intensive care during pregnancy, or whether the effect is attributable to immortal time bias, as women with a stillbirth before week 28 of pregnancy had not yet been offered GDM screening (12, 25). But it is important to note that hyperglycemia in GDM usually only occurs in the second half of pregnancy. For example, a meta-analysis showed an increased risk of stillbirth associated with GDM on inclusion of births from week 28 of pregnancy (12), although it needs to be taken into account that the meta-analysis is based on relatively heterogeneous studies.

In line with earlier studies, our analysis showed for all pregnancy complications assessed greater increases in risk among women with preDM than with GDM in comparison to women without diabetes (7–9, 13). In women with preDM, hyperglycemia is more pronounced and already present before conception and during early pregnancy (26). There are some significant variations in the risk increase estimates in published analyses: OR for premature birth: 2.0–5.8, OR for LGA: 3.4–7.7, OR for cesarean section: 3.2–4.3, OR for transfer of the newborn: 4.0–4.8, and OR for stillbirth: 1.8–9.0 (7–9, 13). This may be attributable to differences in the age composition among the study populations and in the proportions of type 1 and type 2 diabetes in the preDM category, as higher risks are reported for type 1 diabetes than for type 2 diabetes (7, 27). The fact that type 1 diabetes is more prevalent in the population among women under 30 years of age (28) may explain why the risk of pregnancy complications is greatest in the under-25 age group. These differences decreased with increasing maternal age as the proportion of type 2 diabetes in the population increases and maternal age is itself a major risk factor (29).

During the observation period, the risk of premature birth, LGA and especially stillbirth increased in women with preDM, while they remained constant in women with GDM. The increase in risk of stillbirth among women with preDM was also found in the

comparison with one of the earlier analyses from Bavaria which was based on the same dataset (9). Further analyses should continue the time series and take into account effects of maternal risk factors, aspects of care, and social contextual factors. We hope the results will help improve guideline-compliant care for all women with GDM and preDM (11, 26) to reduce the risk of complications and adverse effects on child health.

Strengths and limitations

Our analysis comprises about 98% of all births in Germany, since approximately 2% of births took place in out-of-hospital settings (30). The prevalence of GDM may be underestimated if diabetes status is incorrectly documented in the maternity records or not reported by maternity hospitals (5). Assuming that potential documentation errors were random, the risks of complications would also be underestimated. In contrast, incorrect classification of less severe GDM cases could lead to risk overestimation. When compared with data of the German Federal Statistical Office, discrepancies of 4%–10% were seen in the frequencies of cesarean section (31) and stillbirth (*eTable 1*). For perinatal mortality within 7 days postpartum, differences of 30% were found. With regard to preDM, it was not possible to distinguish between type 1 and type 2 diabetes, making it difficult to interpret differences between age groups and over time. Furthermore, the risk of stillbirth in women with GDM is likely to be underestimated since women may not have been screened for GDM at that time (12, 25). When interpreting the RR, it is important to note that, with the exception of age, our analysis did not take other maternal risk factors (e.g. obesity or smoking) into account.

Conclusion

The analysis of all inpatient births in the years 2013–2019 confirmed that diabetes mellitus continues to be a major risk factor for pregnancy complication in today's care context. Most notably, there was a more than twofold higher risk of stillbirth in women with preDM compared to women without diabetes. These associations strengthened between 2013 and 2019. While GDM was associated with a decrease in risk of stillbirth, the risks of premature birth, LGA, cesarean section, and transfer of the newborn were also significantly higher compared to women without diabetes and did not decrease over time. The goal to reduce the risks of pregnancy complications in women with diabetes set forth in the St. Vincent Declaration has not been achieved for preDM and GDM, so further efforts to improve the care of women with diabetes mellitus before and during pregnancy as well as during childbirth are required. The trend over time of pregnancy complications in association with GDM and preDM should be further monitored under inclusion of maternal risk factors as well as aspects of care.

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Conflict of interest statement

Dr. Kalthéuner is managing director of the non-profit winDiab GmbH.

Dr. Adamczewski is one of the spokespersons for the Diabetes and Pregnancy Working Group of the German Diabetes Association (DDG, Deutsche Diabetes Gesellschaft). She received consulting fees (advisory board) from Dexcom CGM and Glooko. Congress fees and travel expenses were reimbursed for her by Science-Consulting in Diabetes. She is co-founder of the GestDiab register (German nationwide register for diabetes in pregnancy) and collaborates on the GestDiNa_basic research project, which is funded by the Innovation Fund of the German Federal Joint Committee (G-BA).

The remaining authors declare that no conflict of interest exists.

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► Supplementary material

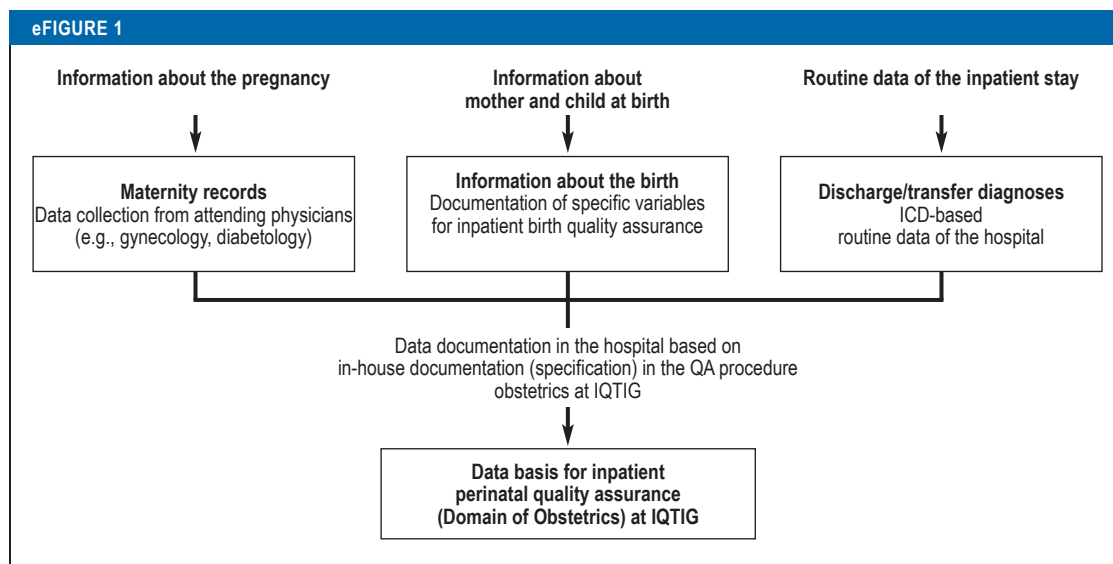
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Supplementary material to:

Pregnancy Complications in Women With Pregestational and Gestational Diabetes Mellitus

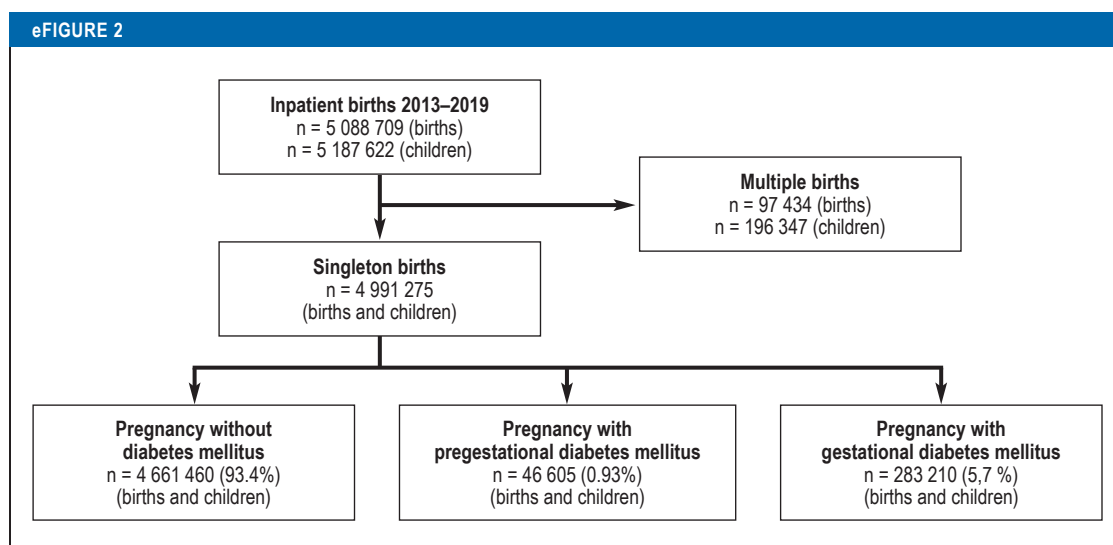
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Flowchart for inpatient perinatal medicine quality assurance data collection (Domain of Obstetrics)

ICD, International Statistical Classification of Diseases and Related Health Problems; IQTIG, German Institute for Quality Assurance and Transparency in Health Care (Institut für Qualitätssicherung und Transparenz im Gesundheitswesen); QA, quality assurance



Flowchart for exclusion of multiple births and documentation of gestational diabetes mellitus as well as pregestational diabetes mellitus

eTABLE 1

Comparison of live births, stillbirths, perinatal mortality, and cesarean section per year between IQTiG and Destatis.

	2013		2014		2015		2016		2017		2018		2019	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Live births*1														
– IQTiG	668 988		701 764		725 937		770 606		773 317		765 645		762 688	
– Destatis	682 069		714 927		737 575		792 141		784 901		787 523		778 090	
– Difference	-13 081	-1.9	-13 163	-1.8	-11 638	-1.6	-21 535	-2.7	-11 584	-1.5	-21 878	-2.8	-15 402	-2.0
Stillbirths*1														
– IQTiG	2366	0.35	2388	0.34	2559	0.35	2732	0.35	2871	0.37	2813	0.37	2948	0.39
– Destatis	2556	0.37	2597	0.36	2787	0.38	2914	0.37	3003	0.38	3030	0.38	3180	0.41
– Difference	-190	-7.4	-209	-8.0	-228	-8.2	-182	-6.2	-132	-4.4	-217	-7.2	-232	-7.3
Death up to 7 days after birth*1														
– IQTiG	840	0.13	927	0.13	973	0.13	1077	0.14	1019	0.13	977	0.13	1026	0.13
– Destatis	1173	0.17	1310	0.18	1352	0.18	-	-	1411	0.18	1410	0.18	1437	0.18
– Difference	-333	-28.4	-383	-29.2	-379	-28.0	-	-	-392	-27.8	-433	-30.7	-411	-28.6
Cesarean section														
– IQTiG*2	219 863	33.4	231 545	33.5	234 804	32.9	247 529	32.6	248 444	32.6	241 728	32.1	242 414	32.3
– Destatis*3	210 580	31.9	220 540	31.8	222 919	31.1	232 479	30.5	232 505	30.5	220 343	29.1	221 709	29.6
– Difference	9283	4.4	11 005	5.0	11 885	5.3	15 050	6.5	15 939	6.9	21 385	9.7	20 705	9.3

*1 Includes children of all births, including multiple births. *2 Denominator is all inpatient births according to the perinatal medicine quality assurance data (IQTiG). *3 Denominator is all inpatient births according to the hospital statistics (Destatis) (28): Destatis, German Federal Statistical Office (Statistisches Bundesamt); IQTiG, German Institute for Quality Assurance and Transparency in Health Care (Institut für Qualitätssicherung und Transparenz im Gesundheitswesen)

eTABLE 2

Relative risks for pregnancy complications among inpatient singleton births in women with preDM and GDM, respectively, compared to women without diabetes mellitus overall and in relation to maternal age

Maternal age	preDM		GDM		No DM
	RR	[95% CI]	RR	[95% CI]	
Premature birth	2.13	[2.08; 2.18]	1.13	[1.12; 1.15]	Ref.
< 25 years	2.54	[2.35; 2.75]	1.03	[0.98; 1.08]	
25–29 years	2.27	[2.16; 2.38]	1.10	[1.06; 1.13]	
30–34 years	2.05	[1.97; 2.14]	1.14	[1.11; 1.16]	
35–39 years	2.02	[1.92; 2.12]	1.15	[1.12; 1.18]	
≥ 40 years	1.79	[1.64; 1.95]	1.12	[1.07; 1.17]	
Large for gestational age^{*1, *2}	2.72	[2.67; 2.77]	1.57	[1.55; 1.58]	Ref.
< 25 years	4.28	[4.02; 4.55]	2.19	[2.10; 2.27]	
25–29 years	3.08	[2.97; 3.20]	1.67	[1.64; 1.71]	
30–34 years	2.56	[2.48; 2.64]	1.47	[1.45; 1.50]	
35–39 years	2.20	[2.12; 2.28]	1.37	[1.35; 1.40]	
≥ 40 years	2.15	[2.00; 2.31]	1.34	[1.28; 1.39]	
Cesarean section	1.62	[1.60; 1.64]	1.26	[1.25; 1.27]	Ref.
< 25 years	1.88	[1.79; 1.97]	1.32	[1.29; 1.35]	
25–29 years	1.68	[1.64; 1.73]	1.25	[1.23; 1.27]	
30–34 years	1.58	[1.54; 1.61]	1.23	[1.22; 1.25]	
35–39 years	1.49	[1.45; 1.53]	1.18	[1.17; 1.20]	
≥ 40 years	1.34	[1.28; 1.40]	1.12	[1.10; 1.15]	
Transfer to a children's hospital^{*1}	2.61	[2.56; 2.66]	1.54	[1.52; 1.55]	Ref.
< 25 years	2.86	[2.69; 3.04]	1.47	[1.42; 1.53]	
25–29 years	2.76	[2.66; 2.87]	1.57	[1.53; 1.60]	
30–34 years	2.61	[2.52; 2.69]	1.57	[1.54; 1.59]	
35–39 years	2.49	[2.40; 2.59]	1.53	[1.50; 1.56]	
≥ 40 years	2.31	[2.16; 2.47]	1.41	[1.36; 1.47]	
Stillbirth^{*1}	2.34	[2.11; 2.60]	0.67	[0.62; 0.72]	Ref.
< 25 years	4.38	[3.38; 5.67]	0.53	[0.39; 0.73]	
25–29 years	2.88	[2.36; 3.52]	0.78	[0.67; 0.92]	
30–34 years	2.16	[1.79; 2.61]	0.62	[0.54; 0.72]	
35–39 years	1.77	[1.41; 2.23]	0.63	[0.54; 0.73]	
≥ 40 years	1.24	[0.82; 1.88]	0.66	[0.52; 0.83]	

^{*1}The denominator is the number of children and is equal to the number of births, since multiples were excluded.

^{*2}Data are missing (n = 4814) due to incomplete information.

DM, diabetes mellitus; GDM, gestational diabetes mellitus; CI, confidence interval; preDM, pregestational diabetes mellitus; Ref., reference; RR, relative risk

eTABLE 3

Description of the included study population Inpatient singleton births in Germany by year (data of IQTiG)

	2013		2014		2015		2016		2017		2018		2019	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Number of inpatient births	646 344		677 204		700 819		744 039		746 403		739 885		736 581	
Maternal age														
< 25 years	93 587	14.5	92 198	13.6	92 052	13.1	98 226	13.2	92 520	12.4	89 156	12.0	86 444	11.7
25–29 years	183 154	28.3	191 950	28.3	200 222	28.6	210 142	28.2	207 455	27.8	200 749	27.1	194 528	26.4
30–34 years	225 082	34.8	238 899	35.3	246 839	35.2	260 010	34.9	265 012	35.5	266 405	36.0	272 132	36.9
35–39 years	117 510	18.2	126 202	18.6	133 489	19.0	145 321	19.5	149 971	20.1	151 498	20.5	151 396	20.6
≥ 40 years	27 011	4.2	27 955	4.1	28 217	4.0	30 340	4.1	31 445	4.2	32 077	4.3	32 081	4.4
Diabetes mellitus														
GDM	29 092	4.5	30 623	4.5	35 178	5.0	40 808	5.5	44 526	6.0	49 713	6.7	53 270	7.2
preDM	6 125	0.95	6 246	0.92	6 421	0.92	6 593	0.89	6 919	0.93	6 910	0.93	7 391	1.0
Complications														
Premature birth	44 843	6.9	46 573	6.9	47 517	6.8	49 687	6.7	49 256	6.6	47 723	6.5	47 804	6.5
Large for gestational age*1,*2	60 845	9.4	63 762	9.4	66 097	9.4	71 941	9.7	73 234	9.8	72 766	9.8	73 450	10.0
Cesarean section	200 901	31.1	211 062	31.2	213 999	30.5	225 805	30.3	226 149	30.3	220 712	29.8	220 955	30.0
Transfer to a children's hospital*1	61 673	9.5	63 946	9.4	65 234	9.3	71 365	9.6	73 308	9.8	72 261	9.8	71 841	9.8
Stillbirth*1	2 084	0.32	2 145	0.32	2 264	0.32	2 410	0.32	2 564	0.34	2 523	0.34	2 649	0.36

*1The denominator is the number of children and is equal to the number of births, since multiples were excluded.

*2Data are missing (n = 4814) due to incomplete information.

GDM, gestational diabetes mellitus; IQTiG, German Institute for Quality Assurance and Transparency in Health Care (Institut für Qualitätssicherung und Transparenz im Gesundheitswesen); preDM, pregestational diabetes mellitus

eTABLE 4

Trend in relative risks for pregnancy complications in relation to diabetes type among women with inpatient singleton birth

	2013		2014		2015		2016		2017		2018		2019	
	RR	[95% CI]	RR	[95% CI]	RR	[95% CI]	RR	[95% CI]	RR	[95% CI]	RR	[95% CI]	RR	[95% CI]
Premature birth														
preDM	1.85	[1.72; 1.99]	1.98	[1.85; 2.12]	2.04	[1.91; 2.18]	2.28	[2.14; 2.43]	2.16	[2.03; 2.30]	2.28	[2.14; 2.43]	2.30	[2.17; 2.45]
GDM	1.08	[1.04; 1.13]	1.13	[1.08; 1.18]	1.17	[1.13; 1.22]	1.18	[1.14; 1.22]	1.14	[1.10; 1.18]	1.14	[1.10; 1.18]	1.13	[1.10; 1.17]
No DM	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Large for gestational age*1, *2														
preDM	2.53	[2.39; 2.66]	2.62	[2.49; 2.76]	2.60	[2.47; 2.74]	2.84	[2.71; 2.98]	2.75	[2.63; 2.88]	2.77	[2.65; 2.91]	2.84	[2.72; 2.97]
GDM	1.57	[1.52; 1.62]	1.55	[1.50; 1.59]	1.61	[1.56; 1.65]	1.57	[1.53; 1.61]	1.55	[1.51; 1.59]	1.54	[1.50; 1.58]	1.57	[1.53; 1.60]
No DM	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Cesarean section														
preDM	1.56	[1.51; 1.62]	1.58	[1.52; 1.63]	1.61	[1.56; 1.67]	1.66	[1.60; 1.72]	1.65	[1.59; 1.71]	1.63	[1.57; 1.68]	1.66	[1.60; 1.71]
GDM	1.25	[1.22; 1.27]	1.26	[1.24; 1.28]	1.26	[1.24; 1.29]	1.26	[1.24; 1.28]	1.26	[1.24; 1.28]	1.27	[1.25; 1.29]	1.28	[1.27; 1.30]
No DM	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Transfer to a children's hospital*1														
preDM	2.37	[2.24; 2.50]	2.53	[2.40; 2.67]	2.74	[2.61; 2.88]	2.71	[2.58; 2.85]	2.64	[2.52; 2.77]	2.58	[2.45; 2.70]	2.69	[2.57; 2.82]
GDM	1.57	[1.53; 1.62]	1.54	[1.49; 1.59]	1.58	[1.53; 1.62]	1.53	[1.49; 1.57]	1.55	[1.51; 1.59]	1.53	[1.49; 1.57]	1.49	[1.45; 1.52]
No DM	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	
Stillbirth*1														
preDM	1.97	[1.43; 2.70]	1.70	[1.21; 2.39]	2.07	[1.53; 2.79]	2.47	[1.88; 3.24]	2.30	[1.76; 3.01]	3.09	[2.45; 3.90]	2.55	[2.01; 3.24]
GDM	0.72	[0.57; 0.92]	0.66	[0.52; 0.85]	0.74	[0.59; 0.92]	0.66	[0.54; 0.82]	0.70	[0.58; 0.85]	0.67	[0.56; 0.81]	0.55	[0.46; 0.67]
No DM	Ref.		Ref.		Ref.		Ref.		Ref.		Ref.		Ref.	

*1 The denominator is the number of children and is equal to the number of births, since multiples were excluded

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DM, diabetes mellitus; GDM, gestational diabetes mellitus; CI, confidence interval; preDM, pregestational diabetes mellitus; Ref., reference; RR, relative risk