Received: 5 May 2021 | Accepted: 20 April 2022

DOI: 10.1111/dme.14861

DIABETIC Medicine

RESEARCH ARTICLE

Postpartum screening of women with GDM in specialised practices: Data from 12,991 women in the GestDiab register

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Funding information
This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Abstract

Background: Gestational diabetes (GDM) in the short term is associated with various complications during pregnancy; however, in the long run, women have an increased risk of type 2 diabetes mellitus (T2DM). Therefore, short- and long-term follow-up postpartum is recommended.

Methods: We assessed the proportion of postpartum diabetes screening among 12,991 women with their first GDM-diagnosed pregnancy in the study period in the nationwide German GestDiab register between 2015 and 2017. In addition to assessing prevalence, we assessed if the probability of postpartum screening was associated with maternal characteristics or pregnancy outcomes.

Results: In total, 38.2% (95% CI 32.8%–43.7%) of our sample underwent postpartum diabetes screening, irrespective of its timing. Around 50% of women (19.3% of the total sample) undertook the screening in the recommended time frame of 6–12 weeks postpartum. We found that age, native language, pre-pregnancy BMI, smoking status, number of previous pregnancies, fasting plasma glucose and HbA_{1c} levels as well as previous pregnancies with GDM and treatment with insulin were associated with participation in the postpartum diabetes screening in our sample.

Conclusion: In our study, more than 60% of the women with GDM did not participate in postpartum diabetes screening. This is a missed opportunity in a high-risk population to detect glucose intolerance. Consequently, appropriate interventions to prevent the progression to T2DM cannot be initiated. Further research should investigate barriers and enabling factors and allow developing a multilevel approach for GDM postpartum care.

KEYWORDS
gestational diabetes, postpartum follow-up, postpartum screening, type 2 diabetes screening

Ute Linnenkamp and Gregory Gordon Greiner shared first authorship.

1 | INTRODUCTION

It is assumed that about 4% to over 20% of pregnant women develop gestational diabetes (GDM). The variance of estimates is based on a substantial heterogeneity in screening methods and diagnostic criteria for GDM as well as on the difference in databases used.[1,2] Since 2012, the German maternity guidelines recommend screening every woman without a previous diagnosis of diabetes between 24+0 and 27+6 weeks of gestation for GDM.[3] In 2014 and 2015, around 80% of pregnant women insured with a statutory health insurance in Germany were screened for GDM [1] and the overall prevalence of GDM was 13.2%. GDM is associated with serious perinatal complications for both mother and child. GDM in the short term is associated with caesarean section, induction of labour, macrosomia and shoulder dystocia.[4] However, in the long run, even though blood sugar metabolism normalises after pregnancy in many cases, affected women have a significantly increased risk of developing type 2 diabetes mellitus (T2DM) during their life.[5] Therefore, thorough screening for GDM is assumed to be not enough. Short- and long-term follow-up of women postpartum is recommended to support prevention and early identification of T2DM.[6]

Evaluations of postpartum diabetes screening show a wide range of screening activity. Depending on the method of screening, data collection and population studied, the number varies from 3.4% up to 83.1%.[7–16] For example, a 2011 study using Medicaid claims data from South Carolina found 3.4% of women with GDM attended postpartum screening within 5–13 weeks after childbirth.[8] Whereas the Belgian Diabetes in Pregnancy study, a multi-centric prospective cohort study of 1841 pregnant women showed that more than 80% of the women with GDM attended postpartum screening within 14.4 ± 4.1 weeks postpartum.[14]

Current data for Germany are lacking. Consequently, we assessed the proportion of women with their first GDM-diagnosed pregnancy that engaged in postpartum diabetes screening within the nationwide German GestDiab register between 2015 and 2017. We assessed screening prevalence and whether the likelihood of postpartum screening was associated with maternal characteristics or pregnancy outcomes.

What's new?

- Data on postpartum diabetes screening rates in women with GDM and associated factors from population-based studies are scarce. They are important to quantify the number of missed opportunities in a high-risk population to detect impaired glucose regulation and identify groups with low screening adherence.
- We evaluated screening rates and factors associated with attending postpartum screening. In our sample, more than 60% of the women with GDM did not participate in screening.
- Factors associated with participation included smoking and obesity, indicating a low general health awareness.
- Further studies should evaluate reasons for the women's screening behaviour in more detail.

2 | METHODS

2.1 | GestDiab register and health-care setting

The 'GestDiab' register is a project coordinated by the scientific institute of resident diabetologists (WissenschaftlichesInstitut der niedergelassenen Diabetologen, winDiab gGmbH) and the Association of resident diabetologists in North-Rhine (Berufsverband der diabetologischenSchwerpunktpraxen in Nordrhein, BdSN) that monitors the treatment of pregnant women in diabetes specialist practices (DSPs). The GestDiab register was launched in North Rhine in 2004 and originally served as a quality control tool. DSPs all over Germany became interested and participation was widen to be nationwide, but North Rhine remains the region with the most practices on the register (78.2%), while 11.6% are based in Westphalia and the remaining 10.2% are distributed across the rest of Germany. The project data are collected during the course of routine care by employees of the DSPs. Since January 2015, data are entered into an online tool (www.gestdiab.de). The transfer of patient-related data (anonymised during the processing from the different DSPs) is performed annually into a separate data set. Data are routinely analysed centrally and participating DSPs receive benchmarking reports based on the analyses. The GestDiab-register was approved by the ethics committee of the Medical Association of North Rhine (Ethics Committee No.: 2019272). The use of register data is in line with the common data protection regulations.

All pregnant women received written information on the project and gave written consent to enter their data and the data of their newborn in pseudonymised form into the GestDiab database. The DSPs took part on a voluntary basis and did not receive any form of compensation.

The German health-care system provides a universal, multi-payer system paid for by a combination of statutory health insurance (covering around 90% of the population)

and private health insurance. In Germany, outpatient care is mostly provided in private general practices run by sole general practitioners or increasingly shared practices with multidisciplinary cooperation. DSPs offer specialist endocrinology multidisciplinary care. Any pregnant woman with diabetes in pregnancy is referred to a DSP or potentially an outpatient diabetes centre in hospitals, although these are rare within the health system.

2.2 | Study population

During the period 2015–2017, 13,908 pregnancies with GDM in 73 DSPs were registered within GestDiab. For 198 women, two pregnancies with GDM were registered and for a single woman, three pregnancies with GDM. For women with more than one pregnancy with GDM during the study period, the first pregnancy was included in the analysis and the second and third pregnancy data were excluded. For the remaining 13,709 women with their first GDM-diagnosed pregnancy, 718 had fasting blood glucose levels ≥126 mg/dl or an HbA_{1c} ≥ 48 mmol/mol (6.5%) at the time of screening. These were excluded because current guidelines classify these women as having pre-existing diabetes and they would receive different postpartum care compared to those with previous GDM. We thus included 12,991 women with their first GDM-diagnosed pregnancy registered in GestDiab between 2015 and 2017 in our analysis (Figure 1).

2.3 | Data assessment

The GestDiab database contains information on estimated due date, pre-pregnancy height, weight and BMI, number of previous pregnancies, number of children and any multiple pregnancies, weight of heaviest child at birth, child health records, previous GDM diagnosis, smoking status, native language and command of German language, family history of diabetes, expecting multiple folic acid supplement or metformin intake prior to pregnancy, insulin treatment during pregnancy including start date and mode of delivery, maternal complications (e.g. placental insufficiency, pre- and eclampsia) and HbA_{1c} and oral glucose tolerance test results from GDM diagnosis. Birth outcome data such as date of birth, infant Apgar score, mode of birth, induction of labour, birth complications, transfer to neonatal intensive care, infant gender, height, weight, maternal weight and breastfeeding status were also included in the GestDiab

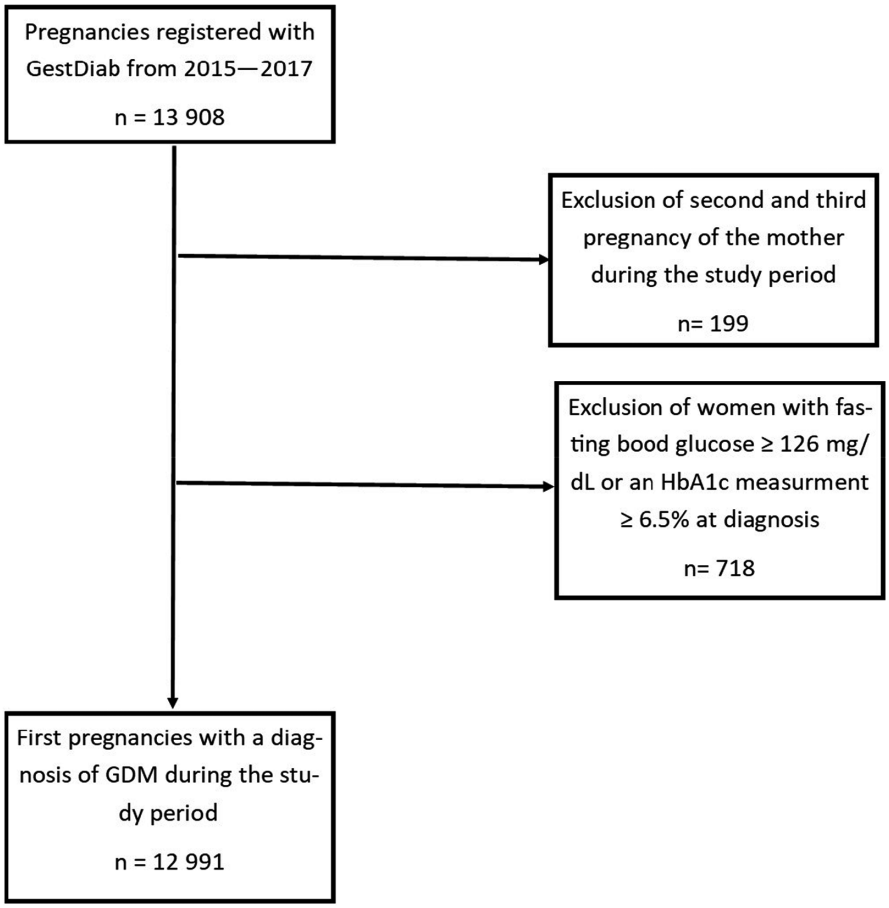

FIGURE 1 Description of the study population

register. Data from the woman's postnatal appointment can be completed by information provided by the clinic where the woman gave birth using a fax template which was provided to the participating DSP. The evidence-based S3 guideline on GDM recommends a postpartum 75 g oral glucose tolerance test (ppOGTT) 6–12 weeks postpartum irrespective of the woman's breastfeeding status.[17] The normal OGTT values according to the WHO guidelines were applied. If women attended their DSP to complete their ppOGTT, the results were entered into the GestDiab register as well.

2.4 | Statistical analysis

Patient characteristics were described using means ± standard deviation (SD) and frequency tables. The proportion of women attending postpartum diabetes screening was estimated including cluster (DSP) adjusted 95% confidence intervals, overall and in specific time intervals after GDM diagnosis. To assess the potential associated factors with the ppOGTT screening rate, univariate and multiple logistic regressions were performed considering cluster adjustment by random effects for DSPs. The dependent variable was participation at the ppOGTT as a dichotomous variable. As potential associated factors we considered: maternal age at delivery, pre-pregnancy BMI (<25.0, 25.0–29.9, 30.0–34.9, >40.0), gravidity and parity, native language, smoking during pregnancy (yes/no), week of pregnancy when diagnosed with GDM, fasting plasma glucose and HbA_{1c} at diagnosis, insulin during pregnancy (yes/no), previous pregnancies with GDM (yes/no). In addition, we used the number of patients per DSP and the year of entry into the registry as possible associated factors on the side of the DSP. The categorisation of age, fasting plasma glucose, HbA_{1c}, week of pregnancy when diagnosed with GDM and number of patients at the responsible practice were performed by quintiles of the corresponding variables. The categorisation of the other variables was based on external criteria. For multiple logistic regressions, we performed statistical variable selection stepwise and backward. As a significance level for inclusion of a further variable into the model, a level of 0.10 was used. On the other hand for variables included in the model, an exclusion criterion of a significance level of 0.15 for each variable was applied (in the statistical software SAS, these significance levels are called slentry and slstay). Furthermore, the variable selection was used to define a final model that is presented. For each variable, missing values were considered as a specific category and included in the model. In secondary analyses (data not shown), complete case analyses were performed.

3 | RESULTS

3.1 | Patient characteristics

Table 1 describes the 12,991 women with their first GDM-diagnosed pregnancies during the study period 2015–2017. Women's mean age was 32 ± 5 years and pre-pregnancy BMI was 27.9 ± 6.6 kg/m². The pre-pregnancy BMI distribution was about 40% normal BMI (BMI < 25 kg/m²) and about 32% in the obese category (BMI ≥ 30 kg/m²). For around one-third of the women, it was their first pregnancy and more than 40% were nulliparous. Roughly one-third of women reported a history of diabetes in their family and almost every sixth woman reported a previous pregnancy with accompanying GDM. For some variables, there were a considerable proportion of missing values, in particular in the subgroup of women who did not participate in the ppOGTT but these variables are often only collected at the end or after the pregnancy.

For the observed pregnancies, around 2% were pregnancies with multiples. GDM was on average diagnosed in gestational week 25 ± 6 and almost one-third of women received treatment with insulin (1749 missing values). Around 11% smoked during pregnancy (1474 missing values) and 3.5% experienced complications during the pregnancy (2388 missing values). Half of the women gave birth in a perinatal centre (5010 missing values). The average birth weight of singletons was 3422.1 ± 529.7g (4829 missing values).

3.2 | Participation rate

In total, 38.2% (cluster adjusted 95% CI 32.8%–43.7%) underwent the ppOGTT, irrespective of its timing. Around 50% of these women (19.3% of the total sample) underwent the ppOGTT during the recommended 6– 12 weeks postpartum time frame. More than 90% (35.8% of the total population) underwent the ppOGTT by 26 weeks postpartum and only around 10% completed it after that time.

3.3 | Predictors of participation

Table 2 shows the results of the cluster-adjusted multivariate logistic regression models in the final model after variable selection. Missing values in the independent variables were included as specific categories. Although the year of pregnancy was not selected by stepwise and backward procedures, it was included to adjust for differences between the calendar years. 'GDM in previous pregnancies' was selected only in the backward procedure. Women with Turkish or Arabic as their native language were less likely

TABLE 1 Description study population 12,991 women with their first GDM-diagnosed pregnancy registered in GestDiab between 2015 and 2017

Variable	Total sample	Missing	ppOGTT completed	Missing	ppOGTT not completed	Missing
n	12991		4966		8025	
Age (at delivery date), mean (SD) year.	32 (5)	4	33 (5)	1	32 (5)	3
Height, mean (SD) cm	165.6 (6.9)	369	165.8 (6.9)	107	165.4 (6.8)	262
Weight (pre- pregnancy), mean (SD) kg	76.8 (19.5)	364	76.4 (18.7)	125	77.1 (20.0)	239
Body mass index (pre- pregnancy), mean (SD) kg/m²	27.9 (6.6)	399	27.7 (6.3)	131	28.0 (6.8)	268
Body mass index (pre- pregnancy) categorised, *n* (%) kg/m²		399		131		268
<25.0	4995 (39.7%)		1938 (40.1%)		3057 (39·4%)	
25.0–29.9	3550 (28.2%)		1424 (29.5%)		2126 (27.4%)	
30.0–34.9	2214 (17.6%)		843 (17.4%)		1371 (17.7%)	
35.0–39.9	1098 (8.7%)		386 (8.0%)		712 (9.2%)	
≥40	735 (5.8%)		244 (5.1%)		491 (6.3%)	
Polycystic ovarian syndrome, *n* (%)	282 (2.2%)	290	112 (2.3%)	70	170 (2.2%)	220
Gravidity, *n* (%)		172		58		114
1	4575 (35.7%)		1886 (38.4%)		2689 (34.0%)	
2	3844 (30.0%)		1504 (30.6%)		2340 (29.6%)	
>2	4400 (34.3%)		1518 (30.9%)		2882 (36.4%)	
Parity, *n* (%)		254		83		171
0	5496 (43.2%)		2260 (46.3%)		3236 (41.2%)	
1	4380 (34.4%)		1696 (34.7%)		2684 (34.2%)	
>1	2861 (22.5%)		927 (18.9%)		1934 (24.6%)	
Family history of diabetes, *n* (%)	4198 (33.7%)	548	1662 (34.5%)	152	2536 (33.2%)	396
Previous pregnancies with GDM, *n*[a] (%)	1936 (15.6%)	563	703 (14.6%)	158	1233 (16.2%)	405
Pregnancy with multiples, *n* (%)	289 (2.3%)	239	101 (2.1%)	64	188 (2.4%)	175
Insulin during pregnancy, *n* (%)	3230 (28.7%)	1749	1614 (34.0%)	219	1616 (24.9%)	1530
Smoking during pregnancy, *n* (%)	1218 (10.6%)	1474	274 (6.0%)	412	944 (13.6%)	1062
Week of pregnancy when diagnosed with GDM, mean (SD)	25.6 (5.7)	111	25.5 (5.7)	23	25.7 (5.8)	88
Fasting glucose when diagnosed with GDM, mean (SD) mg/dl	95.0 (9.9)	192	94.8 (10.0)	64	95.2 (9.8)	128
HbA_{1c} when diagnosed with GDM, mean (SD) mmol/mol (%)	33 (5.2%) (3 (0.3%))	731	33 (5.2%) (3 (0.3%))	182	34 (5.3%) (4 (0.4%))	549
Native language						
German	6840 (61.6%)		2866 (63.9%)		3974 (60.1%)	
Turkish	1171 (10.6%)	1895	403 (9.0%)	481	768 (11.6%)	1414
Arabic	555 (5,0%)		204 (4.6%)		351 (5.3%)	
Others, *n* (%)	2530 (22.8%)		1012 (22.6%)		1518 (23.0%)	
Complications of the mother during pregnancy, *n* (%)	371 (3.5%)	2388	177 (3.8%)	288	194 (3.3%)	2100
Delivery in a perinatal centre, *n* (%)	4057 (50.8%)	5010	2490 (53.4%)	303	1567 (47.2%)	4707
Birthweight of singletons, mean (SD) g	3422.1 (529.7)	4829	3437.6 (515.4)	232	3399.1 (549.6)	4597

(Continues)

TABLE 1 (Continued)

Variable	Total sample	Missing	ppOGTT completed	Missing	ppOGTT not completed	Missing
Number of contacts with DSP, mean (SD)	6.5 (3.9)	1480	7.5 (4.0)	113	5.9 (3.7)	1367
ppOGTT up to 12 weeks, prev (95% CI[b])	19.9 (15.1–4.7)	181	53.3 (44.3–62.4)	181	0%	
ppOGTT between 6 to 12 weeks, prev (95% CI[b])	19.3 (14.6–3.9)	181	51.6 (43.0–60.2)	181	0%	
ppOGTT up to 26 weeks, prev (95% CI[b])	35.8 (30.3–41.3)	181	95.9 (94.3–97.5)	181	0%	
ppOGTT irrespective of timing, prev (95% CI[b])	38.2 (32.8–43.7)		100%		0%	

Abbreviations: CI, confidence interval; DSP, diabetes specialist practice; GDM, gestational diabetes; ppOGTT, postpartum oral glucose tolerance test; SD, standard deviation.

[a]Not treated in specialised practice (DSP) during the observation period.

[b]Cluster adjusted confidence interval.

to attend ppOGTT. Likewise, women with a higher fasting glucose and women with higher HbA_{1c} at point of diagnosis were also less likely to attend ppOGTT. Moreover, women who smoked were less likely to take part in a ppOGTT.

Women older than 27 years were more likely to participate in ppOGTT with small differences between the age groups. Women with BMIs of 35 or above were less likely to attend a ppOGTT. Treatment with insulin was associated with a higher probability of participating in the ppOGTT (OR 1.79 [1.63–1.98]) whereas a previous pregnancy complicated by GDM was associated with a lower probability of attending the ppOGTT (OR 0.85 [0.75–0.96]). Patients who were treated in a DSP that joined the register in 2016 were less likely to attend ppOGTT (OR 0.45 [0.24–0.86]). Within the multivariate analysis, the year of the pregnancy had no significant influence on the uptake of the ppOGTT.

4 | DISCUSSION

4.1 | Results in context

In our study, more than 60% of the women with GDM have not attended postpartum screening with an OGTT. This is a missed opportunity in a high-risk population to detect glucose intolerance. Consequently, appropriate interventions to prevent the progression to T2DM cannot be initiated. We found that age, native language, pre-pregnancy BMI, smoking status, number of previous pregnancies, fasting plasma glucose and HbA_{1c} levels as well as previous pregnancies with GDM and treatment with insulin were associated with participation in the ppOGTT in our sample.

Adamczewski et al. is the only other study evaluating postpartum OGTT in Germany. They found a participation rate of 43% in 2013–2014 using data from the same register.[11] That analysis included 4640 pregnancies among 28 DSPs. The participation rate of postpartum screening varied in the different DSPs from 6% to 100%. However, factors that are associated with not taking part in postpartum screening have not been analysed.

Other studies have found varying participation rates from 3.4% up to 83.1% among women with previous GDM.[7–16] These results are influenced by the method of data collection and population studied. Egglestone et al. analysed data of 447,556 women covered by commercial insurance with at least one delivery between 2000 and 2012 in the United States.[7] They found that within 1 year postpartum, rates of the recommended 75-g ppOGTT increased from 4% (2000) to 10% (2011) which is clearly below the rate we found in our study. According to an analysis by Shannon and colleagues (2016) carried out in the United States, only around 12% of women with GDM have seen an endocrinologist during pregnancy. This is in contrast to Germany where it is assumed that the majority of women with GDM are treated in DSPs[18] which will have practitioners that are more aware of the associated risks of GDM with T2DM and the need for postpartum screening. This assumption is reinforced by the finding that women who visited an endocrinologist during pregnancy were more likely to be screened according to Egglestone et al.[7] Additionally, they found, similar to our results, that women who received an antihyperglycaemic treatment during their pregnancy were more likely to be screened postpartum.[7] An analysis of 6239 in South Carolina of Medicaid-insured women with a singleton live birth and a diagnosis of GDM between 2004 and 2007 found that only 3.4% of woman with GDM received postpartum testing within 5–13 weeks postpartum.[8] Within our sample, we found almost six times higher participation rates between

TABLE 2 Multiple logistic regression model of factors potentially associated with participating in the postpartum OGTT, irrespective of the OGTT timing after delivery

Variable (classes)	Odds ratio for participation in ppOGTT	95% Confidence interval	*p* value
Year of pregnancy			
2015 (ref)	1.00	—	
2016	0.93	0.84–1.04	0.204
2017	0.91	0.81–1.01	0.085
Maternal age			
≤27 (ref)	1.00	—	
28–30	1.54	1.35–1.76	<0.001
31–33	1.72	1.52–1.96	<0.001
34–36	1.64	1.44–1.87	<0.001
≥37	1.80	1.57–2.05	<0.001
Missing ($n = 4$)	2.56	0.15–42.77	0.512
Native language			
German (ref)	1.00	—	
Turkish	0.79	0.69–0.91	0.001
Arabic	0.80	0.65–0.97	0.022
Others	0.98	0.88–1.08	0.637
Missing ($n = 1895$)	0.88	0.75–1.04	0.132
Body mass index (pre-pregnancy)			
<25.0	1.00	—	
25.0–29.9	1.05	0.95–1.16	0.298
30.0–34.9	1.00	0.89–1.13	0.981
35.0–39.9	0.82	0.71–0.96	0.014
≥40	0.75	0.62–0.90	0.002
Missing ($n = 399$)	1.05	0.82–1.36	0.689
Smoking during pregnancy			
No (ref)	1.00	—	
Yes	0.39	0.34–0.45	<0.001
Missing ($n = 1474$)	0.82	0.70–0.96	0.013
Gravidity 1 (ref)	1.00	—	
2	0.85	0.77–0.95	0.002
>2	0.65	0.58–0.72	<0.001
Missing ($n = 172$)	0.82	0.56–1.20	0.306
Fasting plasma glucose mg/dl			
≤87.0 (ref)	1.00	—	
88.0–92.0	0.84	0.74–0.96	0.013
93.0–96.0	0.84	0.75–0.95	0.005
97.0–101.0	0.83	0.73–0.95	0.005
≥102.0	0.84	0.74–0.95	0.008
Missing ($n = 192$)	1.02	0.70–1.47	0.930
HbA_{1c} at diagnosis mmol/mol (%)			
≤30 (4.9) (ref)	1.00	—	
31–32 (5.0– 5.1)	0.97	0.85–1.10	0.608
33–33 (5.2–5.2)	0.98	0.85–1.13	0.781

(Continues)

TABLE 2 (Continued)

Variable (classes)	Odds ratio for participation in ppOGTT	95% Confidence interval	*p* value
34–36 (5.3–5.4)	0.88	0.77–0.999	0.048
≥37 (5.5)	0.80	0.70–0.91	0.001
Missing ($n = 731$)	0.71	0.55–0.91	0.006
Week of pregnancy when diagnosed with GDM			
≤23.9 (ref)	1.00		
24.0–25.6	1.12	0.98–1.27	0.098
25.7–27.0	1.16	1.02–1.32	0.024
27.1–29.2	1.01	0.89–1.16	0.824
≥29.3	0.99	0.87–1.13	0.893
Missing ($n = 111$)	0.71	0.40–1.24	0.228
Insulin during pregnancy			
No (ref)	1.00	—	
Yes	1.79	1.63–1.98	<0.001
Missing ($n = 1749$)	0.23	0.20–0.27	<0.001
GDM in previous pregnancies			
No (ref)	1.00	—	
Yes	0.85	0.75–0.96	0.010
Missing ($n = 563$)	0.78	0.62–0.97	0.027
Number of patients at the responsible DSP			
≤68 (ref)	1.00	—	
69–97	1.00	0.83–1.20	0.961
98–137	0.97	0.78–1.20	0.777
138–250	1.09	0.84–1.43	0.515
≥251	1.64	0.998–2.68	0.051
DSP joined GestDiab in year			
2015 (ref)	1.00	—	
2016	0.45	0.24–0.86	0.016
2017	1.33	0.61–2.87	0.467

6 and 12 weeks postpartum (19.3%) than participation rates in the analysis of Hale et al. (2012). This difference might partially be explained by the fact that women in our sample were treated by a diabetologist and partially by differences in the health-care systems of the two different countries.

Three systematic reviews have gathered current evidence mainly from the United States and few studies from Australia, Canada, Poland and Turkey, on postpartum screening rates among women with GDM and associated factors, which all found that screening rates were low.[9,19,20] The majority of included studies were based on clinical samples rather than population-based samples.

Tovar and colleagues (2011) found—similar to our results—attendance of postpartum screening to be associated with older age, no previous pregnancy, higher income or education and treatment with insulin.[9] Similarly, Jones et al. (2019) found in their review focusing on studies carried out among US women only that high levels of health literacy and education were associated with postpartum screening.[19] Additionally, similar to our results, they found younger age and tobacco consumption were associated with not attending postpartum screening. Women treated by an obstetrician or endocrinologist were more likely to receive postpartum screening. Herrick et al. (2020) focused on potential racial and ethnic disparities in postpartum diabetes screening rates among US women with GDM.[20] They found screening rates to be low among ethnic groups. Within our analysis, we have only taken into account native language as a proxy for ethnicity and found that women with Turkish or Arabic as their native language were less likely to attend postpartum screening.

Other factors that affected the attendance of postpartum screening in international studies were a higher

socioeconomic status of women with GDM (better education, higher income) as well as geographical location and age.[7,9,21] Within our sample, the linking and connecting aspect of most variables that influence participation rates in the ppOGTT is probably general health awareness. Women who were very young, smoked during pregnancy, had BMIs >35 in pregnancy, multiparous and were irregular DSP attendees with few contacts might have a lower general awareness about their own health. Furthermore, some women were missing indicators for variables with frequent missing values that were also significantly associated with lower participation rates in the ppOGTT for possibly similar reasons leading to low interest in documenting health data in medical studies. For Germany, it is unknown if women who do not participate in postpartum screening do so because they are not aware of the need for the screening or because they decide not to participate. More information on the knowledge of women with GDM about postpartum screening and their opinions about its importance are necessary to increase uptake.

4.2 | Strengths and limitations

Several limitations have to be mentioned when discussing the results of our study. Firstly, the register includes routine care data from different practices and mistakes or some heterogeneity in documentation cannot be excluded. However, plausibility checks were performed and we excluded data that appeared irregular and checked the data for validity to minimise associated bias. Moreover, missing values were probably not at random with most missing values found among variables that were collected at the end of the pregnancy. The high number of missing values, for example, for the variable location of birth or birth weight, are mainly due to the fact that these participants did not return after delivery, did not complete a ppOGGT and the clinic did not send a report to the DSP. Therefore, the practice team could not enter this information. We considered missing values by using indicator variables in the regression models. Most ORs of the missing value indicators were <1, some of them were significant (Table 2) corresponding to an association between missing values and a lower participation probability at the ppOGTT. The study mainly represents the situation in one German region. However, this region includes about one-eighth of the German population. Additionally, we have only included ppOGTT documented by a DSP and it is possible that women may have completed their ppOGTT at a different health service provider, for example, their general practitioner, gynaecologist or another medical practice. The percentage of women in Germany receiving the ppOGTT at a different health service provider is not known, but after discussion with experts, this is assumed to be low. Lastly, variable selection in the regression model may have resulted in an overestimation of the observed associations. However, our estimates are built on a large population-based sample and not on a selected clinic-based sample allowing for robust estimates. Moreover, an important strength of the GestDiab project is that it reflects the reality of the care of women with GDM in DSPs and the associated network of care providers. For this register, data on pregnant women with GDM or diabetes were collected without reimbursement as part of routine care. Since all women treated during pregnancy are recorded by the DSPs, even those that would not be included in scientific studies, for example, due to partial lack of data or communication restrictions, this register offers the only and best information on routine care especially in a decentralised health system like the German one.

5 | CONCLUSION

With a total of 38.2% engaging in a ppOGTT in our sample, screening rates appear suboptimal. In more than 60% of cases, opportunities to diagnose T2DM and provide appropriate medical care or to identify those at an increased risk of developing T2DM in the coming years have been missed. Additionally, appropriate information and possible interventions to prevent the progression to T2DM could not be offered to these women. Factors associated with participating in the ppOGTT were mostly related to general health awareness among women. Our analyses show that women with high HbA_{1c} values at the time of diagnosis and high fasting glucose values are less likely to participate in the ppOGTT, even though they are at higher risk of hyperglycaemia. However, there is a lack of knowledge about why women in Germany miss the opportunity to engage in postpartum screening but we assume the reasons align with those described by Dennison and colleagues in their systematic review. [22] Better exchange of information needs to be achieved between women with GDM and their health-care providers during pregnancy and in the longer term. Studies in Australia show that information on postpartum diabetes prevention is limited and associated with intermediate risk and lower socioeconomic status by the women, and targeted campaigns can significantly increase participation rates.[23] Further research should investigate barriers and enabling factors from a patient point of view as well as from the health-care providers' point of view to develop a multilevel approach for GDM postpartum care. Using registry data or a mixed-methods approach will potentially help to achieve this objective.[24,25]

AUTHORS' CONTRIBUTIONS

UL wrote the original draft and administered the project; AI conceptualised the study; UL, GGG and BH developed the methodology for the statistical analysis; DW, HA and MK set up the GestDiab register and provided data; DW analysed the data under supervision of BH. All authors have carefully read and revised the manuscript.FUNDING INFORMATION

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

CONFLICT OF INTEREST

None.

THE GUARANTOR'S NAME

Prof. Dr. Dr. Andrea Icks and Ute Linnenkamp.

STATEMENTS OF ASSISTANCE

None.

DATA AVAILABILITY STATEMENT

The data sets generated and analysed during the current study are not publicly available due to data protection regulations but are available from the corresponding author on reasonable request.

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REFERENCE

1. Melchior H, Kurch-Bek D, Mund M. The prevalence of gestational diabetes: a population-based analysis of a nationwide screening program. *Dtsch Aerzteblatt*. 2017. 10.3238/arztebl.2017.0412
2. Guariguata L, Linnenkamp U, Beagley J, Whiting DR, Cho NH. Global estimates of the prevalence of hyperglycaemia in pregnancy. *Diabetes Res Clin Pract*. 2014;103(2):176-185.
3. Bundesministerium für Gesundheit. Bekanntmachung eines Beschlusses des Gemeinsamen Bundesausschusses über ein Änderung der Richtlinicen über die ärztlichen Betreuung während der Schwangerschaft und nach der Entbindung (Mutterschafts-Richtlinie): Einführung eines Screenings auf Gestationsdiabetes vom 15.12.2011, BAnz_036_Amtlich_ 1.pdf, page 6 @ Preflight (BAnz_109_Amtlich_1).
4. Farrar D, Simmonds M, Bryant M, et al. Hyperglycaemia and risk of adverse perinatal outcomes: systematic review and meta-analysis. *BMJ*. 2016;354:i4694.
5. Vounzoulaki E, Khunti K, Abner SC, Tan BK, Davies MJ, Gillies CL. Progression to type 2 diabetes in women with a known history of gestational diabetes: systematic review and meta-analysis. *BMJ*. 2020;m1361.
6. Sanderson H, Loveman E, Colquitt J, Royle P, Waugh N, Tan B. Improving uptake of postnatal checking of blood glucose in women who had gestational diabetes mellitus in universal healthcare settings: a systematic review. *J Clin Med*. 2018;8(1):4.
7. Eggleston EM, LeCates RF, Zhang F, Wharam JF, Ross-Degnan D, Oken E. Variation in postpartum glycemic screening in women with a history of gestational diabetes mellitus. *Obstet Gynecol*. 2016;128(1):159-167.
8. Hale NL, Probst JC, Liu J, Martin AB, Bennett KJ, Glover S. Postpartum screening for diabetes among Medicaid-eligible South Carolina women with gestational diabetes. *Womens Health Issues*. 2012;22(2):e163-e169.
9. Tovar A, Chasan-Taber L, Eggleston E, Oken E. Postpartum screening for diabetes among women with a history of gestational diabetes mellitus. *Prev Chronic Dis*. 2011;8(6):A124.
10. Oza-Frank R. Postpartum diabetes testing among women with recent gestational diabetes mellitus: PRAMS 2009–2010. *Matern Child Health J*. 2014;18(3):729-736.
11. Adamczewski H, Weber D, Faber-Heinemann G, Heinemann L, Kaltheuner M. Einfluss der Gestationsdiabetes-Leitlinie der DDG auf die Versorgungsrealität: analysen des Register GestDiab. *Diabetol Stoffwechs*. 2016;11(05):341-349.
12. Butalia S, Donovan L, Savu A, Johnson J, Edwards A, Kaul P. Postpartum diabetes testing rates after gestational diabetes mellitus in Canadian women: a population-based study. *Can J Diabetes*. 2017;41(6):613-620.
13. Carson MP, Frank MI, Keely E. Original research: postpartum testing rates among women with a history of gestational diabetes–systematic review. *Prim Care Diabetes*. 2013;7(3):177-186.
14. Benhalima K, Van Crombrugge P, Moyson C, et al. Prediction of glucose intolerance in early postpartum in women with gestational diabetes mellitus based on the 2013 WHO criteria. *J Clin Med*. 2019;8(3):383.
15. Herrick CJ, Keller MR, Trolard AM, Cooper BP, Olsen MA, Colditz GA. Postpartum diabetes screening among low income women with gestational diabetes in Missouri 2010–2015. *BMC Public Health*. 2019;19(1):148.
16. Schaefer-Graf UM, Klavehn S, Hartmann R, et al. How do we reduce the number of cases of missed postpartum diabetes in women with recent gestational diabetes mellitus? *Diabetes Care*. 2009;32(11):1960-1964.
17. Schäfer-Graf U, Laubner K, Hummel S, et al. Gestationsdiabetes mellitus (GDM), Diagnostik, Therapie und Nachsorge: Praxisempfehlung – Kurzfassung der S3-Leitlinie (AWMF-Registernummer: 057–008). *Diabetol*. 2019;15(4):333-343.
18. Shannon MH, Wintfeld N, Liang M, Jovanovic L. Pregnancy snapshot: a retrospective, observational case–control study to evaluate the potential effects of maternal diabetes treatment during pregnancy on macrosomia. *Curr Med Res Opin*. 2016;32(7):1183-1192.
19. Jones EJ, Hernandez TL, Edmonds JK, Ferranti EP. Continued disparities in postpartum follow-up and screening among women with gestational diabetes and hypertensive disorders of pregnancy: a systematic review. *J Perinat Neonatal Nurs*. 2019;33(2):136-148.
20. Herrick CJ, Puri R, Rahaman R, Hardi A, Stewart K, Colditz GA. Maternal race/ethnicity and postpartum diabetes screening: a systematic review and meta-analysis. *J Womens Health*. 2020;29(5):609-621.
21. Nielsen KK, Kapur A, Damm P, de Courten M, Bygbjerg IC. From screening to postpartum follow-up – the determinants

and barriers for gestational diabetes mellitus (GDM) services, a systematic review. *BMC Pregnancy Childbirth*. 2014;14(1):41.

22. Dennison RA, Fox RA, Ward RJ, Griffin SJ, Usher-Smith JA. Women's views on screening for type 2 diabetes after gestational diabetes: a systematic review, qualitative synthesis and recommendations for increasing uptake. *Diabet Med*. 2020;37(1):29-43.
23. O'Reilly SL, Versace VL, Skinner TC, Dunbar JA, the MAGDA Study Group. Women's engagement with diabetes prevention activities and the influence of contact by the Australian national gestational diabetes register. *Pract Diabetes*. 2021;38(3):14.
24. Greiner GG, Viehmann A, Linnenkamp U, et al. Study protocol for a mixed methods exploratory investigation of aftercare services for gestational diabetes in women to develop a new patient-centred model in Germany: the GestDiNa_basic study. *BMJ Open*. 2021;11(8):e046048.
25. Boyle DIR, Versace VL, Dunbar JA, et al. Results of the first recorded evaluation of a national gestational diabetes mellitus register: challenges in screening, registration, and follow-up for diabetes risk. *PLoS One*. 2018;13(8):e0200832.

How to cite this article: Linnenkamp U, Greiner GG, Haastert B, et al. Postpartum screening of women with GDM in specialised practices: Data from 12,991 women in the GestDiab register. *Diabet Med*. 2022;00:e14861. doi:10.1111/dme.14861