Rates of Postpartum Glucose Testing After Gestational Diabetes Mellitus

Michelle A. Russell, MD, Maureen G. Phipps, MD, MPH, Courtney L. Olson, H. Gilbert Welch, MD, MPH, and Marshall W. Carpenter, MD

OBJECTIVE: To estimate rates of postpartum glucose tolerance testing in women diagnosed with gestational diabetes mellitus (GDM) and to assess factors associated with testing.

METHODS: This was a retrospective cohort study of 344 women with GDM who received prenatal care in a maternal diabetes clinic during 2001–2004. Rates of postpartum glucose testing were estimated from hospital, clinic, and laboratory records. Demographic, clinical (obstetric history, antenatal, and delivery), and health care information was obtained from chart review.

RESULTS: Less than one half (45%) of women with GDM in our cohort underwent postpartum glucose testing—more than one third (36%) of whom had persistent abnormal glucose tolerance. After adjusting for clinical and health care characteristics, there was no independent relationship between most demographic characteristics and postpartum testing. Nor was there an association between clinical characteristics and the likelihood of being tested. Postpartum testing was strongly associated only with attendance of the postpartum visit: 54% of women who attended the visit were tested compared with 17% of women who did not attend (adjusted relative risk 3.04, 95% confidence interval 1.75–5.34, $P<.001$).

CONCLUSION: Although persistent abnormal glucose tolerance was common in our cohort, less than half of the women were tested for it. Our data suggest that to increase rates of postpartum glucose testing, improved attendance at the postpartum visit with greater attention to testing and better continuity between antenatal and postpartum care are required.

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Gestational diabetes mellitus (GDM) is defined as carbohydrate intolerance that is first recognized during pregnancy. Estimates of the incidence of GDM among pregnancies in the United States range from 2 to 14% and appears to be increasing.[1–3] Offspring exposed to GDM face risks both in the short term (eg, macrosomia and birth trauma) and the long term (eg, diabetes and hypertension). Consequently, most obstetric care providers screen all pregnant women with the belief that diagnosis and treatment of GDM improves neonatal outcomes.[4,5]

Additionally, GDM has well-known implications for the mother—most notably an increased risk of type 2 diabetes mellitus after pregnancy. Estimates of the risk of type 2 diabetes mellitus after GDM vary widely from 2–70% and reflect the population tested, the criteria used for diagnosis, and the length of follow-up.[2] Studies restricted to the immediate postpartum period have estimated the risk of glucose intolerance to be as high as 36% and diabetes to be 2–16%.[6–12] Detecting impaired glucose tolerance in high-risk, asymptomatic individuals permits interventions such as dietary counseling, exercise, and weight management to delay or prevent diabetes.[13,14]

Consequently, both the American Diabetes Association and the American College of Obstetricians and Gynecologists (ACOG) recommend postpartum glucose tolerance testing in women diagnosed with GDM.[15] However, only a fraction of eligible women get tested.[6–12] In this article, we examine the factors associated with testing, specifically the demographic, clinical, and health care characteristics that may influence testing.

From the Brown Medical School, Women and Infants' Hospital, Providence, Rhode Island; VA Outcomes Group, White River Junction, Vermont; and Center for Evaluative Clinical Sciences, Dartmouth Medical School, Hanover, New Hampshire.

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Corresponding author: Dr. Michelle Russell, VA Outcomes Group, (111B) Department of Veteran's Affairs Medical Center, White River Junction, VT, 05009; e-mail: Michelle.A.Russell@dartmouth.edu.

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MATERIALS AND METHODS

We performed a retrospective cohort study of women with GDM whose prenatal care was provided by a maternal diabetes clinic and who delivered at Women and Infants' Hospital of Rhode Island. This clinic is a comprehensive referral practice for pregnant women with diabetes staffed by Maternal–Fetal Medicine physicians. It provides nursing care, diabetes and nutrition education, social work support, and obstetric management. The majority of patients in this specialty clinic are referred either from the academic hospital-based clinic (a low-risk obstetric clinic) or from the hospital-affiliated community clinics (one of five neighborhood health centers located in the surrounding urban neighborhoods). Once referred (from either the hospital-based or hospital-affiliated clinics), patients received prenatal care in this specialty clinic. Antenatal management of GDM in this setting follows ACOG clinical management guidelines.[15] Postpartum visits occurred in either the hospital-based or hospital-affiliated community clinics, which are staffed by providers who follow ACOG guidelines.

Our cohort included women with GDM referred to the maternal diabetes clinic between January 4, 2001, and May 27, 2004. Patients with pregestational diabetes were excluded. Ninety-five percent of GDM cases were identified through a routine 1-hour, 50-g oral glucose challenge test. Those with a test result of between 130 mg/dL and 180 mg/dL underwent a fasting 3-hour, 100-g oral glucose tolerance test. Gestational diabetes mellitus was diagnosed when two or more values met or exceeded the threshold venous plasma glucose concentration of 95, 180, 155, or 140 mg/dL at fasting, 1, 2, and 3 hours, respectively. Those with a 1-hour, 50-g glucose challenge test venous plasma glucose concentration of more than 180 mg/dL were diagnosed with GDM. Five percent of GDM cases were identified by a 2-hour, 75-g glucose tolerance test when one or more of the values exceeded the threshold venous plasma glucose concentration of 105 mg/dL or more at fasting or 200 mg/dL or more at 2 hours or by incidental hyperglycemia first recognized during pregnancy. Glucose concentrations were measured using glucose oxidase methods in a College of American Pathologists–approved analyzer. The final sample was 344 women with GDM.

All GDM patient counseling and education was uniform and language-specific. It addressed healthy dietary practices, weight management, exercise, lifetime risk of diabetes, and the need for a 6-weeks postpartum and periodic reevaluation of glucose tolerance. At hospital discharge after delivery, women were reminded to schedule a 6-weeks postpartum visit. All patients were also reminded to schedule a 2-hour, 75-g oral glucose tolerance test, and some were given a laboratory slip to facilitate testing before the postpartum visit. It is the protocol in all clinics that any woman presenting to the postpartum visit without having had a glucose test is scheduled for testing. In all clinics, patients who fail to attend a scheduled postpartum visit are sent a letter advising them to reschedule this appointment.

The primary outcome measure was postpartum glucose testing after hospital discharge. To be considered as tested, the patient either underwent a 2-hour, 75-g oral glucose tolerance test or fasting plasma glucose. We excluded women whose glucose tests were performed during a subsequent pregnancy. In our setting, almost all of the glucose tolerance tests are performed in the hospital; therefore, we first sought the presence of postpartum glucose tests directly from the hospital computer system. If results of a test were not found in the computer search, then the hospital-based and hospital-affiliated community clinic charts were examined for evidence of glucose testing (either glucose tolerance test or fasting glucose). To be certain that all completed tests were identified; we contacted the single referral laboratory for the hospital-affiliated community clinics to identify testing not performed in the hospital laboratory.

The secondary outcome measure was the diagnosis of persistent postpartum glucose intolerance. Persistent glucose intolerance was diagnosed when either a fasting plasma glucose concentration was 100 mg/dL or more or the 2-hour, 75-g oral glucose tolerance test plasma glucose concentration was 140 mg/dL or more. Diabetes was suspected when these values exceeded 126 mg/dL or 200 mg/dL, respectively.[16]

To explain the variability in postpartum testing we considered factors that might influence the patient's willingness to return for testing and factors that might influence the provider's perceived need for testing (eg, the patient's risk of persistent glucose intolerance as measured by the magnitude of the antenatal glucose abnormality). The factors we examined fell into three categories: demographic, clinical, and health care factors. Demographic factors plausibly related to testing included maternal age, race or ethnicity, marital status, and education level. Data pertaining to the demographic factors were extracted from the prenatal record and hospital computer system.

Clinical factors plausibly related to testing included maternal parity, prior history of GDM, body

mass index, tobacco use, length of gestation, and mode of delivery. Other evaluated clinical factors included infant birth weight and intensive care unit admission. Additionally, we looked at one antenatal metabolic factor, fasting plasma glucose concentration on the diagnostic glucose tolerance test. These data were obtained from the prenatal record, hospital delivery record, and hospital computer system.

Health care factors potentially related to testing included type of insurance, referral source, and attendance at the postpartum visit. Data pertaining to the insurance type were obtained from the hospital computer system. Referral source data were obtained from a file maintained by the maternal diabetes clinic. All of the postpartum visits occurred in the hospital-based or hospital-affiliated community clinics, and given this, data pertaining to the postpartum visit were derived from the hospital-based or hospital-affiliated community clinic charts. If a patient chart or record for a postpartum visit was not located, we searched the hospital computer system for visit history and laboratory services. A patient was considered to have attended a postpartum visit if the visit history or laboratory services indicated that the patient received postpartum care from an obstetrics and gynecology provider after delivery.

Because educational achievement has been associated with lower health care utilization rates and poor health outcomes, our primary hypothesis was that women with less education would be less likely to be tested. We wanted to be able to detect a 20% absolute decrease in testing among women who did not complete high school (eg, 30% compared with 50%).[17–21] Based on an α=.05 and β =.20, the estimated sample size was 206 women. All data were collected by one of three trained investigators and subjected to double entry. Our protocol was approved by the Research and Human Subjects Committee of Women and Infants' Hospital of Rhode Island.

Analyses to evaluate group differences and calculate relative rates were performed using the Student *t* test for continuous data and Pearson's χ^2 test for proportions. All tests were two-tailed, and $P<.05$ was considered statistically significant. To avoid reporting odd ratios, which can exaggerate readers' perception of the strength of association when outcomes are common, we sought an alternative approach to logistic regression to adjust for potential confounders. We thus used modified Poisson regression with a robust error variance that directly generates adjusted relative rate ratios and 95% confidence intervals.[22,23] We used STATA 9 (STATA Corporation, College Station, TX) for all data analyses.

RESULTS

Demographic characteristics of the women are presented by postpartum glucose testing status in Table 1. Overall, the typical patient was an unmarried minority woman, aged more than 30 years and eligible for Medicaid. The only demographic characteristic that differed between tested and not tested was marital status. Women who were tested were more likely to be married than those who were not tested (52% compared with 40%, P=.025)

Of the 344 women included in the study, only 156 (45%; 95% confidence interval [CI] 40–50%) underwent postpartum glucose testing. The tests were performed at a mean of 7.5 weeks postpartum (interquartile range 5.1 to 8.4 weeks). Of the 156 women tested, 56 women (36%, 95% CI 28–44%) had abnormal results; this included 44 (28%, 95% CI 0.21–0.35%) with persistent glucose intolerance and 12 (8%, 95% CI 4–12%) with suspected diabetes mellitus.

In the univariable analysis of the demographic factors potentially related to testing (Table 2) only ethnicity or race and marital status were significant. The rate of testing was 30% higher in married women than unmarried women (relative risk [RR] 1.30, 95% CI 1.03–1.64, P=.02) and the rate of testing in non-Hispanic black women was 43% higher than non-Hispanic white women (RR 1.43, 95% CI 1.02–1.68, P=.04). However, our primary hypothesis that edu-

Table 1. Demographic Characteristics of Women by Postpartum Glucose Tolerance Test Status

Characteristic	Tested (n=156)	Not Tested (n=188)	*P*
Age group (y)			
Younger than 25	11 (7.1)	19 (10.2)	.547
25–29	30 (19.2)	39 (21.0)	
30–35	41 (26.3)	39 (21.0)	
Older than 35	74 (47.4)	89 (47.8)	
Ethnicity or race			.200
White non-Hispanic	37 (23.7)	62 (33.0)	
Black non-Hispanic	37 (23.7)	32 (17.0)	
Hispanic	64 (41.0)	75 (39.9)	
Asian or other	18 (11.6)	19 (10.1)	
Marital status			.025
Unmarried	74 (47.4)	112 (59.6)	
Married	82 (52.6)	76 (40.4)	
Maternal education (y)			.138
12 or more	93 (69.9)	98 (61.6)	
Less than 12	40 (30.1)	61 (38.4)	

Data are n (%).
P values were calculated with χ^2 test.

Table 2. Comparison of Demographic Characteristics by Prevalence of Postpartum Glucose Tolerance Testing

Demographics	n	Prevalence of Follow-up Testing	RR (95% CI)	Adjusted RR* (95% CI)
Age group (y)				
Younger than 25	30	0.37	1 (Reference)	1 (Reference)
25–29	69	0.43	1.18 (0.69–2.04)	1.19 (0.66–2.14)
30–35	80	0.51	1.40 (0.83–2.34)	1.26 (0.70–2.25)
Older than 35	163	0.45	1.24 (0.75–2.04)	1.09 (0.60–1.97)
Ethnicity or race				
White non-Hispanic	99	0.37	1 (Reference)	1 (Reference)
Hispanic	139	0.46	1.23 (0.90–1.68)	1.52 (1.02–2.27)
Black non-Hispanic	69	0.54	1.43 (1.02–1.68)	1.61 (0.99–2.61)
Asian or other	37	0.49	1.30 (0.86–1.98)	1.27 (0.71–2.295)
Marital status				
Unmarried	186	0.40	1 (Reference)	1(Reference)
Married	158	0.52	1.30 (1.03–1.64)	1.22 (0.89–1.66)
Maternal education (y)				
12 or more	191	0.49	1 (Reference)	1 (Reference)
Less than 12	101	0.40	0.81 (0.61–1.07)	1.20 (0.87–1.66)

RR, relative risk; CI, confidence interval.
* Adjusted for all covariates listed in Tables 1–3, and fasting plasma glucose concentration during pregnancy.

cation would predict testing was not supported by the data. There was no difference in the rate of testing between the women who did and did not complete high school. In the fully adjusted model, marital status and non-Hispanic black race were no longer significant, but the rate of testing in Hispanic women was 52% higher than in non-Hispanic white women (RR 1.52, 95% CI 1.02–2.27, P=.039). None of the other demographic factors were significantly associated with testing.

In the univariable analysis of the clinical factors potentially related to testing (Table 3) no significant predictors of testing were found. Nor was there a relationship between the risk of diabetes (as measured by the magnitude of the antenatal fasting glucose abnormality) and the likelihood of being tested. The fully adjusted model did not change these findings.

In the univariable analysis of the health care factors potentially related to testing (Table 4), insurance source and attendance of the postpartum visit were significantly related to testing. The rate of testing was 32% higher in women with private insurance than in women with Medicaid (RR 1.32, 95% CI 1.02–1.70, P=.05). However, in the fully adjusted model there was no difference in rates of testing by insurance type. In our study, 77% of women attended the postpartum visit. The rate of testing was nearly four-fold higher in those who attended a postpartum visit compared with those who did not (54 compared with 17%, RR 3.74, 95% CI 2.14–6.52, P<.001). In the fully adjusted model, the rate of testing remained three-fold higher in women who attended the postpartum visit than in women who did not (RR 3.04, 95% CI 1.72–5.33, P<.001).

In a subgroup analysis that included only the women who attended a postpartum visit, Hispanic ethnicity was still a predictor of testing, and we found the site of care to also be an important predictor after adjusting for the same covariates included in the complete cohort analysis. The rate of testing in Hispanic women attending a postpartum visit was 53% higher than in non-Hispanic white women (RR 1.53, 95% CI 1.03–2.28, P=.035). Women who returned to the hospital-based clinic were twice as likely be tested as were women seen in the hospital-affiliated community clinics (62 compared with 32%, fully adjusted RR 2.19, 95% CI 1.43–3.34, P<.001).

DISCUSSION

Women with GDM are at increased risk of persistent glucose intolerance after delivery, and yet, many are not retested postpartum. More than one third of those tested in our study had persistent glucose intolerance, which is consistent with other reports.[12,24] We set out to define factors associated with successful testing, because few prior investigations have specifically evaluated the relationship of demographic, clinical, and health care factors with achievement of postpartum glucose testing. We found that only attendance at the postpartum visit was strongly associated with testing.

Other studies designed to explore the risk factors for persistent glucose intolerance after GDM have similarly identified few predictors of testing.[6,12] In one

Table 3. Comparison of Clinical Characteristics by Prevalence of Postpartum Glucose Tolerance Testing

Characteristic	n	Prevalence of Follow-up Testing	RR (95% CI)	Adjusted RR* (95% CI)
Obstetric history				
Parity				
Less than 1	103	0.47	1 (Reference)	1 (Reference)
1 or more	239	0.44	0.99 (0.74–1.32)	0.92 (0.65–1.29)
Prior history of GDM				
No	271	0.45	1 (Reference)	1 (Reference)
Yes	73	0.45	0.99 (0.75–1.32)	0.88 (0.60–1.29)
Antenatal				
Body mass index (kg/m^2)				
18–24	55	0.53	1 (Reference)	1 (Reference)
25–29	106	0.44	0.84 (0.61–1.16)	0.75 (0.50–1.13)
30–34	74	0.47	0.90 (0.63–1.27)	0.63 (0.39–1.00)
35 or more	89	0.46	0.87 (0.62–1.22)	0.79 (0.51–1.24)
Antenatal tobacco use				
No	280	0.47	1 (Reference)	1 (Reference)
Yes	62	0.40	0.86 (0.62–1.20)	1.06 (0.71–1.58)
Delivery				
Gestational age at delivery (wk)				
37 weeks or more	277	0.48	1(Reference)	1(Reference)
Less than 37 weeks	60	0.38	0.80 (0.57–1.13)	0.84 (0.54–1.31)
Cesarean delivery				
No	202	0.43	1 (Reference)	1 (Reference)
Yes	142	0.49	1.15 (0.92–1.46)	1.17 (0.87–1.57)
Birth weight (g)				
Less than 4,000	300	0.45	1 (Reference)	1 (Reference)
4,000 or more	44	0.50	1.12 (0.81–1.54)	1.17 (0.79–1.74)
Neonatal intensive care				
No	299	0.45	1 (Reference)	1 (Reference)
Yes	33	0.45	1.01 (0.68–1.49)	1.32 (0.87–2.02)

RR, relative risk; CI, confidence interval.
* Adjusted for all covariates listed in Tables 1–3, and fasting plasma glucose concentration during pregnancy.

Table 4. Comparison of Health Care Factors by Prevalence of Postpartum Glucose Tolerance Testing

Characteristic	n	Prevalence of Follow-up Testing	RR (95% CI)	Adjusted RR* (95% CI)
Health care information				
Insurance				
Medicaid	282	0.43	1 (Reference)	1 (Reference)
Private	62	0.56	1.32 (1.02–1.70)	1.27 (0.91–1.77)
Referral Source				
Hospital-based clinic	171	0.44	1 (Reference)	1 (Reference)
Hospital-affiliated community clinics	141	0.45	1.00 (0.78–1.29)	0.90 (0.66–1.21)
Nonaffiliated practices	31	0.55	1.23 (0.86–1.77)	0.97 (0.53–1.76)
Attended postpartum visit				
No	78	0.17	1 (Reference)	1 (Reference)
Yes	266	0.54	3.74 (2.14–6.52)	3.04 (1.73–5.34)

RR, relative risk; CI, confidence interval.
* Adjusted for all covariates listed in Tables 1–3, and fasting plasma glucose concentration during pregnancy.

such study, an association between patient health care access and lack of postpartum testing was inferred. Greenberg et al[12] reported that failure to return for the six-week postpartum visit and loss of health insurance coverage contributed to patient noncompliance with postpartum 2-hour, 75-g oral glucose tolerance testing.

Although our primary hypothesis was that maternal education would be associated with postpartum glucose testing, we did not find this in our sample.

Similarly, the evaluated health behaviors, such as tobacco use and obesity, were not associated with postpartum glucose testing. On univariable analysis, having private insurance, being married, and being of non-Hispanic black race were associated with a higher rate of postpartum testing. In the fully adjusted analysis, insurance type, non-Hispanic black race, and marital status were no longer associated with testing status. Although Hispanic women had a higher rate of testing after adjusting, overall we observed a low rate in all racial and ethnic groups, with both insurance types and regardless of marital status.

Conversely, postpartum care was strongly associated with postpartum glucose testing and remained so in the fully adjusted analysis. Although rarely examined, risk factors for failure to attend the postpartum visit include lack of prenatal care, low income, low education, and inadequate or discontinuation of health insurance coverage.[12,17,18] Because all subjects received prenatal care and income data were unavailable, this study cannot examine the first two factors. In our study, neither education nor insurance status (during pregnancy) predicted attendance of postpartum visit. However, because we do not know the insurance status of nonattenders of the postpartum visit, we can not determine whether loss of insurance coverage may explain lack of attendance. It remains possible that discontinuance of Medicaid coverage 60 days after delivery played a role in failure to attend the postpartum visit and lack of testing.

Despite 77% of our study sample attending a postpartum visit (consistent with published rates of 72–85%), the impact of postpartum visit attendance on postpartum glucose testing compliance is sufficiently great (a three-fold higher rate of undergoing testing, compared with nonattendees) to suggest that strategies aimed at improving postpartum visit attendance rates should be a goal.[17,18] Some readers might reasonably expect that attendance at a postpartum visit is both necessary and adequate to ensure that postpartum glucose testing occurs. However, our data show that neither is completely true. Attendance of a postpartum visit is not necessary for testing to occur; in our data, 17% of nonattenders were nonetheless tested. This may be a result of patients receiving a requisition for the test at hospital discharge, scheduling a test (but not attending the visit), or having a visit with a provider outside of obstetrics and gynecology who then orders the test.

Simply attending the postpartum visit is not enough to ensure testing. In this study, an opportunity to test occurred in the visit attendees, yet 46% still did not get tested. Important factors in achieving testing in women who return for postpartum care remain unidentified. In a subset analysis of women who attended the postpartum visit, we observed that the rate of testing was affected by the location providing the follow-up. Women attending the postpartum visit in the hospital-based clinic compared with one of the hospital-affiliated community clinics had a two-fold higher likelihood of completing the postpartum glucose testing. This difference may reflect lower patient compliance with testing in the women having a postpartum visit in the hospital affiliated community clinics or lower postpartum provider adherence to care protocols in these clinics. We speculate that this difference may represent a discontinuity in delivery of patient care or differential access to postpartum glucose testing, because nearly all of the 2-hour, 75-g oral glucose tolerance tests were performed in the hospital laboratory. A similar effect of location of postpartum follow-up was observed by Kim et al (C. Kim, personal communication and abstract November, 2005), who reported that the rate of postpartum testing was highest in women who had a follow-up visit with the endocrinologist that had provided the diabetes management during the pregnancy.

This study is limited in that the findings may be less generalizable to nonacademic institutions caring for nonminority or non-Medicaid–eligible women. Although it remains possible that postpartum glucose testing may have occurred in locations beyond our access to the results, we think this is unlikely. Most patients receiving prenatal care in the hospital-based or hospital-affiliated community clinics also receive primary medical care in these clinics. All laboratory tests ordered in these clinics are included in our study. Additional limitations such as unaccounted for confounding are inherent to the retrospective study design. We believe a strength of our study is that it includes a relatively large number of women with GDM for which ascertainment of postpartum data was complete. The consistency of our findings with the rates of postpartum visit attendance and glucose testing reported in other studies further supports the completeness of our data.[6–12,17,18]

Rates of postpartum glucose testing after GDM are low. Although attendance of the postpartum visit is associated with a three-fold higher rate of testing, important factors leading to testing remain unidentified. Continuity between antenatal and postpartum care may be associated with a two-fold higher rate of testing. With the magnitude of the public health problem posed by the rising incidence of diabetes in the United States, further attention needs to be given to these high-risk women, including identifying and

eliminating the obstacles to postpartum care and glucose testing and implementing effective interventions to reduce the rate of subsequent diabetes.

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