Trends in Postpartum Diabetes Screening and Subsequent Diabetes and Impaired Fasting Glucose Among Women With Histories of Gestational Diabetes Mellitus

A report from the Translating Research Into Action for Diabetes (TRIAD) Study

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OBJECTIVE — The purpose of this study was to examine trends in postpartum glucose screening for women with gestational diabetes mellitus (GDM), predictors of screening, trends in postpartum impaired fasting glucose (IFG) and diabetes, and diabetes and pre-diabetes detected by postpartum fasting plasma glucose (FPG) versus a 75-g oral glucose tolerance test (OGTT).

RESEARCH DESIGN AND METHODS — This was a cohort study of 14,448 GDM pregnancies delivered between 1995 and 2006. Postpartum screening was defined as performance of either an FPG or OGTT at least 6 weeks after delivery and within 1 year of delivery.

RESULTS — Between 1995 and 2006, the age- and race/ethnicity-adjusted proportion of women who were screened postpartum rose from 20.7% (95% CI 17.8–23.5) to 53.8% (51.3–56.3). Older age, Asian or Hispanic race/ethnicity, higher education, earlier GDM diagnosis, use of diabetes medications during pregnancy, and more provider contacts after delivery were independent predictors of postpartum screening. Obesity and higher parity were independently associated with lower screening performance. Among women who had postpartum screening, the age- and race/ethnicity-adjusted proportion of IFG did not change over time (24.2 [95% CI 20.0–27.8] in 1995–1997 to 24.3 [22.6–26.0] in 2004–2006), but the proportion of women with diabetes decreased from 6.1 (95% CI 4.2–8.1) in 1995–1997 to 3.3 (2.6–4.0) in 2004–2006. Among women who received an OGTT in 2006, 38% of the 204 women with either diabetes or pre-diabetes were identified only by the 2-h glucose measurements.

CONCLUSIONS — Postpartum screening has increased over the last decade, but it is still suboptimal. Compared with FPGs alone, the 2-h values identify a higher proportion of women with diabetes or pre-diabetes amenable to intervention.

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Gestational diabetes mellitus (GDM) is defined as carbohydrate intolerance with onset of or first recognition during pregnancy. Postpartum diabetes screening may detect diabetes that preceded pregnancy and therefore enable early treatment of hyperglycemia, reducing the risk of adverse fetal outcomes in subsequent pregnancies (1) and maternal microvascular complications (2). Screening can also identify women who might benefit from diabetes prevention interventions (3,4).

Performance rates of postpartum diabetes screening have been low (5–7), but screening performance may have changed recently. At present, only one population-based report has examined postpartum diabetes screening practices, and this report examined fasting plasma glucose (FPG) only (8). We used data from a GDM registry in a large prepaid group practice managed health care organization (the Kaiser Permanente Medical Care Program in Northern California [KPNC]) and examined *1*) postpartum diabetes screening over time, *2*) predictors of postpartum screening in a detailed electronic medical record, *3*) trends in impaired fasting glucose (IFG) or diabetes detected with postpartum screening, and *4*) the proportion of women with diabetes or pre-diabetes identified by the FPG screen versus the proportion of women with these abnormal glucose values identified by the 75-g oral glucose tolerance test (OGTT).

RESEARCH DESIGN AND METHODS

— This study was developed and approved by the Steering Committee of the Translating Research Into Action for Diabetes (TRIAD) Study and conducted in one of TRIAD's six translational research centers, KPNC. KPNC is a group practice, prepaid health plan that provides comprehensive medical services through 17 hospitals and 23 outpatient clinics to >3 million members located in a 14-county region in Northern California (~30% of the general population in the geographic areas covered). The KPNC membership closely approximates the population living in the same geographic area demographically except with respect to income: KPNC members underrepresent the very poor and the very wealthy (9,10). Upon comparison with regional birth certificates over a 14-year period, there were no meaningful differences between women who delivered at a KPNC hospital and women who delivered in the underlying region regarding age at delivery or race, except that women who de-

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livered at a KPNC hospital were slightly less likely to be Hispanic (25.8 vs. 32.0%).

We used the KPNC GDM registry (11) to identify women with GDM who delivered between 1 January 1995 and 31 December 2006. During this 12-year period, the proportion of women who had been screened for GDM with a 50-g, 1-h oral challenge test during the second trimester increased by ~3% over time (age- and race/ethnicity-adjusted proportions 92.5 [95% CI 92.3–92.7] in 1995–1997 vs. 95.7 [95.6–95.9] in 2004–2006). If results were abnormal (1-h plasma glucose levels ≥7.8 mmol/l [140 mg/dl]), this test was followed by a standard diagnostic 100-g, 3-h OGTT. We identified 14,448 pregnancies that had a diagnosis of GDM from a health provider and with plasma glucose results during the index pregnancy that met the National Diabetes Data Group (NDDG) criteria on the 3-h 100-g OGTT for GDM, i.e., ≥2 glucose values at or exceeding the following thresholds: fasting, 105 mg/dl; 1 h, 190 mg/dl; 2 h, 165 mg/dl; and 3 h, 145 mg/dl (12,13) without recognized preexisting diabetes (14). We included only women who met the NDDG criteria of GDM because, in this clinical setting, the NDDG criteria were used for diagnosis of GDM until January 2007. We also required that these women had a diagnosis of GDM. Approximately 550 women had no diagnosis of GDM but met the NDDG criteria (equivalent to 4% of the size of our GDM cohort with a diagnosis); women without a diagnosis of GDM were excluded from the analysis.

For the first and second aims, the primary outcome was performance of postpartum screening for diabetes by either an FPG test alone or a 75-g, 2-h OGTT. Because several weeks may elapse before glucose metabolism returns to normal in most women with GDM (15), the American Diabetes Association (16) and the American College of Obstetricians and Gynecologists (17) both recommend that postpartum glucose screening be performed at 6 weeks postpartum or later. We considered the postpartum screening performed only if it was done during the first year after delivery starting from 6 weeks and if the woman was not pregnant again. For the third aim, the outcome was the proportion of women identified with either IFG (defined as an FPG ≥100 mg/dl but <126 mg/dl) or diabetes diagnosed by FPG ≥126 mg/dl (18). Among women who had postpartum screening, the proportion receiving the OGTT changed over time. Therefore, when we report on trends in postpartum conversion to diabetes, we report only on the fasting values detected by either an FPG or an OGTT. For the fourth aim, we examined the proportion of women who were identified as having pre-diabetes on the postpartum screen (that included IFG as defined above and impaired glucose tolerance [IGT] defined as a 2-h plasma glucose value ≥140 mg/dl) or diabetes (defined as an FPG >126 mg/dl or a 2-h plasma glucose value ≥200 mg/dl) (18).

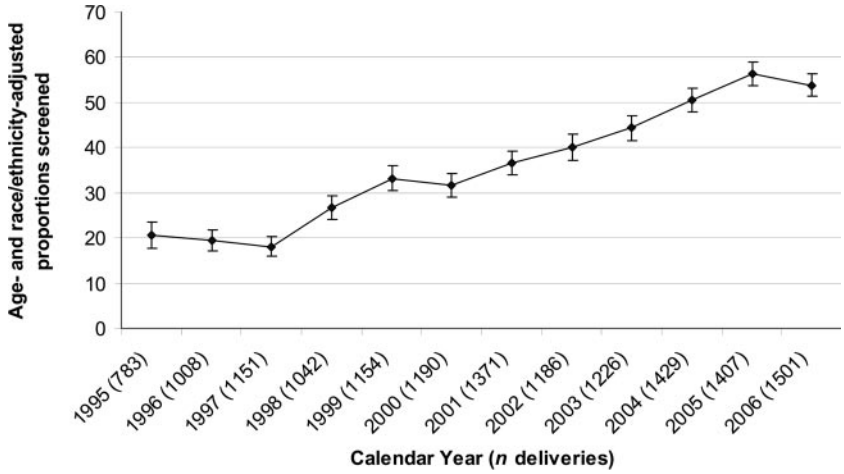

Figure 1—*Age- and race/ethnicity-adjusted proportions of postpartum screening for diabetes among women with histories of GDM by year of delivery. The KPNC GDM registry: 1995–2006.*

Age, gestational age at delivery, race/ethnicity, maternal body weight during the beginning of the second trimester, and gestational age at GDM diagnosis were ascertained from the computerized medical records at birth. Use of insulin or glyburide during pregnancy was obtained from the pharmacy database. Because we had data on body weight but not on height, a woman was considered obese if her weight was ≥90th percentile of the weight distribution of women of her race/ethnicity in this study population. Infant birth weight was obtained from the electronic medical record. Macrosomia was defined as birth weight >4,000 g. Data on annual household income were based on census block data. Education and parity were obtained by linkage with the state of California birth certificate database. Because the lag time before state birth certificates became available is ~3 years, we have these variables for women who delivered between 1995 and 2004.

Statistical analysis

The yearly age- and race/ethnicity-adjusted proportion of women with GDM who had postpartum glucose screening and 95% CIs were calculated by the direct method, in which the age and race/ethnicity distribution of the entire study population was used as the standard. Among women who had postpartum screening, the direct method was used to calculate the yearly age- and race/ethnicity-adjusted rates of IFG and diabetes diagnosed by FPG.

Predictors of postpartum screening were examined in a multivariable logistic regression model adjusted for age, race/ethnicity, education, income, obesity, parity, gestational age at GDM diagnosis, glyburide and insulin use during pregnancy, a macrosomic infant at the index pregnancy, visits to an internal medicine or obstetrics/gynecology provider during the postpartum period, year of delivery, and medical facilities. SAS (version 9.1; SAS Institute, Cary, NC) was used for all analyses. This study was approved by the human subjects committee of the Kaiser Foundation Research Institute.

RESULTS

Trends in postpartum screening with FPG performed alone or with an OGTT

We identified 14,448 pregnancies complicated by GDM occurring between 1995 and 2006 among KPNC members who were aged 15–44 years and delivered live infants or had still births. These pregnancies occurred among 13,547 women, because 901 had more than one pregnancy during the 12-year study period. The mean ± SD age of women with GDM was 32.3 ± 5.4 years. The percentage of women with GDM pregnancies who re-

ceived a postpartum glucose screening test increased from 1995 (20.3%) to 2006 (55.9%).

Between 1995 and 2006, the age of women with GDM increased slightly (28.2 ± 5.7 to 28.8 ± 6.0 years) and the proportion of women with GDM who were Hispanic increased markedly. The race/ethnicity distributions in 1995 versus 2006 were as follows: 60.7 and 43.4% white, 14.5 and 15.4% Asian, 14.1 and 24.9% Hispanic, 6.7 and 6.7% African American, 2.0 and 4.4% other, and 2.0 and 5.2% unknown. Changes in the demographics represent changes in the entire population with GDM, regardless of performance of diagnostic screening. After adjustment for age and race/ethnicity, the proportion of women with GDM who received a postpartum glucose screening increased steadily over time from 20.7% (95% CI 17.8–23.5) in women who delivered in 1995 to 53.8 (51.3–56.3) in women who delivered in 2006 (Fig. 1).

Predictors in postpartum screening

Unadjusted characteristics of women by postpartum screening status are illustrated in Table 1. In a multiple-adjusted logistic regression model (Table 2), older age, Asian or Hispanic race/ethnicity, higher education, at least two prior births, earlier gestational age at GDM diagnosis, use of insulin or glyburide during pregnancy, and visits to an internal medicine or obstetrics/gynecology provider during the postpartum period were independent and significant predictors of postpartum screening. Obesity and higher parity were significantly associated with less frequent screening.

Trends in postpartum IFG and diabetes

On the basis of FPG (either performed alone or as part of the OGTT), 3.5% (n = 191) had diabetes and 22.0% (n = 1,228) had IFG. The proportion of women with IFG postpartum remained similar over time, but the proportion of women with diabetes decreased from 1995–1997 to 1998–2000 and then leveled off (Fig. 2). Among women who delivered in 1995–1997, 564 were screened at postpartum, and 131 had IFG and 32 had diabetes by FPG (age- and race/ethnicity-adjusted rates 24.2 [95% CI 20.–27.8] and 6.1 [4.2–8.1], respectively). Among women who delivered in 2004–2006, 2,381 women were screened, and 583 had IFG and 80 had diabetes by FPG (age- and

Table 1—*Characteristics of women with a history of GDM by postpartum glucose screening status: KPNC GDM registry: 1995–2006*

	Without postpartum glucose screening	With postpartum glucose screening	*P*
n	8,924	5,524	
Age (years)			<0.0001
<25	9.4	5.4	
25–35	64.1	63.0	
≥36	26.6	31.6	
Race/ethnicity			<0.0001
Non-Hispanic white	34.8	28.0	
African American	5.6	3.2	
Asian	23.2	31.3	
Hispanic	24.6	27.1	
Other	4.8	5.6	
Unknown	7.0	4.8	
Education			<0.0001
Less than high school	12.2	11.7	
High school graduate	29.9	24.4	
2-year college	23.4	20.9	
4-year college	21.5	26.4	
Postgraduate degree	11.3	15.2	
Unknown	1.8	1.5	
Annual household income			0.0003
<$30,000	6.6	4.4	
$30,000–59,000	43.3	38.0	
$60,000–99,000	39.8	44.5	
≥$100,000	4.9	6.8	
Unknown	5.4	6.3	
Parity			0.0003
0	37.4	40.4	
1	32.5	32.8	
≥2	30.1	26.8	
Obese	10.4	8.9	<0.0001
Gestational age at GDM diagnosis (weeks)			<0.0001
<20	8.4	13.7	
20–24	3.9	4.8	
25–30	57.2	63.9	
31–37	26.4	14.0	
≥38	0.7	0.2	
Unknown	3.5	3.4	
Plasma glucose at the 100-g OGTT			
Fasting			0.29
<95 mg/dl	58.0	58.0	
≥95 but <105 mg/dl	20.3	21.2	
≥105 mg/dl	21.7	20.9	
1-h			0.16
<180 mg/dl	10.5	9.6	
≥180 but <190 mg/dl	5.9	5.7	
≥190 mg/dl	83.5	84.6	
2-h			0.85
<155 mg/dl	5.5	5.4	
≥155 but <165 mg/dl	3.3	3.2	
≥165 mg/dl	91.1	91.4	
3-h			0.99
<140 mg/dl	46.7	46.7	
≥140 but <145 mg/dl	4.4	4.4	
≥145 mg/dl	49.0	49.0	
Diabetes medication during pregnancy			
Insulin	12.6	15.2	<0.0001
Glyburide	6.4	13.9	<0.0001
Macrosomic infant delivered	15.5	13.8	0.014

Table 2—*Multiple adjusted logistic regression model predicting postpartum glucose screening among women with history of GDM: the KPNC GDM registry: 1995–2006*

	Odds ratio (95% CI)
Age (years)	
<25	1.00
25–35	1.43 (1.23–1.67)
≥36	1.80 (1.52–2.14)
Race	
Non-Hispanic white	1.00
African American	0.86 (0.70–1.05)
Asian	1.36 (1.23–1.51)
Hispanic	1.37 (1.23–1.52)
Other/missing	1.10 (0.96–1.27)
Education	
Less than high school	1.02 (0.87–1.19)
High school graduate	1.00
2-year college	1.03 (0.91–1.17)
4-year college	1.22 (1.08–1.38)
Postgraduate education	1.21 (1.04–1.40)
Parity	
0	1.00
1	0.93 (0.84–1.03)
≥2	0.82 (0.74–0.92)
Income	
<$30,000	1.00
$30,000–59,000	1.04 (0.87–1.24)
$60,000–99,000	1.07 (0.89–1.28)
≥$100,000	1.24 (0.98–1.57)
Obese	
No	1.00
Yes	0.73 (0.63–0.86)
Gestational age at diagnosis of GDM (weeks)	
<20	1.00
20–24	0.89 (0.72–1.09)
25–30	0.90 (0.79–1.02)
31–37	0.55 (0.47–0.63)
≥38	0.30 (0.14–0.62)
Insulin use during pregnancy	1.51 (1.35–1.69)
Glyburide use during pregnancy	1.27 (1.12–1.45)
Macrosomic infant delivered	
No	1.00
Yes	1.01 (0.90–1.12)
Postpartum visits	
0 visits	1.00
1 visit	2.48 (1.95–3.16)
≥2 visits	4.85 (3.86–6.10)

race/ethnicity-adjusted rates 24.3 [22.6–26.0] and 3.3 [2.6–4.0], respectively).

Proportion of women with diabetes and pre-diabetes on the basis of FPG alone versus OGTT

The proportion of women receiving an OGTT increased from 1995 (5.0%) to 2005 (16.6%) and markedly increased in 2006 (71.5%). In 2006, KPNC instituted a nurse managed care program that included greater attention to postpartum screening guidelines. Among the 600 women who underwent a 75-g OGTT in 2006, 16 had diabetes at postpartum. Diabetes was diagnosed in 4 (25%) by FPG alone. Of the remaining 12 women, 8 (50%) had IFG and 4 (25%) had normal FPG. Of the 188 women who were found to have pre-diabetes (i.e., either IFG or IGT according to the fasting or 2-h glucose values measured during the 75-g OGTT), only 114 (60%) were diagnosed with IFG; 74 (40%) would have been classified as having normal glucose tolerance on the basis of FPG alone. Therefore, 78 (38%) of the 204 women with either diabetes or pre-diabetes were identified only by the 2-h glucose measurements.

CONCLUSIONS — In a managed care plan with a large number of women with GDM pregnancies, we found that between 1995 and 2006, screening for postpartum diabetes increased from 20.7 to 53.8%. The increase in screening performance is not likely to be due to advancing maternal age or changes in the racial/ethnic composition of women with GDM, as this trend in screening performance was similar after adjustment for age and race/ethnicity, and almost the entire population of pregnant women was screened for GDM between 1995 and 2006. Although the proportion of women with IFG on their postpartum screen did not significantly change over time, the proportion of women with diabetes (diagnosed by FPG levels) at postpartum decreased by ~50%. This observed decrease in diabetes among women with postpartum screening is not likely to be a consequence of the small increase (3%) in GDM screening over time. The decrease is more likely because of better identification of diabetes before pregnancy, as suggested by the reported increase in postpartum screening among women with GDM and because of an increase in glucose screening in postpartum women without GDM (1.9% in 1995 vs. 8.2% in 2006).

As in other reports (5–8), the majority of women in our cohort did not undergo postpartum diabetes screening in the early years of the study. Asian and Hispanic women were more likely to undergo postpartum screening. It is possible that health care providers might have recommended more postpartum screening among these racial/ethnic groups, given their higher prevalence of diabetes (19). It is also possible that Asian women were more likely to have had a recent physical examination, giving the health care provider the opportunity to recommend screening, as suggested by racial/ethnic differences in access to care among GDM women (20). Similar to other reports, we found that greater contact with medical care, either through a postpartum visit or other contacts, was associated with greater postpartum screening and may have provided additional opportunities to perform screening (6,7). Women who were more likely to be screened also were

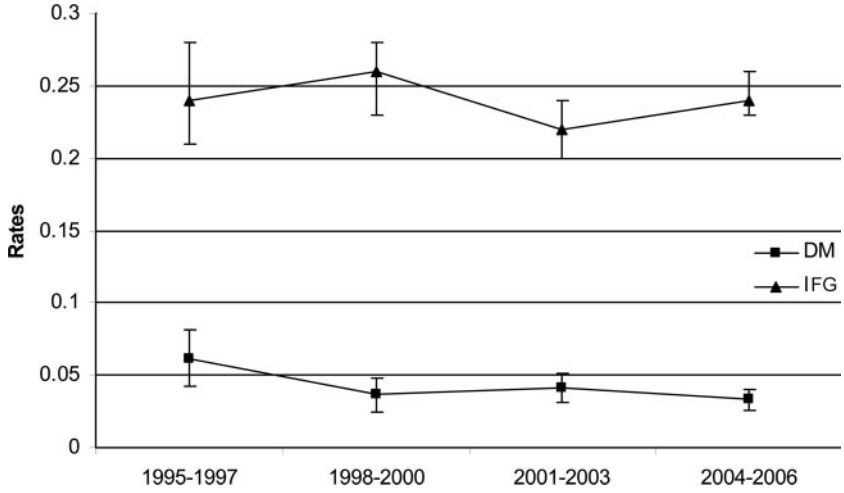

Figure 2—*Age- and race/ethnicity-adjusted proportions of diabetes (DM) or IFG on a fasting glucose measure during postpartum screening among women with histories of GDM. The KPNC GDM registry: 1995–2006.*

older and had higher educational attainment. Although reasons are speculative, these women may have had greater awareness of their diabetes risk and the recommendation for screening. In women who were screened postpartum, GDM was diagnosed earlier in their index pregnancy, and they were more likely to have been treated with medications, which may have increased their and their provider's awareness of their diabetes risk. Glucose levels on the diagnostic 3-h OGTT during pregnancy were similar in women who were and were not screened, suggesting that these were not used to guide testing. As shown by others (21), there was a suggestion that some of the women with a history of GDM who might have had a higher risk of developing diabetes during the postpartum period, such as those who were obese or with higher parity, were less likely to perform postpartum screening.

The American Diabetes Association (16), the American College of Obstetricians and Gynecologists (17), and the Fifth International Congress Workshop for Gestational Diabetes (15) endorse the postpartum OGTT and FPG to different extents. If only FPG were used in postpartum screening, 74 (40%) cases of IGT and 16 (75%) cases of diabetes would have been missed. Kitzmiller et al. (19) reported that among 527 women with GDM, at postpartum 16.5% had isolated IGT, only 16% of women in whom diabetes was diagnosed met the criteria for both elevated FPG and 2-h values, and 21 of 25 women met the criteria for diabetes according to their 2-h values alone. Hunt and Conway (21) also reported that one-third of their postpartum GDM cohort undergoing the OGTT and who had diabetes or pre-diabetes had isolated 2-h elevations. Their results are very similar to those found in this study: 78 of 204 women compared with 41 of 117 (or 38% vs. 35%). Therefore, the greater convenience of the FPG needs to be weighed carefully against its decreased sensitivity, particularly among women with a history of GDM.

This report has several limitations. We were not able to distinguish whether the lack of screening occurred because of a lack of provider order or other reasons. Such a distinction might have implications for interventions to improve screening performance. However, provider orders for screening might occur only after negotiation with the patient, and a lack of provider order may, at least in part, reflect women's objections to the test. We defined obesity by using race/ethnicity-specific percentiles, rather than height-to-weight ratios, thus introducing the possibility for misclassification and artificially decreasing the association between obesity and screening to the null. Information on other confounders, such as family history of diabetes, was not available from electronic records.

Because the population of women with GDM is of reproductive age, postpartum screening and subsequent diagnoses of diabetes affect not only the mothers but also future pregnancies. The risk of complications, particularly stillbirths and congenital abnormalities, may be reduced with optimal glycemic control before the subsequent pregnancy (1). Prepregnancy glycemic control might also reduce the risk of the infant to the in utero exposure to hyperglycemia that might lead to childhood obesity and diabetes (22). A diagnosis of pre-diabetes would identify women at high risk of future maternal diabetes, but this risk could be reduced through the application of interventions such as thiazolidinediones, metformin, or intensive lifestyle modification (3,4).

We conclude that, among women with a GDM history, postpartum diabetes screening has increased, but screening is still suboptimal. Performance of an FPG alone, as opposed to the OGTT, will miss a subpopulation of women at risk. Interventions that increase postpartum screening performance are needed.

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No potential conflicts of interest relevant to this article were reported.

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