Prevalence and Timing of Postpartum Glucose Testing and Sustained Glucose Dysregulation After Gestational Diabetes Mellitus

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OBJECTIVE — To estimate the prevalence of postpartum glucose testing within 6 months of pregnancies complicated by gestational diabetes mellitus (GDM), assess factors associated with testing and timing of testing after delivery, and report the test results among tested women.

RESEARCH DESIGN AND METHODS — This was a retrospective study of 11,825 women who were identified as having GDM using the 100-g oral glucose tolerance test (OGTT) from 1999 to 2006. Postpartum testing (75-g 2-h OGTT or fasting plasma glucose [FPG]) within 6 months of delivery and test results from laboratory databases are reported. Postpartum test results are categorized as normal, impaired fasting glucose (IFG) and/or impaired glucose tolerance (IGT), and provisionally diabetic.

RESULTS — About half (n = 5,939) the women were tested with either a FPG or 75-g OGTT from 7 days to 6 months postpartum. Of these women, 46% were tested during the 6- to 12-week postpartum period. Odds of testing were independently associated with age, race/ethnicity, household income, education, foreign-born status, parity, mode of delivery, having a postpartum visit, having GDM coded at discharge, and pharmacotherapy for GDM. Of the 5,857 women with test results, 16.3% (n = 956) had IFG/IGT and 1.1% (n = 66) had provisional diabetes. After adjustment for demographic and clinical factors, abnormal postpartum test results was associated with having required insulin, glyburide, or metformin during pregnancy and with longer period from delivery to postpartum testing.

CONCLUSIONS — After a pregnancy complicated by GDM, automated orders for postpartum testing with notification to physicians and electronically generated telephone and e-mail reminder messages to patients may improve the rates of postpartum testing for persistence of glucose intolerance.

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Gestational diabetes mellitus (GDM) is defined as any degree of glucose intolerance with onset or first recognition during pregnancy (1). GDM complicates 4–14% of pregnancies in the U.S. annually, with the prevalence varying significantly with the demographics of the population studied, as well as differences in the study methods (2–6). Women with GDM are at increased risk of GDM recurrence (7). Furthermore, the risk of type 2 diabetes after GDM ranges from 2 to 70% depending on the population being studied and the length of follow-up (8).

The American Diabetes Association (ADA) (9) and the American College of Obstetricians and Gynecologists (ACOG) (10,11) recommend that women with GDM be tested for glucose intolerance from 6 to 12 weeks postpartum. Timely detection of impaired fasting glucose (IFG) and impaired glucose tolerance (IGT) may provide an opportunity to prevent or delay the onset of type 2 diabetes through diet, physical activity, weight management, and/or pharmacological intervention. However, only a fraction of women who have GDM are tested during the postpartum period (12–17).

To assess the prevalence of postpartum glucose testing among women with a recent history of GDM, we examined the proportion of women who had glucose testing in the postpartum period and the demographic, clinical, and health system–related factors that were associated with being tested, as well as the timing of postpartum testing, in a racially/ethnically diverse sample of women from a managed health care organization. Additionally, we reported the prevalence of women tested who had impaired glucose regulation (IFG and/or IGT and a provisional diagnosis of diabetes) and the demographic and clinical characteristics of these women that were associated with having these results.

RESEARCH DESIGN AND METHODS

Population and data sources

The Kaiser Permanente Southern California (KPSC) Medical Care Program is a large prepaid group-practice managed health care organization with over 3.2 million members. Members receive their health care in KPSC-owned facilities throughout the seven-county region. This study was approved by the KPSC institutional review board. The study population consisted of women who had one or more singleton births at ≥20 weeks gestation in KPSC hospitals, who were identified as having GDM using the 100-g oral glucose tolerance test (OGTT) from 1 January 1999 through 31 December 2006, and who remained KPSC members for at least 6 months postpartum. One randomly selected pregnancy was included in the analyses for women who had had

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more than one GDM-affected pregnancy during the study period. Of the women in the final sample, 3% had more than one GDM-affected pregnancy during the study period.

Identification of women with GDM

An algorithm using outpatient encounter and inpatient hospitalization codes, laboratory test results, and pharmacy prescription records was applied to identify women with evidence of diabetes before pregnancy (2,18). After excluding these women, we used the results from the 100-g 3-h OGTT to identify women who had had GDM based on at least two abnormal plasma glucose measurements greater than or equal to the Carpenter and Coustan threshold values recommended by the ADA (fasting 95 mg/dl, 1-h 180 mg/dl, 2-h 155 mg/dl, 3-h 140 mg/dl) (19).

Postpartum glucose testing

Women who had a 2-h 75-g OGTT or fasting plasma glucose (FPG) alone in the period from 7 days to 6 months postpartum were considered "tested," while women without testing or those with only a random (nonfasting) plasma glucose during this period were considered "not tested" for the purposes of this study. Time to first OGTT or FPG after delivery was calculated by determining the number of days from the infant birth date to the first testing date. We further categorized tested women based on timing of their first test as 7 days postpartum up to 6 weeks postpartum ("early" testing window), 6–12 weeks postpartum ("ADA-recommended" testing window) (9,10), and after 12 weeks through 6 months postpartum ("late" testing window).

Categorization of postpartum glucose testing results

Using the ADA criteria, we defined women with an FPG (whether alone or as part of a 75-g OGTT) <100 mg/dl as normal, 100–125 mg/dl as IFG, and ≥126 mg/dl as having a provisional diagnosis of diabetes (1). Categories based on the glucose concentration 2 h after a 75-g postglucose load were as follows: <140 mg/dl normal, 140–199 mg/dl IGT, and ≥200 mg/dl provisionally diabetic. Women with IFG and/or IGT (IFG/IGT) were combined into one category. For women with more than one test during the follow-up period during separate visits, the outcome is reported based on the most abnormal test result.

Other measures

Information derived from the infants' birth certificates that were included in these analyses included maternal age, race/ethnicity (categorized as Hispanic [regardless of race], white, black, Asian, or Pacific Islander [Asian/PI] and all "others"), country of birth (U.S. or foreign born), infant birth weight, and gestational age at delivery. Median household income was based on the estimated median household income in the census block group in which the woman resided. Pharmacotherapy for GDM was defined as having one or more prescriptions filled for oral hyperglycemia agents (metformin or glyburide) and/or insulin at a KPSC pharmacy during pregnancy. GDM was considered noted in the medical record if the *International Classification of Diseases* (ICD) code 648.8 was included among the discharge diagnoses after delivery. The postpartum visit was defined as a clinical visit with a physician, certified nurse midwife, or nurse practitioner in the obstetrics and gynecology department from 6–12 weeks postpartum.

Statistical analysis

We estimated the prevalence of postpartum glucose testing by dividing the number of women with postpartum glucose testing giving birth that year by the total number of women with GDM pregnancies giving birth during that year. We examined the associations between demographic, clinical, and health care–related characteristics and postpartum glucose testing (yes/no) and time to first postpartum glucose test after delivery (7 days to <6 weeks, 6–12 weeks, >12 weeks to 6 months). Associations between categorical variables and postpartum outcomes were assessed using χ^2 tests. Multiple logistic regression models were used to calculate the adjusted odds ratio (OR) and corresponding 95% CIs to assess the associations between demographic, clinical, and health care–related characteristics and postpartum glucose testing.

Among women with a postpartum glucose test, we examined the associations between these characteristics and postpartum test results (normal, IFG/IGT, or diabetes). We also explored the mean fasting, 1-h, 2-h, and 3-h values from the 100-g 3-h OGTT during pregnancy and postpartum glucose testing (yes/no), timing of postpartum testing, and outcomes of postpartum testing. Differences were evaluated using the Student's *t* tests and one-way ANOVA in conjunction with Tukey's honestly significant difference to account for multiple comparisons.

The associations between the postpartum test result (normal, IFG/IGT, diabetes) and the timing of postpartum testing and pharmacological GDM treatment, respectively, were examined using multinomial logistic regression to adjust for maternal demographic characteristics as well as year of delivery. Women with normal postpartum glucose values served as the reference group. Age was treated as a linear ordinal variable in 5-year increments. ORs and 95% CIs are reported. Analyses were performed with SAS version 9.1 (SAS Institute, Cary, NC).

RESULTS

Postpartum glucose testing

Of the 11,825 women with a GDM-affected pregnancy during the 8-year study period, just over half (50.2%; n = 5,939) had at least one FPG or 75-g OGTT during the 6-month postpartum period (Table 1). Of the tested women, 2,458 (41.4%) were first tested during the early window, 2,749 (46.3%) during the ADA recommended 6- to 12-week window, and 732 (12.3%) during the late window (Table 1); 79.1% were tested with FPG only, 18.2% were assessed with a 75-g OGTT, and 2.7% were given both tests. Approximately 7% (n = 408) of these women were tested more than once in the 6 months postpartum, although repeated testing was not found to be contingent upon the results of the first test (data not shown).

In the unadjusted analyses, demographic, clinical, health care characteristics, and year of delivery were all significantly associated with testing (Table 1). Timing of the first postpartum test was significantly associated with all demographic variables except age and income tertile, all clinical variables except parity, and year of delivery. In the multiple logistic regression model (Table 1), odds of testing increased with increasing maternal age, education, and income and were higher for foreign-born women compared with U.S.-born women. The odds of testing decreased with increasing parity and were lower for women who were black or white compared with Hispanic women, for women with cesarean deliveries, and for women with babies weighing ≥4,000 g. Women who were treated with insulin (± oral agents) had

Table 1—*Characteristics of 11,825 women with GDM, proportion of women having postpartum glucose testing, timing of first test, and adjusted OR and 95% CI for testing during the 6 months postpartum in KPSC clinics, 1999–2006*

	All women with GDM	Testing after hospital discharge to 6 months postpartum				Timing of first test among 5,939 tested women			
	Total n = 11,825 (%)‡	Tested n = 5,939 (%)§	Not tested n = 5,886 (%)§	P*	Adjusted OR (95% CI)†	7 days to <6 weeks n = 2,458 (%)§	6 to 12 weeks n = 2,749 (%)§	>12 weeks to 6 months n = 732 (%)§	P*
Demographics									
Age (years)				<0.0001					
13–19	144 (1.2)	47 (32.6)	97 (67.4)		0.47 (0.32–0.68)	17 (36.2)	23 (48.9)	7 (14.9)	
20–24	889 (7.5)	354 (39.8)	535 (60.2)		0.64 (0.55–0.75)	144 (40.7)	162 (45.7)	48 (13.6)	
25–29	2,806 (23.7)	1,349 (48.1)	1,457 (51.9)		0.88 (0.80–0.98)	548 (40.6)	646 (47.9)	155 (11.5)	
30–34	3,971 (33.6)	2,032 (51.2)	1,939 (48.8)		Referent	877 (43.2)	912 (44.9)	243 (12.0)	
35–39	3,035 (25.7)	1,643 (54.1)	1,392 (45.9)		1.20 (1.10–1.33)	668 (40.7)	766 (46.6)	209 (12.7)	
≥40	980 (8.3)	514 (52.4)	466 (47.6)		1.16 (1.00–1.34)	204 (39.7)	240 (46.7)	70 (9.6)	
Race/ethnicity				<0.0001					<0.0001
Hispanic	6,144 (52.0)	3,139 (51.1)	3,005 (48.9)		Referent	1,294 (41.2)	1,484 (47.3)	361 (11.5)	
Black	804 (6.8)	219 (27.2)	585 (782.8)		0.37 (0.31–0.44)	63 (28.8)	96 (43.8)	60 (27.4)	
Asian/Pacific Islander	2,259 (19.1)	1,333 (59.0)	926 (41.0)		1.00 (0.89–1.12)	616 (46.2)	575 (43.1)	142 (10.7)	
Other/unknown	134 (1.1)	64 (47.8)	70 (52.2)		0.84 (0.59–1.19)	24 (37.5)	28 (43.7)	12 (18.8)	
Non-Hispanic white	2,484 (21.0)	1,184 (47.7)	1,300 (52.3)		0.79 (0.71–0.89)	461 (38.9)	566 (47.8)	157 (13.3)	
Highest education				<0.0001					0.0018
<High school	1,771 (15.0)	874 (49.4)	897 (50.6)		1.03 (0.90–1.16)	367 (42.0)	403 (46.1)	104 (11.9)	
High school graduate	3,345 (28.3)	1,561 (46.7)	1,784 (53.3)		Referent	602 (38.6)	754 (48.3)	205 (13.1)	
>High school graduate	6,194 (52.4)	3,281 (53.0)	2,913 (47.0)		1.12 (1.02–1.23)	1,419 (43.3)	1,477 (45.0)	385 (11.7)	
Unknown	515 (4.3)	223 (43.3)	292 (56.7)		1.04 (0.68–1.60)	70 (31.4)	115 (51.6)	38 (17.0)	
Median household income tertile				<0.0001					0.1968
Highest	3,887 (32.9)	2,140 (55.1)	1,747 (44.9)		1.44 (1.31–1.60)	877 (41.0)	1,025 (47.9)	238 (11.1)	
Middle	3,871 (32.7)	1,977 (51.1)	1,894 (48.9)		1.26 (1.14–1.38)	832 (42.1)	903 (45.7)	242 (12.2)	
Lowest	3,925 (33.2)	1,754 (44.7)	2,171 (55.3)		Referent	719 (41.0)	793 (45.2)	242 (13.8)	
Unknown	142 (1.2)	68 (47.9)	74 (52.1)		1.20 (0.84–1.70)	30 (44.1)	28 (41.2)	10 (14.7)	
Country of birth				<0.0001					0.0004
U.S.	5,238 (44.3)	2,374 (45.3)	2,864 (54.7)		Referent	946 (39.9)	1,116 (47.0)	312 (13.1)	
Outside U.S.	6,163 (52.1)	3,383 (54.9)	2,780 (45.1)		1.30 (1.18–1.42)	1,457 (43.1)	1,540 (45.5)	386 (11.4)	
Unknown	424 (3.6)	182 (42.9)	2,429 (57.1)		0.70 (0.43–1.13)	55 (30.2)	93 (51.1)	34 (18.7)	
Clinical									
Parity				<0.0001					0.4107
0	4,167 (35.2)	2,213 (53.1)	1,954 (46.9)		Referent	939 (42.4)	1,017 (46.0)	257 (11.6)	
1	3,617 (30.6)	1,866 (51.6)	1,751 (48.4)		0.90 (0.82–0.99)	774 (41.5)	865 (46.4)	227 (12.2)	
≥2	4,040 (34.2)	1,860 (46.0)	2,180 (54.0)		0.66 (0.59–0.73)	745 (40.1)	867 (46.6)	248 (13.3)	
Unknown	1 (0.0)	0 (0.0)	1 (100.0)		NA				

Table 1—*Continued*

	All women with GDM	Testing after hospital discharge to 6 months postpartum				Timing of first test among 5,939 tested women			
	Total $n = 11,825$ (%)‡	Tested $n = 5,939$ (%)§	Not tested $n = 5,886$ (%)§	P*	Adjusted OR (95% CI)†	7 days to <6 weeks $n = 2,458$ (%)§	6 to 12 weeks $n = 2,749$ (%)§	>12 weeks to 6 months $n = 732$ (%)§	P*
Pharmacological GDM treatment				0.0060					<0.0001
None	9,001 (76.1)	4,530 (50.3)	4,471 (49.7)		Referent	1,920 (42.4)	2,135 (47.1)	475 (10.5)	
Insulin (+/− oral agents)	2,418 (20.5)	1,236 (51.1)	1,182 (48.9)		1.07 (0.98–1.18)	473 (38.3)	539 (43.6)	224 (18.1)	
Oral agents only	406 (3.4)	173 (42.6)	233 (57.4)		0.65 (0.53–0.80)	65 (37.6)	75 (43.3)	33 (19.1)	
Mode of delivery				0.4602					<0.0001
Cesarean	3,634 (30.7)	1,794 (49.4)	1,840 (50.6)		0.90 (0.82–0.97)	672 (37.5)	868 (48.4)	254 (14.2)	
Vaginal	8,046 (68.1)	4,071 (50.6)	3,975 (49.4)		Referent	1,769 (43.5)	1,837 (45.1)	465 (11.4)	
Unknown	145 (1.2)	74 (51.0)	71 (49.0)		1.50 (0.98–2.16)	17 (23.0)	44 (59.5)	13 (17.6)	
Infant birth weight				<0.0001					0.0007
<2,500 g	765 (6.5)	380 (49.7)	385 (50.3)		0.97 (0.83–1.13)	140 (36.8)	171 (45.0)	69 (18.2)	
2,500–3,999 g	9,681 (81.9)	4,944 (51.1)	4,737 (48.9)		Referent	2,072 (41.9)	2,301 (46.5)	571 (11.6)	
≥4,000 g	1,379 (11.6)	615 (44.6)	764 (55.4)		0.83 (0.74–0.93)	246 (40.0)	277 (45.0)	92 (15.0)	
Health care									
GDM coded (648.8)				<0.0001					0.2173
Yes	9,904 (83.8)	5,199 (52.5)	4,705 (47.5)		Referent	2,173 (41.8)	2,393 (46.0)	633 (12.2)	
No	1,921 (16.2)	740 (38.5)	1,181 (61.5)		0.61 (0.55–0.68)	285 (38.5)	356 (48.1)	99 (13.4)	
Postpartum visit				<0.0001					0.4415
Yes	11,164 (94.4)	5,785 (51.8)	5,379 (48.2)		3.60 (2.98–4.35)	2,395 (41.4)	2,682 (46.4)	708 (12.2)	
No	661 (5.6)	154 (23.3)	507 (76.7)		Referent	63 (40.9)	67 (43.5)	24 (15.6)	
Year of delivery				<0.0001					<0.0001
1999	1,445 (12.2)	497 (34.4)	948 (65.6)		Referent	134 (27.0)	297 (59.8)	66 (13.3)	
2000	1,501 (12.7)	715 (47.6)	786 (52.4)		1.79 (1.53–2.09)	296 (41.4)	340 (47.6)	79 (11.0)	
2001	1,569 (13.3)	799 (50.9)	770 (49.1)		2.03 (1.74–2.37)	361 (45.2)	355 (44.4)	83 (10.4)	
2002	1,631 (13.8)	855 (52.4)	776 (47.6)		1.99 (1.71–2.32)	412 (48.2)	325 (38.0)	118 (13.8)	
2003	1,439 (21.2)	807 (56.1)	632 (43.9)		2.33 (1.99–2.73)	360 (44.6)	355 (44.0)	92 (11.4)	
2004	1,389 (11.7)	765 (55.1)	624 (44.9)		2.38 (2.03–2.79)	349 (45.6)	331 (43.3)	85 (11.1)	
2005	1,418 (12.0)	770 (54.3)	648 (45.7)		2.28 (1.95–2.68)	310 (40.3)	356 (46.2)	104 (13.5)	
2006	1,433 (12.1)	731 (51.0)	702 (49.0)		1.90 (1.61–2.23)	236 (32.3)	390 (53.3)	105 (14.4)	

*P value based on χ^2test for categorical variables; Fisher's exact test used for variables with any cell count <10. †ORs are simultaneously adjusted for all other variables shown. ‡The distribution of each variable within the population is shown as a column percent. §The proportions tested and not tested are shown as row percentages within each strata of the variable.

the same odds of being tested as those who did not receive pharmacotherapy, whereas women treated with oral agents alone were less likely to be tested. Finally, women who did not have GDM coded at discharge had 39% lower odds of being tested than those who were so coded. In contrast, the odds of postpartum testing were over three times greater for women who had a postpartum visit than for those who had not.

Women who had blood glucose testing postpartum had slightly lower mean fasting (91.4 vs. 92.8 mg/dl, $P < 0.0001$) and 3-h values (124.9 vs. 126.6 mg/dl, $P < 0.001$) on their 100-g OGTT performed during pregnancy than women who were not tested postpartum (supplementary Fig. 1, available in an online appendix at http://care.diabetesjournals.org/cgi/content/full/dc09-2095/DC1). The mean fasting glucose on the 100-g OGTT during pregnancy was similar for women tested during the early postpartum period and those tested during the 6- to 12-week period (90.9 and 90.8 mg/dl, respectively), whereas women tested in the late window had a higher mean fasting value during pregnancy (95.1 mg/dl, $P < 0.0001$) (supplementary Fig. 2).

Postpartum test results

Of the women tested for whom results were available ($n = 5,857$; 99%), 16.3% ($n = 956$) were classified as IFG/IGT and 1.1% ($n = 66$) as having diabetes. Of the 1,154 women who were given a 2-h 75-g OGTT postpartum, 810 (70.2%) had normal fasting and postchallenge values, 172 (14.9%) IFG only, 75 (6.5%) IGT only, 71 (6.2%) both IFG and IGT (for a total of 318 women [27.6%] with IFG and/or IGT), and 26 (2.3%) were found to have diabetes based on the fasting and/or 2-h values. Of the 1,065 women who were given a 2-h 75-g OGTT postpartum without a prior FPG test, 8.1% of 835 women with a normal FPG had an abnormal 2-h value (IGT = 7.9%, diabetes = 0.2%), and 16.7% of 921 women with normal 2-h values had an abnormal FPG (IFG = 16.5%, diabetes = 0.2%). Of the women who had an FPG only, 12.8% had IFG and 0.8% were found to have diabetes.

In the unadjusted analyses, demographic characteristics significantly associated with test result categories included all except country of birth (Table 2). OGTT values observed during pregnancy all differed significantly ($P < 0.001$) between the three postpartum glucose categories (supplementary Fig. 3). Both

Table 2—*Demographic, clinical, and health care–related characteristics associated with postpartum glucose test results among 5,857 women* who had GDM and who had postpartum glucose testing, 1999–2006*

	Normal‡	IFG/IGT‡	Presumptive diabetes‡	Unadjusted *P*†
n	4,835	956	66	
Demographics				
Age category (years)				0.0402
13–19	37 (78.7)	9 (19.2)	1 (2.1)	
20–24	283 (80.8)	64 (18.3)	3 (0.9)	
25–29	1,127 (84.3)	197 (14.7)	13 (1.0)	
30–34	1,682 (84.0)	294 (14.7)	27 (1.3)	
35–39	1,307 (80.9)	292 (18.1)	16 (1.0)	
≥40	399 (79.0)	100 (19.8)	6 (1.2)	
Race/ethnicity				0.0074
Hispanic	2,522 (81.4)	535 (17.3)	43 (1.4)	
Black	176 (80.4)	39 (17.8)	4 (1.8)	
Asian/Pacific Islander	1,078 (82.4)	218 (16.7)	12 (0.9)	
Non-Hispanic white	1,004 (86.1)	156 (13.4)	6 (0.5)	
Other	55 (85.9)	8 (12.5)	1 (1.6)	
Highest education				0.0033
<High school	674 (79.1)	167 (19.6)	11 (1.3)	
High school graduate	1,256 (81.1)	268 (17.3)	24 (1.6)	
>High school graduate	2,728 (84.3)	478 (14.8)	29 (0.9)	
Unknown	177 (79.7)	43 (19.4)	2 (0.9)	
Median household income				0.0002
Lowest	1,403 (80.5)	308 (17.7)	32 (1.8)	
Middle	1,589 (81.4)	343 (17.6)	19 (1.0)	
Highest	1,789 (85.3)	293 (14.0)	14 (0.7)	
Unknown	54 (80.6)	12 (17.9)	1 (1.5)	
Country of birth				0.6564
U.S.	1,963 (83.5)	365 (15.5)	24 (1.0)	
Outside U.S.	2,722 (81.9)	561 (16.9)	40 (1.2)	
Unknown	150 (82.4)	30 (16.5)	2 (1.1)	
Clinical				
Parity				0.0065
0	1,849 (84.3)	324 (14.8)	19 (0.9)	
1	1,523 (82.9)	291 (15.8)	23 (1.3)	
≥2	1,463 (80.0)	341 (18.7)	24 (1.3)	
Pharmacological GDM treatment				<0.0001
None	3,923 (88.0)	527 (11.8)	9 (0.2)	
Insulin (+/− oral agents)	789 (64.4)	385 (31.4)	51 (4.2)	
Oral agents only	123 (71.1)	44 (25.4)	6 (3.5)	
Infant birth weight				<0.0001
<2,500 g	287 (77.6)	78 (21.1)	5 (1.3)	
2,500–3,999 g	4,075 (83.5)	756 (15.5)	47 (1.0)	
≥4,000 g	473 (77.7)	122 (20.0)	14 (2.3)	
Health care				
Timing of glucose testing				<0.0001
7 days to <6 weeks	2,207 (85.0)	373 (6.4)	16 (0.6)	
6–12 weeks	2,258 (82.8)	443 (16.2)	27 (1.0)	
>12 weeks to 6 months	370 (69.4)	140 (26.3)	23 (4.3)	
Year				<0.0001
1999	331 (72.6)	120 (25.3)	5 (1.1)	
2000	542 (79.9)	128 (18.9)	8 (1.2)	
2001	655 (82.3)	133 (16.7)	8 (1.0)	
2002	734 (85.8)	110 (12.9)	11 (1.3)	
2003	698 (86.5)	100 (12.4)	9 (1.1)	
2004	637 (83.4)	121 (15.8)	6 (0.8)	
2005	635 (82.5)	128 (16.6)	7 (0.9)	
2006	603 (82.5)	116 (15.9)	12 (1.6)	

*Excludes 82 women who were tested but for whom test results were not available. †*P* value is for the χ^2 test for each variable separately for the three categories; Monte Carlo simulations for exact *P* values were used when any cell size was <10. ‡All percentages are shown as row percentages for outcome distribution within each covariate strata.

Table 3—*Adjusted OR and 95% CI for characteristics associated with postpartum glucose test result categories among 5,508 women with a history of GDM who had postpartum glucose testing, 1999–2006*

	IFG/IGT (n = 893) vs. normal (n = 4,552)*	Presumptive diabetes (n = 63) vs. normal (n = 4,552)*
Demographics		
Age category, per 5 years	1.02 (0.95–1.10)	0.97 (0.75–1.25)
Race/ethnicity		
Hispanic	Referent	Referent
Black	0.97 (0.73–1.30)	1.06 (0.46–2.48)
Asian/Pacific Islander	1.24 (1.05–1.45)	1.46 (0.82–2.61)
Non-Hispanic white	0.79 (0.66–0.94)	0.45 (0.23–0.91)
Highest education		
<High school	1.09 (0.95–1.26)	0.82 (0.50–1.36)
High school graduate	Referent	Referent
>High school graduate	0.89 (0.79–1.00)	0.91 (0.60–1.38)
Median household income		
Lowest	Referent	Referent
Middle	1.09 (0.98–1.21)	0.91 (0.62–1.33)
Highest	0.88 (0.78–0.98)	0.74 (0.48–1.13)
Clinical		
Parity		
0	Referent	Referent
1	0.97 (0.87–1.08)	1.04 (0.72–1.49)
≥2	1.09 (0.97–1.22)	0.99 (0.67–1.48)
Pharmacological GDM treatment		
None	Referent	Referent
Insulin (+/− oral agents)	1.57 (1.34–1.83)	3.30 (2.15–5.05)
Oral agents only	1.40 (1.09–1.81)	2.31 (1.22–4.36)
Infant birth weight		
<2,500 g	1.21 (0.99–1.48)	1.05 (0.51–2.16)
2,500–3,999 g	Referent	Referent
≥4,000 g	0.98 (0.82–1.16)	1.33 (0.78–2.25)
Health care		
Timing of glucose testing		
7 days to <6 weeks	0.74 (0.66–0.83)	0.42 (0.28–0.63)
6–12 weeks	Referent	Referent
>12 weeks to 6 months	1.55 (1.33–1.80)	3.13 (2.13–4.61)
Temporal trend, per 1 year	0.94 (0.91–0.98)	1.03 (0.91–1.16)

*Data are adjusted OR (95% CI) for the outcome of IFG and/or IGT and presumptive diabetes versus normal test results. Final model includes 5,508 observations with complete data for each covariate (94% of the sample with test results).

pharmacotherapy and time to postpartum test were highly associated with abnormal outcomes in the multinomial logistic regression analysis (Table 3). Women treated with insulin during pregnancy had 57% higher odds of IFG/IGT and were over three times as likely to have diabetes as women who did not take medication for GDM. Women who took oral agents only had 40% higher odds of having IFG/IGT and were over two times as likely to have diabetes. In addition, women tested before 6 weeks postpartum were 26% less likely to have IFG/IGT and 58% less likely to have diabetes than women tested between 6 and 12 weeks postpartum. In contrast, women who were tested from 12 weeks to 6 months postpartum were 55% more likely to have IFG/IGT and over three times as likely to have diabetes as were women tested from 6 to 12 weeks postpartum. The associations between postpartum testing period and GDM treatment and the test result categories remained highly significant, even after adjustment for the prenatal OGTT fasting values (data not shown)—the only prenatal value that differed by testing period (supplementary Fig. 2).

CONCLUSIONS — Among the membership of a large managed health care plan with a high prevalence of GDM, approximately one-half of women identified as having GDM had postpartum glucose testing in the 6 months after delivery. The majority of women (79%) tested in the 6 months postpartum had an FPG only. Only one-half of women who had postpartum glucose testing had their tests during the 6- to 12-week postpartum period recommended by the ADA. Postpartum testing and timing of testing were associated with demographic, clinical, and health care–related factors. Women whose treatment included insulin alone or insulin plus oral hypoglycemic agents had the same odds of being tested postpartum as those whose treatment did not include any pharmacologic agents. However, individuals treated with oral agents alone had lower odds for being tested than those who did not receive pharmacotherapy during pregnancy.

Of the women tested, a relatively small proportion (~1%) met the criteria for diabetes, while a greater proportion (~16%) had IFG and/or IGT. However, detection of IFG/IGT or diabetes was independently and positively associated with having been treated with insulin or oral agents during pregnancy and timing of postpartum glucose testing. While women tested between 12 weeks and 6 months postpartum had higher mean FPG during pregnancy compared with those tested in the early and ADA-recommended windows, the association between being tested in the later period and having abnormal results postpartum persisted after controlling for the prenatal FPG value.

The observation that women not tested postpartum had higher fasting and 3-h values during pregnancy suggests that if a larger number of women had been tested postpartum, a greater proportion of the entire sample of GDM women would have been found to be glucose intolerant postpartum. Furthermore, 79% were tested by FPG only. If a 75-g OGTT postpartum test had been consistently administered, the prevalence of diagnosed diabetes would most likely have increased (20). Of the women in our sample who had an OGTT postpartum with normal FPG results, 8% had IGT or diabetes based on their 2-h value.

Postpartum glucose testing

There has been significant heterogeneity across studies that have examined rates and correlates of postpartum glucose testing after GDM with respect to calendar years studied, time between delivery, and postpartum testing population (hospital-

based samples [12–14,17] versus managed care [15,16]) and the approach used to identify women with GDM. The present study included all women who met the ADA criteria for GDM based on the results from the 100-g OGTT test performed during pregnancy, since ICD-9 codes alone was found to be an unreliable means of identifying women with GDM in our health plan database (2). Indeed, while 16% of the women identified as having GDM based on their prenatal 100-g OGTT results did not have a discharge diagnosis of GDM, over one-third (38.5%) of these women had postpartum glucose testing. In spite of the differences and consistent with the present study, approximately half of the women with GDM in the earlier studies underwent postpartum testing (12,13,15–17).

Of the studies that examined GDM pharmacological treatment in relation to whether or not postpartum testing was performed, two found a positive association (14,16), one found a negative association (13), and one found no association (15). In the present study, we found that while 50.3% of the women with no pharmacotherapy and 51.1% of the women on insulin were tested, only 42.6% of women on oral agents had postpartum glucose testing. Given that the women who took oral agents only or insulin during their GDM pregnancy and received postpartum testing were 40 or 57% as likely to have IFG/IGT and two to three times as likely to have diabetes, respectively, as women not treated with these medications, women who require pharmacotherapy to control their blood glucose during pregnancy should be tested in the postpartum period.

Postpartum test results

In the three other studies reporting the results of postpartum glucose testing (12,13,16), the prevalence of diabetes ranged from 2 to 8% compared with 1% reported in the present study. Additionally, the prevalence of IFG and/or IGT ranged from 11 to 33%, compared with 16% in the present study. In the two studies (12,13) that used the same ADA criteria to identify women as having GDM in their clinical center as were used in the present study, 72% of those tested for glucose intolerance in one of the centers had an OGTT postpartum (13) compared with only 21% in the present study. This may have resulted in a higher proportion of women identified as having impaired glucose regulation in their population. One study used the higher NDDG blood glucose threshold (21) to identify women with GDM and included tests conducted from 6 weeks through 1 year postpartum (16). Either or both of these factors may have accounted for the higher prevalence of impaired glucose regulation in their population compared with our findings.

Limitations and strengths

We were unable to assess the occurrence of postpartum glucose testing among the ~15% of women with GDM who disenrolled from the health plan within 6 months after their deliveries. We could not determine whether women were advised by a health care professional to have postpartum testing or whether the test was ordered but not completed, since this information is not retained in the laboratory database during the study period. We could also not determine if the patient received a reminder to report for testing by mail or telephone. Thus, missed tests could be a result of lack of physician orders or women not returning for postpartum testing. Additionally, we were not able to explore the associations between obesity, postpartum testing, and ongoing glucose abnormalities in the postpartum period because maternal height and weight were not available in clinical databases or the California birth certificates for the period of this study.

The strengths of this study include the use of multiple clinical and administrative databases to identify and characterize women with GDM, including pharmacotherapy for GDM during pregnancy from a diverse insured cohort and to determine whether members of that cohort had been tested for glucose abnormalities postpartum. Because 95% (n = 11,187) of the women in the sample had KPSC prescription drug coverage during pregnancy, we were able to examine the associations requiring anti-hyperglycemic agents, postpartum testing, and test results with a high level of accuracy. Our sample included all women from 1999 through 2006 identified as having GDM using a standard laboratory test (100-g 3-h OGTT) using ADA criteria to assess the presence of GDM. Additionally, we were able to identify those women found to have IGT/IFG and those having a provisional diagnosis of diabetes using the results of their 75-g OGTT and FPG tests done during the postpartum period and to describe the demographic, clinical, and health service utilization characteristics of those women.

Clinical implications

Testing for ongoing glucose dysregulation after a GDM-affected pregnancy may allow the opportunity for clinical interventions to reduce the risk of developing diabetes or treatment to reduce the risk of diabetes-related complications among women found to have diabetes (22). The risk of pregnancy-related complications among women with diabetes, a population that is growing (2,23), may be reduced by optimal use of preconception care (24). The findings from this and other studies suggest that the rates of postpartum glucose testing after GDM are suboptimal. Rates of postpartum glucose testing after GDM pregnancies may be increased by incorporating alerts into electronic medical records so that postpartum glucose testing orders are automatically generated or physician-generated. Automated live or recorded telephone or e-mail messages could also be used to remind women to obtain testing after the tests are ordered. Postpartum glucose testing is an important first step in attempting to prevent both recurrence of GDM and the development of nongestational diabetes subsequent to a pregnancy complicated by GDM.

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