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Uptake of guideline-recommended postpartum diabetes screening among diverse women with gestational diabetes: associations with patient factors in an integrated health system in the USA

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ABSTRACT

Introduction Clinical guidelines urge timely postpartum screening for diabetes among women with gestational diabetes mellitus (GDM), yet patient factors associated with screening uptake remain unclear. We aimed to identify patient factors associated with completed postpartum diabetes screening (2-hour oral glucose tolerance test within 4–12 weeks postpartum), as recommended by the American Diabetes Association (ADA).

Research design and methods Within the context of Gestational Diabetes' Effects on Moms (GEM), a pragmatic cluster randomized trial (2011–2012), we examined survey and electronic health record data to assess clinical and sociodemographic factors associated with uptake of ADA-recommended postpartum screening. Participants included 1642 women (76% racial/ethnic minorities) identified with GDM according to the Carpenter and Coustan criteria in a health system that deploys population-level strategies to promote screening. To contextualize these analyses, screening rates derived from the GEM trial were compared with those in the health system overall using registry data from a concurrent 10-year period (2007–2016, n=21 974).

Results Overall 52% (n=857) completed recommended postpartum screening in the analytic sample, comparable to 45.7% (n=10 040) in the registry. Screening in the analytic sample was less likely among women at elevated risk for type 2 diabetes, assessed using items from an ADA risk test (vs non-elevated; adjusted rate ratio (aRR)=0.86 (95% CI 0.75 to 0.98)); perinatal depression (0.88 (0.79 to 0.98)); preterm delivery (0.84 (0.72 to 0.98)); parity ≥2 children (vs 0; 0.80 (0.69 to 0.93)); or less than college education (0.79 (0.72 to 0.86)). Screening was more likely among Chinese Americans (vs White; 1.31 (1.15 to 1.49)); women who attended a routine postpartum visit (5.28 (2.99 to 9.32)); or women who recalled receiving healthcare provider advice about screening (1.31 (1.03 to 1.67)).

Conclusions Guideline-recommended postpartum diabetes screening varied by patient clinical and sociodemographic factors. Findings have implications for developing future strategies to improve postpartum care.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Clinical guidelines from the American Diabetes Association (ADA) urge postpartum screening for diabetes after a pregnancy complicated by gestational diabetes mellitus (GDM). However, screening uptake is suboptimal and patient factors associated with uptake remain unclear.

WHAT THIS STUDY ADDS

⇒ Uptake of recommended postpartum screening varied by patient factors, including patients' level of diabetes risk as assessed with the ADA risk score.

⇒ Variation in screening uptake emerged despite existing health system-level strategies to promote postpartum screening after GDM, and despite near-universal attendance at the standard postpartum medical visit.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE AND/OR POLICY

⇒ Novel strategies are needed to increase screening uptake among subgroups at risk for missing recommended care.

⇒ Results may be useful to clinicians, health systems, and researchers seeking improved care for patients with GDM.

INTRODUCTION

Gestational diabetes mellitus (GDM) is a common pregnancy complication whose rates are increasing steadily in the USA.[1] GDM confers lifetime risk for type 2 diabetes (T2D); indeed, a recent comprehensive meta-analysis of 45 studies and over 4 million women estimates that women with GDM are 8.3 times more likely to develop T2D than those with normoglycemic pregnancies.[2 3] American Diabetes Association (ADA) guidelines urge

screening via 2-hour, 75-g oral glucose tolerance test (OGTT), which offers superior sensitivity in the early postpartum period over a fasting plasma glucose test alone or glycated hemoglobin (HbA1c).[4] Guidelines recommend screening at 4–12 weeks postpartum for timely T2D prevention and treatment, which coincides with timing for the standard postpartum medical visit. Several alternative approaches to the type and timing of postpartum screening have been examined,[5–7] in addition to studies examining the use of pregnancy glucose levels to predict postpartum diabetes risk.[8–10] However, the OGTT remains the gold standard for detecting postpartum abnormalities.

Despite clinical guidelines, uptake of timely postpartum screening after GDM is suboptimal. Prior research on screening via OGTT, HbA1c, or fasting glucose has identified higher socioeconomic status, nulliparity, GDM managed by medication, comorbidities (eg, depression), and increased contact with healthcare providers during and after pregnancy are associated with higher uptake.[11–14] Recent work examining the period 2010–2015 also revealed the impact of patients' access to public transportation and prenatal diabetes education in Medicaid populations.[15] While a 2020 meta-analysis underscored race and ethnicity as a significant patient-level predictor of screening uptake,[16] no large-scale studies have examined diverse Asian subgroups, despite substantial heterogeneity in rates of GDM and the highest rates across all racial and ethnic groups being observed among Asian Indian women.[1 17] Importantly, patient-level factors of screening via OGTT remain understudied in healthcare contexts that have addressed system-level barriers through standardized models of GDM care.

Here we examined patient factors in a large, racially/ethnically diverse, and integrated health system which previously implemented population-level strategies to promote screening uptake, such as laboratory orders in the electronic health record (EHR) and patient reminders. We aimed to identify patient characteristics associated with missing recommended screening, which could inform further strategies to improve postpartum care.

METHODS

Setting

Kaiser Permanente Northern California (KPNC) is an integrated health system of >4.5 million members. KPNC provides care to approximately a third of the underlying population in the Greater San Francisco Bay Area, and its diversity approximates that of the Northern California region.[18] Since 2006 the KPNC Regional Perinatal Service Center has implemented a population health approach for GDM care.[19] In addition to universal screening for GDM, the Center supplements care women receive from their individual prenatal providers through a standardized, system-wide program including identification of all women with GDM in the EHR; telephone-based nurse case management during pregnancy; centralized laboratory ordering of the postpartum 2-hour, 75-g OGTT in the EHR; and mailed patient reminders to complete the OGTT around 6 weeks postpartum.[19] Laboratory tests in both pregnancy and postpartum are performed at the KPNC regional laboratory. Using this population health approach, women with GDM across the health system are provided with the postpartum OGTT laboratory order and instructions; women can complete it at their convenience with no appointment necessary, and there is no need for prescription or referral by women's individual providers.

Participants

Participants were identified in Gestational Diabetes' Effects on Moms (GEM), a pragmatic cluster-randomized trial of T2D prevention strategies (ClinicalTrials.gov registration NCT01344278).[20] The present research was approved by the Kaiser Foundation Research Institute Human Subjects Committee (institutional review board nos 1269719 and 1274361). The GEM pragmatic cluster randomized trial included nearly all women diagnosed with GDM in over a 1-year period (2011–2012) across KPNC's 44 medical facilities; consent was not required to participate in the trial (but was obtained for the survey component, described below).[21] Exclusion criteria for the trial were minimal (eg, neonatal loss, missing data on body mass index (BMI), lack of contact with the health system), resulting in 92% of potentially eligible women being included in analysis of the trial's primary outcomes, regardless of their response to GEM surveys.[20] Per cluster randomization at the medical facility level, women received usual care (22 facilities) or were offered a telehealth lifestyle intervention (22 facilities) consisting of individual telephone calls with a lifestyle coach and mailed materials, delivered primarily after 6 weeks postpartum. The GEM study identified 2207 women according to the Carpenter and Coustan criteria,[4 22] excluding those with evidence of pregestational diabetes or without a diagnostic OGTT during pregnancy. Of those, a total of 1642 (74.4%) completed the baseline survey after GDM diagnosis and formed the analytic sample for the present study.

Outcome definition

Adherence to ADA-recommended screening was defined by EHR laboratory values indicating a completed 2-hour, 75-g OGTT within 4–12 weeks postpartum.

Patient factors

We leveraged patient-reported survey and EHR data.[20] Briefly, the GEM baseline survey was administered by mail, phone, or online and in English or Spanish, according to participant preference. Factors derived from the survey included age, education (< vs ≥a 4-year college degree), race or ethnicity, family history of diabetes, and physical activity (corresponding to the ADA risk test item,[23] 'Are you physically active?' (yes/

no)). Factors assessed by EHR included parity (0, 1, or ≥2 other children; data supplemented by survey); preterm delivery (<37 weeks' gestation); cesarean delivery; GDM treatment with medication; evidence of hypertension (systolic blood pressure ≥140 mm Hg, diastolic ≥90 mm Hg, or antihypertensive medication in the year before or during pregnancy); and prepregnancy BMI calculated as weight (kg)/height (m^2).[20] Evidence of perinatal depression, during pregnancy or at approximately 6 weeks postpartum, was assessed via survey as ≥10 on the Patient Health Questionnaire (PHQ)-8[24] or via EHR using the PHQ-9,[25] physician diagnosis, or use of antidepressant medications.

T2D risk was computed using the widely available ADA risk score,[23 26] whose items include current gestational diabetes, age, BMI, hypertension, family history of diabetes, and physical activity (using the data as described above); scores ≥5 indicate elevated risk. Attendance at the routine 6-week postpartum visit was assessed via EHR using standard Healthcare Effectiveness Data and Information Set specifications for prenatal and postpartum care issued by the National Committee for Quality Assurance, defined as a visit within 21–56 days after delivery and identified using procedure, diagnostic, and laboratory codes.[27]

Women were asked to complete a follow-up GEM survey at approximately 6 weeks postpartum, which included two items to assess recall of advice from a healthcare provider during pregnancy: one about postpartum screening ('During pregnancy, did one or more Kaiser Permanente healthcare professional(s) say you needed to have your blood sugar tested after delivery?') and a second about diabetes risk ('During pregnancy, did one or more Kaiser Permanente healthcare professional(s) say you could develop diabetes after delivery?').

To contextualize results derived from the GEM data, we used the KPNC GDM registry (described in detail elsewhere)[28] to examine rates of screening approximately 5 years before and after the GEM trial. The observation period began in 2007, directly after KPNC's implementation of the standardized population health approach to GDM care, as described above. We identified women with GDM who delivered a live birth in the 10-year period from 2007 to 2016 and extracted patient characteristics from registry data. Inclusion criteria included age 18–45 years and no more than a 5-month gap in health plan membership during the first year postpartum; women of unknown race/ethnicity were excluded (n=211). We included only the first pregnancy for women with multiple GDM pregnancies in the observation period.

Statistical analysis

We used Pearson's χ^2 test to examine bivariate associations between patient factors and screening completion. The modified Poisson regression model was used to estimate adjusted rate ratios (aRRs) and 95% CIs, avoiding potential misinterpretation of ORs from the alternative logistic regression for binary outcomes. We implemented an extension of the model to accommodate the correlated binary outcomes arising from cluster randomization on facility, a feature of the underlying design of the GEM trial.[29] Regression model 1 included patient factors of primary interest, that is, race/ethnicity, education, parity, postpartum visit attendance, perinatal depression, and T2D risk. To examine the robustness of those findings, model 2 further adjusted for preterm delivery, cesarean delivery, GDM medication, and GEM trial arm. Among the subset of participants who completed the postpartum survey, a final model further adjusted for recall of provider advice about screening and about diabetes risk. Analyses were conducted using SAS 9.4.

RESULTS

Of the 2207 eligible women, a total of 1642 (74.4%) responded to the GEM baseline survey after GDM diagnosis and formed the analytic sample for the present study. Responders were similar to non-responders in demographic data available from the EHR, except for being more likely to be Chinese American, Filipina, or South Asian and less likely to be of other Asian backgrounds (online supplemental table 1). The analytic sample of responders was racially and ethnically diverse (76% from minority groups) with a mean age at delivery of 33.2 years (SD=4.9); nearly half did not have a college degree (table 1). Participant characteristics did not differ by GEM trial arm (online supplemental table 2).

Over half of the analytic sample completed recommended screening via OGTT within 4–12 weeks postpartum (52.2%; 857 of 1642 patients), comparable to that observed in the larger GEM sample which included survey non-responders (47.9%; 1058 of 2207 patients). Screening in the analytic sample was completed at a mean of 6.6 weeks postpartum (SD=1.5). Of the 857 women screened via OGTT within 4–12 weeks postpartum, 14.6% (n=125) already evidenced either pre-diabetes (13.3%; n=114) or diabetes (1.3%; n=11).

In bivariate analyses, race/ethnicity, education, parity, elevated T2D risk, depression, and attendance at the postpartum visit were associated with screening status in the analytic sample (table 2). Results of regression models 1 and 2 were similar (table 3). In model 2, screening was less likely among women with elevated T2D risk (aRR: 0.86 (95% CI: 0.75 to 0.98)); perinatal depression (0.88 (0.79 to 0.98)); preterm delivery (0.84 (0.72 to 0.98)); parity ≥2 children (vs 0; 0.80 (0.69 to 0.93)); or less than a college degree (0.79 (0.72 to 0.86)). Compared with white women, screening trended lower among black women (0.83 (0.66 to 1.04)) and women from multiracial/other backgrounds (0.85 (0.71 to 1.02)), although these CIs crossed 1. Screening was more likely among Chinese Americans (1.31 (1.15 to 1.49)) and the 93.6% of women who attended a postpartum visit versus the 6.4% who did not (5.28 (2.99 to 9.32)).

Of 1642 women in the analytic sample, 1497 (91.2%) responded to the postpartum follow-up survey. Among

Table 1 Participant characteristics: the Gestational Diabetes' Effects on Moms (GEM) study (N=1642)

Racial/ethnic background	
Black	61 (3.7)
Chinese American	175 (10.7)
Filipina	181 (11.0)
South Asian	151 (9.2)
Asian, other	164 (10.0)
Latina	341 (20.8)
Non-Hispanic White	394 (24.0)
Multiracial/other	175 (10.7)
Education: less than a 4-year college degree	816 (49.7)
Parity	
0	705 (42.9)
1	566 (34.5)
≥2	371 (22.6)
Elevated T2D risk	297 (18.1)
Perinatal depression	407 (24.8)
Attended postpartum visit	1537 (93.6)
Preterm delivery	182 (11.1)
Cesarean delivery	547 (33.3)
Use of GDM medication	457 (27.8)
GEM trial arm	
Usual care	838 (51.0)
Intervention	804 (49.0)

Values are presented as frequencies (%).
T2D risk was computed per the American Diabetes Association risk test,[23 26] including the following factors: age, body mass index, family history of diabetes, physical activity, history of hypertension, and history of GDM.
Missing data: education, n=2 (0.1%); T2D risk, n=28 (1.7%).
Asian, other included women who identified as East Asian (eg, Japanese, Korean) or Southeast Asian (eg, Vietnamese).
Multiracial/other included women who identified with more than one racial/ethnic group, Hawaiian/Pacific Islander, or backgrounds not otherwise indicated.
GDM, gestational diabetes mellitus; T2D, type 2 diabetes.

Table 2 Bivariate associations of patient factors with completion of guideline-recommended postpartum screening among women with gestational diabetes mellitus (GDM): the Gestational Diabetes' Effects on Moms (GEM) study (N=1642)

	Screened (n=857)	Unscreened (n=785)	P value
Racial/ethnic background			<0.0001
Black	21 (2.5)	40 (5.1)	
Chinese American	128 (14.9)	47 (6.0)	
Filipina	100 (11.7)	81 (10.3)	
South Asian	86 (10.0)	65 (8.3)	
Asian, other	95 (11.1)	69 (8.8)	
Latina	161 (18.8)	180 (22.9)	
Non-Hispanic White	198 (23.1)	196 (25.0)	
Multiracial/other	68 (7.9)	136 (13.6)	
Education: less than a 4-year college degree	347 (40.5)	469 (59.7)	<0.0001
Parity			<0.0001
0	496 (46.9)	296 (37.7)	
1	362 (34.2)	264 (33.6)	
≥2	193 (18.2)	225 (28.7)	
Elevated T2D risk	121 (14.1)	176 (22.4)	<0.0001
Perinatal depression	175 (20.4)	232 (29.6)	<0.0001
Attended postpartum visit	846 (98.7)	691 (88.0)	<0.0001
Preterm delivery	84 (9.8)	98 (12.5)	0.08
Cesarean delivery	286 (33.4)	261 (33.2)	0.96
Use of GDM medication	223 (26.0)	234 (29.8)	0.09
GEM trial arm			0.08
Usual care	455 (53.1)	383 (48.8)	
Intervention	402 (46.9)	402 (51.2)	

Values are presented as frequencies (%).
Screening was defined as a 2-hour, 75-g oral glucose tolerance test within 4–12 weeks postpartum.
P values are results from Pearson's χ^2 tests comparing those screened versus unscreened.
T2D, type 2 diabetes.

those, the screening rate was higher among the 94.1% who recalled receiving provider advice about screening versus the 6.0% who did not (55.9% vs 40.5%; aRR 1.31 (1.03 to 1.67)), with a similar trend among the 96.0% who recalled advice about diabetes risk versus the 3.9% who did not (55.5% vs 42.4% (aRR 1.25 (0.97 to 1.60)), although the latter CI included 1. While the response rate to the postpartum survey was high, responders differed from non-responders in race/ethnicity (eg, less likely to be Latina or Filipina); being more likely to have a college education, and attend the postpartum visit (94.1% vs 88.3%); and parity (less likely to have ≥2 prior births; online supplemental table 3).

As an additional point of comparison across the health system, we identified a total of 21 974 women in the KPNC GDM registry during the 10-year observation period (2007–2016). Of those, 45.7% (n=10 040) completed recommended screening via OGTT within 4–12 weeks postpartum, at a mean of 6.7 weeks (SD=1.6). Similar to the analytic sample, bivariate analyses indicated that race/ethnicity, as well as age and BMI (elements of the ADA risk score), were associated with screening status, whereas GDM medication was not (online supplemental table 4). Preterm birth was also associated with screening status in bivariate analyses.

DISCUSSION

We examined guideline-recommended postpartum diabetes screening in an integrated health system where

Table 3 Adjusted rate ratios (aRRs) and 95% CIs for associations between patient factors and completed guideline-recommended postpartum screening among women with gestational diabetes mellitus (GDM): the Gestational Diabetes' Effects on Moms (GEM) study

	Model 1	Model 2
	aRR (95% CI)	aRR (95% CI)
Racial/ethnic background		
Black	0.83 (0.67 to 1.02)	0.83 (0.66 to 1.04)
Chinese American	1.30 (1.15 to 1.48)	1.31 (1.15 to 1.49)
Filipina	1.02 (0.88 to 1.19)	1.02 (0.89 to 1.18)
South Asian	1.00 (0.86 to 1.16)	1.01 (0.87 to 1.17)
Asian, other	1.11 (0.93 to 1.33)	1.12 (0.94 to 1.34)
Latina	1.07 (0.93 to 1.22)	1.07 (0.94 to 1.23)
Non-Hispanic White	1 (reference)	1 (reference)
Multiracial/other	0.84 (0.70 to 1.01)	0.85 (0.71 to 1.02)
Education: less than a 4-year college degree	0.79 (0.72 to 0.87)	0.79 (0.72 to 0.86)
Parity		
0	1 (reference)	1 (reference)
1	0.93 (0.83 to 1.05)	0.93 (0.82 to 1.05)
≥2	0.79 (0.68 to 0.93)	0.80 (0.69 to 0.93)
Elevated T2D risk	0.86 (0.75 to 0.98)	0.86 (0.75 to 0.98)
Perinatal depression	0.88 (0.79 to 0.98)	0.88 (0.79 to 0.98)
Attended postpartum visit	5.23 (2.98 to 9.20)	5.28 (2.99 to 9.32)
Preterm delivery	–	0.84 (0.72 to 0.98)
Cesarean delivery	–	1.01 (0.89 to 1.15)
Use of GDM medication	–	0.99 (0.88 to 1.11)
GEM trial arm		
Usual care	–	1 (reference)
Intervention	–	0.94 (0.86 to 1.04)
Recalled provider advice about screening*	–	1.31 (1.03 to 1.67)
Recalled provider advice about diabetes risk*	–	1.25 (0.97 to 1.60)

aRRs and 95% CIs are from modified Poisson regressions that include race/ethnicity, education, parity, T2D risk, perinatal depression, and attendance at a postpartum visit (model 1), plus preterm delivery, cesarean delivery, use of GDM medication, and GEM trial arm (model 2; n=1642).
*Additional model among postpartum survey responders includes all variables in model 2, plus recall of receiving provider advice about screening and recall of receiving provider advice about diabetes risk (n=1497).
T2D, type 2 diabetes.

the OGTT, the most sensitive test to detect postpartum dysglycemia, is implemented as standard care through centralized ordering in the EHR and patient reminders. Our data derived from the GEM trial indicated that 52% of women were screened via OGTT within 4–12 weeks postpartum as recommended by the ADA. In an effort to place this finding into context, we found a comparable rate of 45.7% in the KPNC GDM registry for the 10-year time period approximately 5 years before and 5 years after the GEM trial (2007–2016); taken together, these results suggest that screening has been stable over time in this health system. These rates are significantly higher than the 7% observed in national claims data, or in Medicaid populations during similar time periods.[11 15] Population health strategies implemented in this healthcare system, including centralized ordering of the OGTT and patient reminders, may have promoted the relatively high observed rate of screening. While population-level strategies may yield higher uptake,[30] here almost half of women remained unscreened and completion varied by patient factors. Results from the present study urge interventions at the patient level to improve uptake.

We found clinical characteristics such as elevated T2D risk, preterm delivery, and perinatal depression were independently associated with lower likelihood of recommended screening. Women with these factors may need additional attention from the health system to complete screening. Elevated T2D risk as assessed with items from the ADA risk test—a brief and widely available tool—could efficiently identify women at risk not only for T2D but also for missing preventive care. This is consistent with the premise that patients likely to benefit most from preventive efforts (ie, those at highest risk) may be least likely to heed preventive advice, given the discomfort of considering oneself at risk for a threatening health condition.[31–33] Indeed, following a pregnancy complicated by GDM, patients often perceive themselves as healthy and discount their diabetes risk once pregnancy is over.[34]

Provider advice about screening delivered during pregnancy was associated with a higher likelihood of screening uptake in the present study. This is consistent with the finding that diabetes education from a prenatal provider was associated with greater uptake in low-income Medicaid populations.[15] It also underscores prior research indicating that women who do *not* complete recommended screening perceive their providers as unconcerned about diabetes risk.[35] A recent systematic review of qualitative research emphasized that clinicians' discussion of screening and women's subsequent understanding of their diabetes risk influence their views about whether to prioritize screening in the demanding postpartum period.[36] While the present study's results must be scrutinized in future research, taken together these findings hint towards the potential utility of interventions that target patients' risk perception, and improved risk communication between patients and providers, to improve screening uptake.

The study findings are particularly intriguing in light of near-universal postpartum visit attendance. While attendance at the routine postpartum visit was strongly associated with screening, and almost all women attended a postpartum visit, nearly half remained unscreened. Despite the postpartum visit explaining important variation in screening, the present findings reinforce the suggestion that its impact is not absolute.[16]

The significant associations observed between screening and education, parity, and race/ethnicity echo those in other large studies, although none have previously examined Asian subgroups.[11 16] A recent meta-analysis revealed higher uptake among Asian and Hispanic women than black and white women, but did not examine Asian subgroups given the dearth of studies that disaggregate data for heterogeneous racial and ethnic groups.[16] Bivariate analyses in the present study's GEM sample and the large GDM registry sample indicated higher screening uptake across Asian subgroups and lower uptake among black and Hispanic women, although we were unable to examine the full range of patient factors in the registry-based sample. Uncovering what facilitates the high screening rate observed here among Chinese Americans could inform future interventions for all women.

Limitations of the present study call for cautious interpretation. The GEM trial's pragmatic design and minimal exclusion criteria offer a reasonable approximation of screening uptake in the underlying population, as evidenced by the comparable rate of screening observed in the GDM registry. However, the present study is limited by its context within that trial and potential for selection bias among survey responders. Several demographic differences between survey responders and non-responders raise caution in interpreting the findings, particularly those arising from the postpartum follow-up survey. The GEM intervention did not aim to improve postpartum screening and thus we did not observe a statistically significant difference in rate of screening within 4–12 weeks postpartum, although screening was slightly higher in the GEM usual care arm as compared with intervention. The population from which our sample was drawn also may differ from and may not be generalizable to those covered by Medicaid and other commercial health plans. Additional study limitations include limited sample sizes in multivariate analyses in some subgroups, including black women, for whom further research is needed; lack of longer-term follow-up data, for example, on diabetes incidence; lack of data on postpartum thyroiditis, the symptoms of which can overlap with postpartum depression; and data on provider advice may be subject to recall bias. Although the GEM trial data arise from 2011 to 2012, results remain relevant given that uptake of postpartum screening is still widely suboptimal; the same system-level strategies continue to be used in this clinical context to promote screening; and patient-level risk factors for missed care are unlikely to have changed in recent years. This unique context offers insight into improving screening uptake which extends beyond system-level barriers. Indeed, results from the GDM registry in the years before and after the GEM trial suggest that screening uptake has been stable over time. Study strengths include the evaluation of timely, 'gold standard' postpartum screening via OGTT; outcome ascertainment via EHR, potentially limiting bias from study attrition; disaggregation of several Asian subgroups, in contrast to prior large-scale studies; and examination of ADA risk scores in relation to screening uptake. The large and diverse sample strengthens generalizability to other populations of patients with GDM.

In sum, timely, ADA-recommended postpartum diabetes screening varied by patient factors in an integrated health system, revealing clinical and sociodemographic subgroups that could benefit from targeted interventions to increase uptake. If these results are replicated in future research, expanded population-level strategies may be warranted in addition to examining the content, delivery, and receipt of patient advice about screening. Strategies could include stronger risk communication to inform and empower women to take action regarding T2D risk; addressing practical barriers; targeted outreach following perinatal complications; and maximizing postpartum visit attendance, emphasizing the visit as an opportunity for screening.

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Contributors All authors critically reviewed the manuscript for important intellectual content and approved the final manuscript. SDB conceived the current study, acquired and interpreted data, and drafted the manuscript. MMH acquired and interpreted data. A-LT conducted the data analysis. YZ interpreted data. CPQ oversaw data analysis and interpreted data. AF conceived the trial from which these data were derived, obtained funding for the trial, and acquired and interpreted data. As guarantor, SDB had access to the data and takes full responsibility for the overall content including the integrity of the data, the accuracy of the data analysis, the finished work, and the decision to publish.

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Supplemental Table 1. Characteristics of responders and non-responders to the GEM baseline survey

	Overall (*N*=2,207)	Baseline survey responders *N*=1,642 (74.4%)	Baseline survey non-responders *N*=565 (25.6%)	*P* value
	n (%)	*n* (%)	*n* (%)	
Racial/ethnic background				<.0001
Black	88 (4.0)	61 (3.7)	27 (4.8)	
Chinese American	178 (8.1)	175 (10.7)	3 (0.5)	
Filipina	191 (8.7)	181 (11.0)	10 (1.8)	
South Asian	158 (7.2)	151 (9.2)	7 (1.2)	
Asian, other	386 (17.5)	164 (10.0)	222 (39.3)	
Latina	480 (21.7)	341 (20.8)	139 (24.6)	
Non-Hispanic White	508 (23.0)	394 (24.0)	114 (20.2)	
Multiracial/other	218 (9.9)	175 (10.7)	43 (7.6)	
Age at delivery (years)				0.38
<25	102 (4.6)	75 (4.6)	27 (4.8)	
25-29	492 (22.3)	368 (22.4)	124 (21.9)	
30-34	813 (36.8)	622 (37.9)	191 (33.8)	
35-39	613 (27.8)	443 (27.0)	170 (30.1)	
≥40	187 (8.5)	134 (8.2)	53 (9.4)	
Pre-pregnancy BMI (kg/m^2)				0.15
<25	775 (35.1)	562 (34.2)	213 (37.7)	
25-29	658 (29.8)	486 (29.6)	172 (30.4)	
≥30	774 (35.1)	594 (36.2)	180 (31.9)	
GEM trial arm				0.06
Usual care	1,152 (52.2)	838 (51.0)	314 (44.4)	
Intervention	1,055 (47.8)	804 (49.0)	251 (55.6)	

Baseline survey responders comprise the analytic sample for the present study.
P values are results from Pearson's $\chi 2$ tests.
BMI, body mass index. GEM, Gestational Diabetes' Effects on Moms.

Supplemental Table 2. Characteristics of the analytic sample (*N*=1,642) by GEM trial arm

	Usual care *N*=838	Intervention *N*=804	*P* value
	n (%)	*n* (%)	
Racial/ethnic background			0.56
Black	31 (3.7)	30 (3.7)	
Chinese American	83 (9.9)	92 (11.4)	
Filipina	93 (11.1)	88 (10.9)	
South Asian	77 (9.2)	74 (9.2)	
Asian, other	76 (9.1)	88 (10.9)	
Latina	179 (21.4)	162 (20.1)	
Non-Hispanic White	216 (25.8)	178 (22.1)	
Multiracial/other	83 (9.9)	92 (11.4)	
Age (years)			0.26
<25	39 (4.7)	36 (4.5)	
25-29	196 (23.4)	172 (21.4)	
30-34	298 (35.6)	324 (40.3)	
35-39	240 (28.6)	203 (25.2)	
≥40	134 (7.8)	69 (8.6)	
Pre-pregnancy BMI (kg/m^2)			0.43
<25	277 (33.1)	285 (35.4)	
25-29	246 (29.4)	240 (29.9)	
≥30	315 (37.6)	279 (34.7)	

P values are results from Pearson's $\chi 2$ tests. BMI, body mass index.
GEM, Gestational Diabetes' Effects on Moms.

Supplemental Table 3. Characteristics of responders and non-responders to the GEM postpartum follow-up survey

	Analytic sample (*N*=1,642)	Postpartum survey responders *N*=1,497 (91.2%)	Postpartum survey non-responders *N*=145 (8.8%)	*P* value
	n (%)	*n* (%)	*n* (%)	
Racial/ethnic background				0.002
Black	61 (3.7)	57 (3.8)	4 (2.8)	
Chinese American	175 (10.7)	168 (11.2)	7 (4.8)	
Filipina	181 (11.0)	157 (10.5)	24 (16.6)	
South Asian	151 (9.2)	141 (9.4)	10 (6.9)	
Asian, other	164 (10.0)	155 (10.4)	9 (6.2)	
Latina	341 (20.8)	295 (19.7)	46 (31.7)	
Non-Hispanic White	394 (24.0)	159 (24.4)	29 (20.0)	
Multiracial/other	175 (10.7)	159 (10.6)	16 (11.0)	
Education: Less than a 4-year college degree	816 (49.7)	727 (48.6)	89 (61.4)	0.01
Parity				0.02
0	705 (42.9)	648 (43.3)	57 (39.3)	
1	566 (34.5)	524 (35.0)	42 (29.0)	
≥ 2	371 (22.6)	325 (21.7)	46 (31.7)	
Elevated type 2 diabetes risk	297 (18.1)	270 (18.0)	27 (18.6)	0.57
Perinatal depression	407 (24.8)	365 (24.4)	42 (29.0)	0.22
Attended postpartum visit	1,537 (93.6)	1,409 (94.1)	128 (88.3)	0.006
Pre-term delivery	182 (11.1)	164 (11.0)	18 (12.4)	0.59
Cesarean delivery	547 (33.3)	497 (33.2)	50 (34.5)	0.75
Use of GDM medication	457 (27.8)	407 (27.2)	50 (34.5)	0.06
GEM trial arm				0.60
Usual care	838 (51.0)	761 (50.8)	77 (53.1)	
Intervention	804 (49.0)	736 (49.2)	68 (46.9)	

Type 2 diabetes risk was computed per the American Diabetes Association (ADA) risk test,(8, 11) including the following factors: age, body mass index, family history of diabetes, physical activity, history of hypertension, and history of GDM.

P values are results from Pearson's $\chi 2$ tests.

Missing data overall in the analytic sample: Education, n=2 (0.1%); type 2 diabetes risk, n=28 (1.7%).

GEM, Gestational Diabetes' Effects on Moms.

Supplemental Table 4. Bivariate associations of patient factors with completion of guideline-recommended postpartum screening among women with gestational diabetes mellitus (GDM): Kaiser Permanente Northern California, 2007-2016.

	Overall (*N*=21,974)	Screened (*n*=10,040)	Unscreened (*n*=11,934)	*P* value
Racial/ethnic background				<.0001
Black	971 (4.4)	272 (2.7)	699 (5.9)	
Chinese American	1,903 (8.7)	1,296 (12.9)	607 (5.1)	
Filipina	2,501 (11.4)	1,170 (11.7)	1,331 (11.2)	
South Asian	1,795 (8.2)	968 (9.6)	827 (6.9)	
Asian, other	2,504 (11.4)	1,293 (12.9)	1,211 (10.1)	
Latina	6,051 (27.5)	2,414 (24.0)	3,637 (30.5)	
Non-Hispanic White	5,121 (23.3)	2,193 (21.8)	2,928 (24.5)	
Multiracial/other	1,128 (5.1)	434 (4.3)	694 (5.8)	
Age at delivery (years)				<.0001
18-29	5,659 (25.8)	2,208 (22.0)	3,451 (28.9)	
30-34	8,117 (36.9)	3,902 (38.9)	4,215 (35.3)	
35-45	8,198 (37.3)	3,930 (39.1)	4,268 (35.8)	
Pre-pregnancy BMI (kg/m^2)				<.0001
<18.5	240 (1.1)	124 (1.2)	116 (1.0)	
18.5-24.9	5,643 (25.7)	3,196 (31.8)	2,447 (20.5)	
25.0-29.9	5,347 (24.3)	2,592 (25.8)	2,755 (23.1)	
≥ 30.0	6,941 (31.6)	2,593 (25.8)	4,348 (36.4)	
Missing	3,803 (17.3)	1,535 (15.3)	2,268 (19.0)	
Use of GDM medication				0.16
No	12,078 (55.0)	5,691 (56.7)	6,387 (53.5)	
Yes	7,611 (34.6)	3,509 (35.0)	4,102 (34.4)	
Missing	2,285 (10.4)	840 (8.4)	1,445 (12.1)	
Gestational age at delivery				<.0001
Pre-term	2,503 (11.4)	1,017 (9.7)	1,486 (12.9)	
Term	19,050 (86.7)	9,306 (88.7)	9,744 (84.9)	
Missing	421 (1.9)	174 (1.7)	247 (2.2)	

Values are presented as frequencies (%).
Screening was defined as a 2-hour, 75-gram oral glucose tolerance test (OGTT) within 4-12 weeks postpartum.
P values are results from Pearson's $\chi 2$ tests comparing those screened vs. unscreened (excluding missing data).
BMI, body mass index.

Supplemental Table 1. Characteristics of responders and non-responders to the GEM baseline survey

	Overall (*N*=2,207)	Baseline survey responders *N*=1,642 (74.4%)	Baseline survey non-responders *N*=565 (25.6%)	*P* value
	n (%)	*n* (%)	*n* (%)	
Racial/ethnic background				<.0001
Black	88 (4.0)	61 (3.7)	27 (4.8)	
Chinese American	178 (8.1)	175 (10.7)	3 (0.5)	
Filipina	191 (8.7)	181 (11.0)	10 (1.8)	
South Asian	158 (7.2)	151 (9.2)	7 (1.2)	
Asian, other	386 (17.5)	164 (10.0)	222 (39.3)	
Latina	480 (21.7)	341 (20.8)	139 (24.6)	
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Multiracial/other	218 (9.9)	175 (10.7)	43 (7.6)	
Age at delivery (years)				0.38
<25	102 (4.6)	75 (4.6)	27 (4.8)	
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35-39	613 (27.8)	443 (27.0)	170 (30.1)	
≥40	187 (8.5)	134 (8.2)	53 (9.4)	
Pre-pregnancy BMI (kg/m^2)				0.15
<25	775 (35.1)	562 (34.2)	213 (37.7)	
25-29	658 (29.8)	486 (29.6)	172 (30.4)	
≥30	774 (35.1)	594 (36.2)	180 (31.9)	
GEM trial arm				0.06
Usual care	1,152 (52.2)	838 (51.0)	314 (44.4)	
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Baseline survey responders comprise the analytic sample for the present study.
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Supplemental Table 2. Characteristics of the analytic sample (*N*=1,642) by GEM trial arm

	Usual care *N*=838	Intervention *N*=804	*P* value
	n (%)	*n* (%)	
Racial/ethnic background			0.56
Black	31 (3.7)	30 (3.7)	
Chinese American	83 (9.9)	92 (11.4)	
Filipina	93 (11.1)	88 (10.9)	
South Asian	77 (9.2)	74 (9.2)	
Asian, other	76 (9.1)	88 (10.9)	
Latina	179 (21.4)	162 (20.1)	
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Multiracial/other	83 (9.9)	92 (11.4)	
Age (years)			0.26
<25	39 (4.7)	36 (4.5)	
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35-39	240 (28.6)	203 (25.2)	
≥40	134 (7.8)	69 (8.6)	
Pre-pregnancy BMI (kg/m^2)			0.43
<25	277 (33.1)	285 (35.4)	
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Supplemental Table 3. Characteristics of responders and non-responders to the GEM postpartum follow-up survey

	Analytic sample (*N*=1,642)	Postpartum survey responders *N*=1,497 (91.2%)	Postpartum survey non-responders *N*=145 (8.8%)	*P* value
	n (%)	*n* (%)	*n* (%)	
Racial/ethnic background				0.002
Black	61 (3.7)	57 (3.8)	4 (2.8)	
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Asian, other	164 (10.0)	155 (10.4)	9 (6.2)	
Latina	341 (20.8)	295 (19.7)	46 (31.7)	
Non-Hispanic White	394 (24.0)	159 (24.4)	29 (20.0)	
Multiracial/other	175 (10.7)	159 (10.6)	16 (11.0)	
Education: Less than a 4-year college degree	816 (49.7)	727 (48.6)	89 (61.4)	0.01
Parity				0.02
0	705 (42.9)	648 (43.3)	57 (39.3)	
1	566 (34.5)	524 (35.0)	42 (29.0)	
≥ 2	371 (22.6)	325 (21.7)	46 (31.7)	
Elevated type 2 diabetes risk	297 (18.1)	270 (18.0)	27 (18.6)	0.57
Perinatal depression	407 (24.8)	365 (24.4)	42 (29.0)	0.22
Attended postpartum visit	1,537 (93.6)	1,409 (94.1)	128 (88.3)	0.006
Pre-term delivery	182 (11.1)	164 (11.0)	18 (12.4)	0.59
Cesarean delivery	547 (33.3)	497 (33.2)	50 (34.5)	0.75
Use of GDM medication	457 (27.8)	407 (27.2)	50 (34.5)	0.06
GEM trial arm				0.60
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Asian, other	2,504 (11.4)	1,293 (12.9)	1,211 (10.1)	
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Age at delivery (years)				<.0001
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