Variation in Prevalence of Gestational Diabetes Mellitus Among Hospital Discharges for Obstetric Delivery Across 23 States in the United States

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OBJECTIVE—To examine variability in diagnosed gestational diabetes mellitus (GDM) prevalence at delivery by race/ethnicity and state.

RESEARCH DESIGN AND METHODS—We used data from the Healthcare Cost and Utilization Project State Inpatient Databases for 23 states of the United States with available race/ethnicity data for 2008 to examine age-adjusted and race-adjusted rates of GDM by state. We used multilevel analysis to examine factors that explain the variability in GDM between states.

RESULTS—Age-adjusted and race-adjusted GDM rates (per 100 deliveries) varied widely between states, ranging from 3.47 in Utah to 7.15 in Rhode Island. Eighty-six percent of the variability in GDM between states was explained as follows: 14.7% by age; 11.8% by race/ethnicity; 5.9% by insurance; and 2.9% by interaction between race/ethnicity and insurance at the individual level; 17.6% by hospital level factors; 27.4% by the proportion of obese women in the state; 4.3% by the proportion of Hispanic women aged 15–44 years in the state; and 1.5% by the proportion of white non-Hispanic women aged 15–44 years in the state.

CONCLUSIONS—Our results suggest that GDM rates differ by state, with this variation attributable to differences in obesity at the population level (or "at the state level"), age, race/ethnicity, hospital, and insurance.

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Diabetes is one of the most common and fastest growing comorbidities of pregnancy, and its prevalence varies among United States racial/ethnic groups (1,2). Data on the prevalence of diabetes during pregnancy are needed at the state level, particularly for different population subgroups such as women aged 25 and older, racial/ethnic group, and socioeconomic status to help monitor disease trends, plan health care services, and develop effective health care practices and policies for prevention and control. However, state-specific data are limited on gestational diabetes mellitus (GDM), defined as diabetes first diagnosed during pregnancy. Little information is available on state variation in GDM rates or on the variation among racial/ethnic groups by state. The influence of contextual factors, such as age, gender, and racial population composition, on use of health services has been identified (3). However, there is limited information on how contextual factors affect the use of preventive obstetrics care. For states with available data for 2008, we examined the variability of GDM rates by state and race/ethnicity, and we performed analyses to determine factors that contribute to the variability in GDM between states.

RESEARCH DESIGN AND METHODS

—We used discharge-level and hospital-level data from the Healthcare Cost and Utilization Project (HCUP) (4) sponsored by the Agency for Healthcare Research and Quality (AHRQ). All discharge-level data are from the State Inpatient Databases (SID) for 2008 and contain information on all inpatient stays from all community hospitals, which account for ~86% of hospitalizations. Our population included 23 states that collected data on race/ethnicity (Arizona, Arkansas, California, Colorado, Florida, Hawaii, Iowa, Kentucky, Maine, Maryland, Massachusetts, Michigan, Nevada, New Jersey, New York, North Carolina, Oregon, Rhode Island, South Dakota, Utah, Vermont, Washington, and Wisconsin). Hospital-level data are from the HCUP Hospital Cost-to-Charge Ratio File, which was merged with the SID.

We used diagnosis-related group (DRG) codes to identify hospital discharges for obstetric delivery because this method captures more high-risk deliveries than using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) V27 codes alone (5). DRG codes categorize hospital stays into groups that are clinically homogeneous with respect to resource use, including diagnosis and type of treatment or procedure. We identified discharges for obstetric delivery as having DRG codes for vaginal delivery (767–768 or 774–775) or cesarean delivery (765–766). We identified deliveries with a GDM diagnosis as those with ICD-9-CM code 648.8× listed anywhere on the discharge record. Some cases with the gestational code were excluded because they also had ICD-9-CM code 648.0× (preexisting diabetes

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during pregnancy) and therefore were considered to be preexisting diabetes during pregnancy. Maternal age was categorized as follows: 15–19, 20–24, 25–29, 30–34, 35–39, and 40–44 years. Race/ethnicity was collected from the discharge record and was categorized as non-Hispanic white, non-Hispanic black, Hispanic, and Asian. We excluded women who were American Indian or other race status because the number of GDM cases was smaller than the number required for confidentiality (≤10) in most states. Categories of patient income were established by using the reported patient zip code from the medical record, assigning a median household income for that zip code and then classifying this income to quartiles based on 2008 median income quartiles (1 = \$1–\$38,999; 2 = \$39,000–\$48,999; 3 = \$49,000–\$63,999; and 4 = >\$64,000) as determined by Claritas (4). Health insurance was included as the primary payment source classified as Medicare, Medicaid, private insurance, no insurance, and other (e.g., Worker's Compensation, Civilian Health and Medical Program of the Uniformed Services, Civilian Health and Medical Program of the Department of Veterans Affairs, Title V, and other government programs) (4). Hospital-level data included hospital type, defined by ownership (proprietary or nonprofit), rural or urban location, and bed size (<100, ≥100 beds, and, for urban hospitals only, ≥300 beds) (4). Rural or urban hospital location was classified using the Core-Based Statistical Area (CBSA) codes. CBSA groups were based on 2000 Census data. Hospitals in counties with a CBSA type of metropolitan were considered urban, whereas hospitals with a CBSA type of micropolitan or noncore were classified as rural. Hospital characteristics were included in our model, not because they cause GDM but because they may contribute to the variability in GDM prevalence between states.

We merged state-level data with the data of AHRQ to include the proportion of obese women in the state (BMI ≥30 kg/m^2) and the proportion of adults with diabetes in the state, which were obtained from the Behavioral Risk Factor Surveillance System (6). Data from the Area Resource File (ARF 2011) for 2008 also were used to examine variables at the state level, including the proportions of women aged 15–44 years by race/ethnicity and the percent of individuals living below the federal poverty level. We used SUDAAN Version 10 (Research Triangle Institute, Research Triangle Park, NC) to conduct logistic regression analyses to obtain age-adjusted rates of GDM by race/ethnicity and to estimate age-adjusted rates of GDM by race/ethnicity for each state. The overall rate was age-standardized and race-standardized to the population of hospital discharges for obstetric delivery in the 2008 HCUP Nationwide Inpatient Sample. Rates of GDM per 100 deliveries are reported and represent the prevalence of GDM among deliveries in the 23 states during 2008.

We used a multilevel model to assess variability in GDM between states. Data were examined with SAS version 9.2 (SAS Institute, Cary, NC) using PROC GLIMMIX to fit a nonlinear mixed model that included both fixed and random effects (e.g., random intercepts at the hospital and state levels). The patient was the first level, the hospital was the second level, and states were the third level. We used the same population for all models that included those with complete individual-level data, with the exception of cases missing hospital type, which were omitted from the models that included hospital type (<0.1%). Because the rate of GDM was low (5.32/100), the distribution of the data were best fit as a Poisson distribution with a logarithmic link. The null hypothesis for the random effects was variance equal to zero (H_0: $\boldsymbol{\sigma}_s^2 = 0$). We estimated the proportional change in the variance of the state random effect [$u_s \sim N(0, \boldsymbol{\sigma}_s^2)$] after entering each of the characteristics into the model (7). Because the variance estimate changes according to the variables in the model, we started with the null model (i.e., fixed intercept and random state effects only) and then assessed the individual-level factors (age, race/ethnicity, insurance type, and median income), hospital-level factors (hospital type), and state-level factors (prevalence of obesity among women, percent living in poverty, and prevalence of women aged 15–44 years by race/ethnicity) (8).

RESULTS—In the 23 states included in our analysis, there were 1,787,703 deliveries. Approximately three-quarters of deliveries were among women 20–34 years of age, approximately equally divided among the age groups 20–24, 25–29, and 30–34 years (Table 1). In terms of race/ethnicity, 53.8% of the deliveries were among non-Hispanic whites, 12.8% were among non-Hispanic blacks, 26.6% were among Hispanics, and 6.8% were among Asians. Unadjusted GDM rates increased with age and were highest among Hispanic and Asian women (6.49/100 and 10.01/100, respectively). Almost 80% of GDM deliveries occurred in nonprofit urban hospitals with >100 beds and rates of GDM were highest in those hospitals (hospitals with 100–299 beds, 5.87/100; hospitals with ≥300 beds, 5.76/100; range of other hospitals, 3.91/100–4.64/100).

Age-adjusted and race/ethnicity-adjusted rates of diagnosed GDM ranged from 3.47 of 100 deliveries in Utah to 7.15 of 100 in Rhode Island (Table 2). The highest rates were in Rhode Island, Kentucky, and Maine (Fig. 1). The mean age-adjusted rate was higher among Asians (8.14/100) and Hispanics (7.02/100) than among non-Hispanic whites (4.40/100) and non-Hispanic blacks (5.30/100). With few exceptions, this pattern held across all states.

Statistical testing found no multicollinearity among variables. The variance estimate of the state-level random intercept in the null model was statistically significant ($P < 0.001$), suggesting variability in GDM between states. Several individual level factors contributed to the variability between states, accounting for a little more than one-third of the total variability in GDM between states (35.3%) (Table 3). The two most important individual-level factors were age and race/ethnicity, which contributed 14.7% and 11.8%, respectively, to the variability in GDM between states. The hospital-level factors contributed to 17.6% of the variability in GDM between states. Variability in GDM between hospitals within states (assessed by random intercepts for hospitals) contributed to 14.7%. Hospital type defined by ownership, bed size, and rural/urban location contributed to 2.9% of the variability in GDM between states. Three state-level factors contributed to the variability in GDM between states, the proportion of obese women in the state (27.4%), the proportion of Hispanic women aged 15–44 years (4.3%), and the proportion of non-Hispanic white women aged 15–44 years (1.5%). Factors assessed that did not contribute to the variability included median household income of the patient's zip code, percent poverty in the state, percent women with diabetes in the state, and prevalence of Asian and non-Hispanic black women aged 15–44 years. The final model

Table 1—*Frequency and proportion of deliveries, and unadjusted GDM rates by individual and hospital characteristics, SID, 2008*

Characteristics	Total	GDM % unadjusted
Individual level		
Age group		
15–19 years	166,225 (9.3)	1.41
20–24 years	417,177 (23.3)	2.86
25–29 years	495,972 (27.7)	4.90
30–34 years	425,333 (23.8)	7.23
35–39 years	230,906 (12.9)	9.80
40–44 years	52,090 (2.9)	12.92
Race/ethnicity		
White, non-Hispanic	961,802 (53.8)	4.67
Black, non-Hispanic	228,403 (12.8)	4.68
Hispanic	475,818 (26.6)	6.49
Asian	121,680 (6.8)	10.01
Insurance		
Medicare/Medicaid	762,845 (42.7)	5.15
Self/no charge	55,162 (3.1)	4.44
Other government	37,671 (2.1)	4.42
Private	931,357 (52.1)	5.93
State median household income by patient zip code		
1st quartile (lowest)	513,021 (29.4)	5.20
2nd quartile	442,786 (25.4)	5.59
3rd quartile	421,340 (24.2)	5.68
4th quartile (highest)	365,712 (21.0)	5.61
Missing	44,844	—
Hospital level		
Type of hospital		
Investor-owned, <100 beds	23,208 (1.3)	4.34
Investor-owned, ≥100 beds	178,794 (10.1)	4.64
Not-for-profit, rural, <100 beds	64,222 (3.6)	3.91
Not-for-profit, rural, ≥100 beds	58,248 (3.3)	4.37
Not-for-profit, urban, <100 beds	46,574 (2.6)	4.33
Not-for-profit, urban, 100–299 beds	512,748 (28.8)	5.87
Not-for-profit, urban, ≥300 beds	895,112 (50.3)	5.76

with individual-level, hospital-level, and state-level factors contributed to 86.1% of the variability in GDM between states, with the remaining variability between states statistically significant at the 5% level (P = 0.044).

CONCLUSIONS—In our large, population-based study, age-adjusted and race-adjusted GDM rates (per 100 deliveries) varied widely among the 23 states. Age, race/ethnicity, and insurance at the individual level, hospital-level factors, and state-level factors explained 86.1% of the variability in GDM rates among states. The analyses conducted for this study produced data that can be used to compare GDM rates across racial/ethnic groups and states. Thus, state prevention programs could use HCUP data as a benchmark to monitor GDM trends.

Our findings of racial differences in GDM are consistent with those of several previous studies (9–11). In general, GDM rates were higher among Asian and Hispanic women than among non-Hispanic white and black women. Race/ethnicity and obesity are the two strongest independent factors for GDM and, not surprisingly, contributed to almost half (47%) of the variability in GDM between states: race at the individual level (independently and as an effect modifier of insurance type), and at the state level by the proportions of white non-Hispanic and Hispanic women aged 15–44 years and the proportion of obese women in the state. Possible reasons for racial differences in GDM are multiple and complex; they include maternal age, obesity, previous neonatal death, and previous cesarean delivery (12). Studies have shown that Asians have a much higher risk of GDM, even at a very low BMI (13). One study found that in pregnant women, Asians have higher postchallenge glucose levels than other race/ethnic groups, and thus it is possible that a screening method for diagnosing GDM (e.g., a 50-g postchallenge test) may increase the rate of GDM among Asians (14).

In the 23 states we examined, the average age-adjusted and race- adjusted GDM rate for 2008 (5.32/100; SE, 0.02) was higher than the national rate (3.9/100; SE, 0.13) reported by a study that used data from the 2001–2005 National Hospital Discharge Survey (15). This difference could be attributed to several factors. We used DRG codes instead of ICD-9-CM V27 codes; the 23 states in our study may not be representative of the entire United States and national GDM rates may have increased since the earlier study (16).

The variability in GDM rates may reflect reporting artifacts and the extent to which screening for GDM occurs rather than true rates of disease. For example, in Rhode Island (the state with the highest GDM rate), ~90% of all deliveries in the state occurred in one hospital. One consistent source of care or delivery may result in higher rates of screening or more consistent reporting of GDM when it occurs. One of the states with the highest rates of GDM, North Carolina, reported nearly universal screening for GDM during the years 2005–2006 (17). Rates of screening and reporting also likely vary by type of health insurance and hospital characteristics, which contributed to the variability in GDM between states. Access to prenatal care, as well as screening and diagnostic practices for GDM by different organizations and health insurance plans, may play a role. Although universal screening is recommended by the American Congress of Obstetricians and Gynecologists and other authoritative bodies, the timing of screening tests and the specific values used to diagnosis GDM vary among current guidelines (18,19). The national rate of GDM screening is unknown. One study using data from patients representative of those who seek medical care and testing in the United States found that only 68% of pregnant women aged 25 to 40 who used laboratory services during the study were screened for GDM (20). This suggests

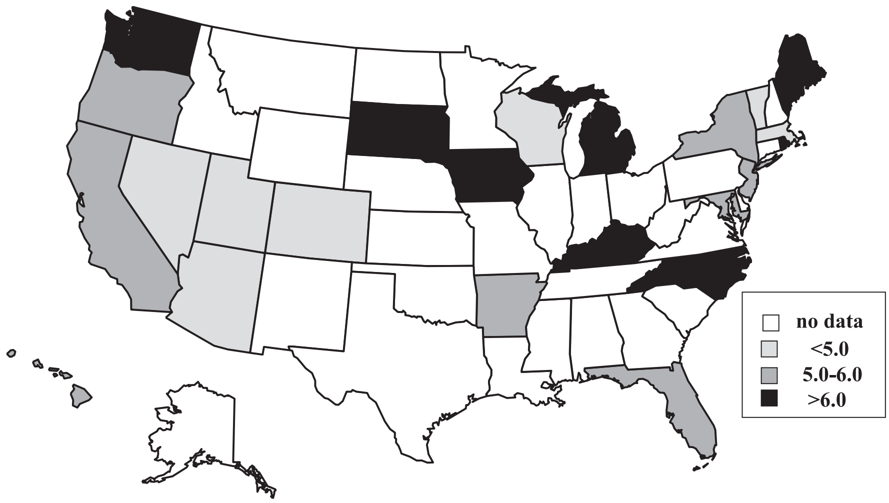

Figure 1—*Age- and race-adjusted GDM prevalence in 23 states, SID 2008.*

that many women may not be receiving GDM screening during pregnancy.

Although our data did not include prepregnancy weight, we did examine the impact of obesity prevalence among women at the state level. Not controlling for obesity at the individual level but including it as an ecologic variable could cause spurious effects (i.e., ecologic fallacy) in a one-level model; however, we used a multilevel model with random effects, which includes effects at their appropriate levels and eliminates the risk. Not surprisingly, it explained 27.4% of the variability in GDM rates between states. In a large multi-ethnic cohort of 123,040 women screened for GDM between 1995 and 2006 at Kaiser Permanente of Northern California, it was estimated that the proportion of GDM that was attributable to the presence of overweight and obesity during pregnancy ranged from 23% for Asians to 65% for African Americans (14). Also, BMI of ≥30 in Asian women would represent significant obesity because the normal BMI for Asian women is lower than that for white women A study using data from birth certificates linked to hospital discharge data in Florida (21) and results of an analysis of data from seven states that participated in the Pregnancy Risk Assessment Monitoring System (PRAMS) showed similar results (22). Although we assessed the state proportion of women of childbearing age for each race/ethnicity group, only the proportion of Hispanic women contributed to the variability in GDM between states. It may be that although GDM was higher among Asians, the number of deliveries among Hispanics was nearly four-times as great and thus resulted in a greater effect.

Table 2—***GDM among hospital discharges for obstetric deliveries in 23 states, by race/ethnicity, SID, 2008****

State	*N* of discharges with GDM	GDM rates per 100 deliveries	Non-Hispanic whites	Non-Hispanic blacks	Hispanics	Asians
Total	98,676	5.32 ± 0.02	4.40 ± 0.02	5.30 ± 0.05	7.02 ± 0.04	8.14 ± 0.08
Arizona	4,076	4.78 ± 0.07	3.44 ± 0.09	4.18 ± 0.34	5.81 ± 0.12	6.68 ± 0.43
Arkansas	1,356	5.01 ± 0.13	3.24 ± 0.11	2.73 ± 0.21	8.03 ± 0.46	4.62 ± 0.88
California	33,522	5.88 ± 0.03	4.67 ± 0.05	5.43 ± 0.15	8.06 ± 0.06	8.73 ± 0.11
Colorado	2,026	4.34 ± 0.09	3.09 ± 0.09	4.24 ± 0.42	6.79 ± 0.26	6.42 ± 0.62
Florida	10,522	5.61 ± 0.05	4.96 ± 0.07	4.95 ± 0.10	5.58 ± 0.11	8.37 ± 0.40
Hawaii	1,143	5.26 ± 0.16	4.29 ± 0.30	6.01 ± 1.36	6.63 ± 1.27	8.23 ± 0.26
Iowa	1,420	6.04 ± 0.15	4.59 ± 0.12	3.76 ± 0.55	†	6.67 ± 1.04
Kentucky	2,649	7.14 ± 0.13	5.24 ± 0.11	4.09 ± 0.32	6.23 ± 0.57	5.42 ± 0.92
Maine	672	6.97 ± 0.25	5.55 ± 0.21	†	†	7.12 ± 1.76
Maryland	3,772	5.86 ± 0.09	4.74 ± 0.11	5.60 ± 0.16	8.11 ± 0.31	9.73 ± 0.46
Massachusetts	3,491	4.67 ± 0.08	4.22 ± 0.09	6.32 ± 0.32	6.20 ± 0.26	8.78 ± 0.39
Michigan	4,668	6.77 ± 0.10	5.29 ± 0.09	5.38 ± 0.18	8.22 ± 0.49	7.70 ± 0.62
Nevada	1,348	3.92 ± 0.10	2.78 ± 0.13	3.53 ± 0.35	5.05 ± 0.19	5.71 ± 0.47
New Jersey	5,340	5.03 ± 0.07	4.33 ± 0.09	5.59 ± 0.20	6.96 ± 0.19	9.47 ± 0.28
New York	11,305	5.06 ± 0.05	4.47 ± 0.06	5.64 ± 0.12	6.08 ± 0.13	8.98 ± 0.21
North Carolina	4,065	6.71 ± 0.10	5.32 ± 0.10	6.27 ± 0.19	‡	8.56 ± 0.57
Oregon	273	5.75 ± 0.33	4.56 ± 0.32	†	8.36 ± 1.20	6.46 ± 1.08
Rhode Island	799	7.15 ± 0.24	6.21 ± 0.26	8.51 ± 0.99	8.27 ± 0.63	11.08 ± 1.57
South Dakota	409	6.43 ± 0.30	4.98 ± 0.24	†	‡	†
Utah	1,430	3.47 ± 0.09	2.42 ± 0.08	2.47 ± 0.70	5.01 ± 0.25	4.68 ± 0.61
Vermont	162	3.78 ± 0.29	3.01 ± 0.24	†	†	†
Washington	1,500	6.48 ± 0.16	5.16 ± 0.17	7.71 ± 0.89	8.65 ± 0.40	8.70 ± 0.61
Wisconsin	2,728	4.89 ± 0.09	3.77 ± 0.08	4.48 ± 0.28	6.74 ± 0.34	6.63 ± 0.53

*Logistic regression analysis was used to estimate age- and race-adjusted GDM rates for each state and region and age-adjusted GDM rates by race and ethnicity. †Number of cases is ≤10. ‡State does not collect data for Hispanic ethnicity.

Table 3—*Between-state variability in GDM by individual, hospital, and state characteristics, SID, 2008*

Variability	Contribution to GDM variability between states (%)
Total variability explained	86.1
Individual level	35.3
Age group	14.7
Race/ethnicity	11.8
Insurance	5.9
Interaction between race and insurance	2.9
State median household income by patient zip code	—
Hospital level	17.6
Variability in GDM rates between hospitals	14.7
Type of hospital	2.9
State level	33.2
Prevalence of obese women	27.4
Prevalence of persons in poverty	—
Prevalence of women with diabetes	—
Proportion of Hispanic women aged 15–44 years among all women aged 15–44 years	4.3
Proportion of white non-Hispanic women aged 15–44 years among all women aged 15–44 years	1.5
Proportion of Asian women aged 15–44 years among all women aged 15–44 years	—
Proportion of black non-Hispanic women aged 15–44 years among all women aged 15–44 years	—

Almost 15% of state variability in GDM rates was attributable to differences in rates of GDM between hospitals within the states. Women with GDM are at higher risk for complications and therefore may be referred to hospitals best-equipped for their care. Accuracy of reporting ICD and DRG codes also may vary by hospitals. Studies have found geographic variation in access to care affects quality of care and perhaps reporting, particularly among hospital referral regions (23). Hospitals with ≥100 beds had higher rates of GDM than those with <100 beds, particularly in urban hospitals. It may be that larger urban hospitals provide the kind of care necessary for pregnant women at higher risk for complications.

One limitation of our study is that because it includes only 23 states, our results may not be representative of the entire United States or all regions. However, 53% of the United States population lived in these 23 states in 2008, and we are aware of no data source that covers all states. A second limitation was inconsistency in the available race/ethnicity data. Some states had ≤10 cases of GDM for some racial/ethnic groups, and North Carolina and South Dakota did not report Hispanic ethnicity in their data. In addition, diagnostic criteria for defining GDM and the extent to which screening occurs may vary by state and provider, and we had no information on what criteria were used or the extent to which pregnant women were screened for GDM. In addition, obesity was self-reported in the state-level data and could be understated, resulting in some unexplained variability in rates between states. Part of the remaining 13.9% of the variability in GDM rates among states that we could not explain could be attributable to such misclassification. Finally, we were unable to control for the following potential confounders known to be associated with GDM: prepregnancy weight, multiparity, and GDM in a previous pregnancy (12,24).

Differences in GDM rates at the state level that are mostly driven by race/ethnicity, obesity, and hospital-level factors call for public health action. Our findings suggest that a large proportion of GDM could be avoided with prevention of overweight and obesity among women of childbearing age. The Diabetes Prevention Program has demonstrated that lifestyle interventions resulting in modest weight loss (~5–7% of body weight) in high-risk groups are effective in preventing type 2 diabetes (25). Whether similar interventions result in the prevention of GDM in overweight and obese women is largely unknown. Data from a nationally representative sample of the United States population showed that the increase in the obesity prevalence has slowed in the past decade (26), a result potentially linked, in part, to population-based strategies to promote healthy eating and physical activity behaviors (27). Whether this trend will continue and reverse the obesity epidemics remains to be assessed. In addition, one study found that women with GDM who received care at medical centers with higher rates of referral by a telephonic nurse management program was associated with a reduced likelihood of having a macrosomic infant without increasing the risk of having a low-birth-weight infant (28).

Women with GDM have an increased risk of development of type 2 diabetes (28), and black women with GDM have the highest risk of development of type 2 diabetes (29). Structured lifestyle changes or pharmaceutical interventions can prevent or delay type 2 diabetes among women with history of GDM (29), and these interventions can start during pregnancy. Breastfeeding also may mitigate the risk of development of type 2 diabetes for mothers, particularly those who are obese or who have GDM, and for their offspring later in adulthood (30).

By monitoring trends and identifying the factors that contribute to differences in GDM rates at the state level, researchers can provide data that can be used to develop effective diabetes prevention strategies for women of childbearing age and their infants.

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B.H.B., L.S.G., A.E., and A.C. researched data. B.H.B., L.S.G., A.E., A.C., H.M.D., E.V.K., and G.I. contributed to discussion. B.H.B., L.S.G., H.M.D., and E.V.K. wrote the manuscript. B.H.B., L.S.G., A.E., A.C., H.M.D., E.V.K., and G.I. reviewed and edited the manuscript. G.I. contributed to data analyses. B.H.B. is the guarantor of this work and, as such, had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

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