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Trends in Gestational Diabetes at First Live Birth by Race and Ethnicity in the US, 2011-2019

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IMPORTANCE Gestational diabetes is associated with adverse maternal and offspring outcomes.

OBJECTIVE To determine whether rates of gestational diabetes among individuals at first live birth changed from 2011 to 2019 and how these rates differ by race and ethnicity in the US.

DESIGN, SETTING, AND PARTICIPANTS Serial cross-sectional analysis using National Center for Health Statistics data for 12 610 235 individuals aged 15 to 44 years with singleton first live births from 2011 to 2019 in the US.

EXPOSURES Gestational diabetes data stratified by the following race and ethnicity groups: Hispanic/Latina (including Central and South American, Cuban, Mexican, and Puerto Rican); non-Hispanic Asian/Pacific Islander (including Asian Indian, Chinese, Filipina, Japanese, Korean, and Vietnamese); non-Hispanic Black; and non-Hispanic White.

MAIN OUTCOMES AND MEASURES The primary outcomes were age-standardized rates of gestational diabetes (per 1000 live births) and respective mean annual percent change and rate ratios (RRs) of gestational diabetes in non-Hispanic Asian/Pacific Islander (overall and in subgroups), non-Hispanic Black, and Hispanic/Latina (overall and in subgroups) individuals relative to non-Hispanic White individuals (referent group).

RESULTS Among the 12 610 235 included individuals (mean [SD] age, 26.3 [5.8] years), the overall age-standardized gestational diabetes rate significantly increased from 47.6 (95% CI, 47.1-48.0) to 63.5 (95% CI, 63.1-64.0) per 1000 live births from 2011 to 2019, a mean annual percent change of 3.7% (95% CI, 2.8%-4.6%) per year. Of the 12 610 235 participants, 21% were Hispanic/Latina (2019 gestational diabetes rate, 66.6 [95% CI, 65.6-67.7]; RR, 1.15 [95% CI, 1.13-1.18]), 8% were non-Hispanic Asian/Pacific Islander (2019 gestational diabetes rate, 102.7 [95% CI, 100.7-104.7]; RR, 1.78 [95% CI, 1.74-1.82]), 14% were non-Hispanic Black (2019 gestational diabetes rate, 55.7 [95% CI, 54.5-57.0]; RR, 0.97 [95% CI, 0.94-0.99]), and 56% were non-Hispanic White (2019 gestational diabetes rate, 57.7 [95% CI, 57.2-58.3]; referent group). Gestational diabetes rates were highest in Asian Indian participants (2019 gestational diabetes rate, 129.1 [95% CI, 100.7-104.7]; RR, 2.24 [95% CI, 2.15-2.33]). Among Hispanic/Latina participants, gestational diabetes rates were highest among Puerto Rican individuals (2019 gestational diabetes rate, 75.8 [95% CI, 71.8-79.9]; RR, 1.31 [95% CI, 1.24-1.39]). Gestational diabetes rates increased among all race and ethnicity subgroups and across all age groups.

CONCLUSIONS AND RELEVANCE Among individuals with a singleton first live birth in the US from 2011 to 2019, rates of gestational diabetes increased across all racial and ethnic subgroups. Differences in absolute gestational diabetes rates were observed across race and ethnicity subgroups.

+ Supplemental content

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Gestational diabetes is a common disorder of pregnancy that is defined by the onset of glucose intolerance during pregnancy. Gestational diabetes is associated with adverse short- and long-term risks for women and their offspring. In mothers, hazard ratios for future diabetes after gestational diabetes ranged from 6.3 (95% CI, 5.0-7.9) in Asian individuals to 9.9 (95% CI, 7.5-13.1) in Black individuals in a retrospective cohort in Southern California,[1] and a meta-analysis showed that gestational diabetes is associated with a relative risk of 2.0 (95% CI, 1.6-2.5) for future cardiovascular disease.[2] In offspring, fetal exposure to gestational diabetes in utero has been linked to macrosomia and adiposity in newborns[3] and impaired glucose tolerance and obesity in childhood,[4,5] thereby increasing risks for adverse cardiometabolic outcomes for offspring across the lifespan.[6]

In 2016, the rate of gestational diabetes in the US was estimated to be 11.1% in Asian women, 6.6% in Hispanic women, 4.8% in non-Hispanic Black women, and 5.3% in non-Hispanic White women.[7] However, it is unclear whether heterogeneity in rates of gestational diabetes exist within race and ethnicity groups (including Asian Indian, Chinese, Filipina, Japanese, Korean, and Vietnamese among non-Hispanic Asian populations and Cuban, Central/South American, Mexican, and Puerto Rican among Hispanic/Latina populations). Identifying gestational diabetes patterns in these disaggregated subgroups is necessary to accurately represent these diverse populations. In this study, data from the National Center for Health Statistics (NCHS) were examined to quantify annual rates of gestational diabetes in individuals at first live birth in race and ethnicity subgroups in the US from 2011 to 2019 to inform equitable strategies for clinical and population-level management and prevention.

Methods

Maternal data from birth registration records collected by the NCHS that capture all first live births to individuals in the US were used to evaluate gestational diabetes rates from 2011 to 2019. In the NCHS data, "nulliparity" is defined as the "first live birth." This activity was reviewed by the Centers for Disease Control and Prevention and was conducted consistent with applicable federal law and Centers for Disease Control and Prevention policy.[8] This study was deemed to be exempt because it was not considered human subjects research due to the de-identified nature of the publicly available vital statistics data set. Records not using the 2003 revised certificate of birth were ineligible because previous versions did not distinguish gestational diabetes from pregestational diabetes. Records from individuals younger than 15 years or older than 44 years, records from nonsingleton births, and records from non-US residents were also ineligible and were removed. Records from nonsingleton deliveries (eg, twins) were removed to avoid duplication of maternal data, given that records could not be linked in the deidentified data set. Records missing data on gestational diabetes or pregestational diabetes were excluded from analysis (**Figure 1**). Data collection from live births is recommended to be completed by the attendant clinician at birth (eg, physician or midwife), who compiles data from various sources, including maternal self-report, prenatal records, labor and delivery triage records, admission history and physical examination, or delivery record, based on a standardized protocol from the NCHS.

Outcomes and Maternal Characteristics

The primary outcome of interest was gestational diabetes, defined on the NCHS protocol worksheet as diabetes that is diagnosed during pregnancy. The secondary outcome of interest was pregestational diabetes, defined as diabetes diagnosed prior to pregnancy. In this data set, gestational diabetes and pregestational diabetes were mutually exclusive, such that individuals with pregestational diabetes could not be categorized as having gestational diabetes and individuals categorized as having gestational diabetes could not also be categorized as having pregestational diabetes.

Data were also collected on maternal demographic characteristics, such as age, race and ethnicity, education, and insurance (ie, primary source of payment for delivery: private, Medicaid, self-pay [no third party identified, ie, no insurance], or other), as well as prenatal characteristics, including pregestational body mass index (BMI) and receipt of prenatal care.

Race and ethnicity were evaluated as the primary stratification because previous regional data suggested differences in gestational diabetes rates by race and ethnicity[9] and contemporary clinical guidelines identify race and ethnicity subgroups for enhanced gestational diabetes screening during pregnancy.[10] Race is recognized as a social construct reflecting a range of factors and is not implied to be a biological determinant. Race and ethnicity were self-identified by the pregnant individual from fixed categories of race and ethnicity groups, which include disaggregated non-Hispanic Asian and Hispanic subgroups. Due to state-level inconsistencies in how multiple-race identification data were collected during the study period, the NCHS recommends use of bridged-race categories in analyses. The 4 bridged-race categories identified by the NCHS and used in our analysis are American Indian or Alaskan Native, Asian or Pacific Islander, Black, and White, which facilitate calculation and comparison of population-level rates and trends across time and states.[11] Single-race categories, which

Key Points

Question Did gestational diabetes rates change from 2011 to 2019 among individuals at first live birth in the US, and were there differences by race and ethnicity subgroups?

Findings In this serial, population-based, cross-sectional study of 12 610 235 individuals at first live birth aged 15 to 44 years, the age-standardized gestational diabetes rate increased from 47.6 to 63.5 per 1000 live births from 2011 to 2019. Rates increased in all racial and ethnic subgroups; in 2019, Asian Indian individuals had the highest gestational diabetes rate (129.1 per 1000 live births).

Meaning Gestational diabetes rates among individuals with a singleton first live birth increased across all race and ethnicity subgroups in the US from 2011 to 2019.

Figure 1. Birth Records Included for Primary Analysis in a Study of the Trends in Gestational Diabetes at First Live Birth by Race and Ethnicity in the US from 2011 to 2019
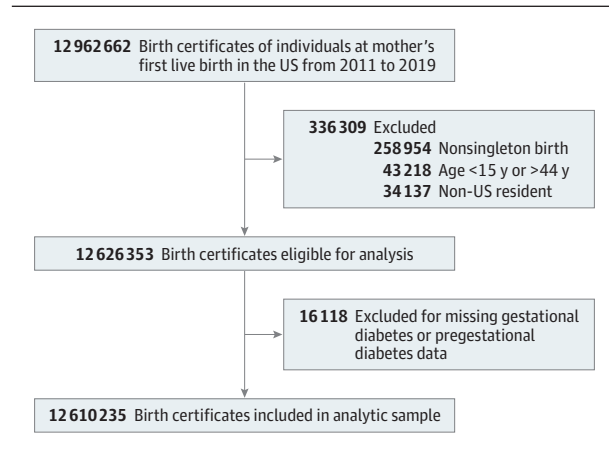
Records from the National Center for Health Statistics birth certificate files. Records that did not use the 2003 revised certificate of birth were not eligible for analysis because previous versions did not distinguish gestational diabetes from pregestational diabetes. Maternal characteristics for those whose records were excluded are shown in eTable 1 in the Supplement.

were collected on the 2003 birth certificate revision, were used to identify non-Hispanic Asian and Pacific Islander and Hispanic subgroups. There were no records with missing race data in this data set, but 0.8% of records were missing ethnicity information, so these individuals were included in bridged-race categories but not in subgroup analyses.

Statistical Analysis

In the primary analysis, gestational diabetes data were evaluated for individuals with a first live birth, each year from 2011 to 2019, overall (comprising all race and ethnicity groups combined), among the 4 largest race and ethnicity groups (Hispanic/Latina, non-Hispanic Asian/Pacific Islander, non-Hispanic Black, and non-Hispanic White), among Hispanic/Latina subgroups (Central/South American, Cuban, Mexican, and Puerto Rican), and among non-Hispanic Asian subgroups (Asian Indian, Chinese, Filipina, Japanese, Korean, and Vietnamese). In a secondary analysis, gestational diabetes data were evaluated in the available smaller subgroups of individuals over the entire study period (2011-2019 combined due to small population size), including American Indian or Alaskan Native, Guamanian, Native Hawaiian, Samoan, Other Asian (not further specified), and Other Pacific Islander (not further specified) (per NCHS terminology).

Age-standardized rates of gestational diabetes per 1000 live births were calculated overall, among race and ethnicity groups, and among Hispanic and non-Hispanic Asian subgroups. Rates were age-standardized to the age distribution of US individuals who gave birth in 2011, the beginning of the study period. Age-specific rates of gestational diabetes at first live birth were also calculated in 5-year age strata (15-19 y, 20-24 y, 25-29 y, 30-34 y, 35-39 y, and 40-44 y), overall, and in each race and ethnicity subgroup. In secondary analyses of the same population of individuals aged 15 to 44 years with singleton first live births,

age-standardized rates of pregestational diabetes were also calculated overall and stratified by race and ethnicity groups.

To quantify trends over time, Joinpoint Regression statistical software, version 4.7.0.0, was used to calculate mean annual percent change (APC) of age-standardized and age-specific rates of gestational diabetes from 2011 to 2019. Joinpoint Regression accounts for potential nonlinear trends by allowing for identification of up to 1 trend inflection point. Where an inflection was identified indicating a nonlinear trend, mean annual change was calculated based on the weight of the component trend segments. If no inflection point was identified, mean APC indicates the annual change in gestational diabetes rate across a linear trend.[12] A secondary analysis was performed to evaluate trend magnitude and direction overall and in all race and ethnicity groups, specifically from 2016 to 2019, which are the years in which all US states and regions adopted the 2003 birth certificate revision. Standardized rate ratios (RRs) and 95% CIs were calculated using modified F intervals, as previously described by Tiwari et al,[13] to compare annual age-standardized rates of gestational diabetes in individuals at first live birth in Hispanic/Latina, non-Hispanic Asian, and non-Hispanic Black subgroups, with non-Hispanic White individuals as the reference category. Age-standardized rate calculations and RR analyses were performed with Stata, version 15.1 (StataCorp). Because of the potential for type I error due to multiple comparisons, findings for secondary outcomes and analyses should be interpreted as exploratory. Two-sided P values <.05 indicate statistical significance.

Results

Maternal Characteristics

Of 12 962 662 birth certificates for the first live birth to individuals in the US from 2011 to 2019, a total of 43 218 (0.3%) were removed because the mothers were younger than 15 or older than 44 years, 258 954 (2.0%) were removed because they were non-singleton births, and 34 137 (0.3%) were removed because they were records from non-US residents; an additional 16 118 (0.1%) were excluded for missing data on gestational diabetes or pregestational diabetes status (Figure 1). Maternal characteristics from the excluded records are listed in eTable 1 in the Supplement.

Of the 12 610 235 individuals with singleton first live births in the primary analytic sample (mean [SD] age, 26.3 [5.8] years), 21% were Hispanic/Latina (mean [SD] age, 24.4 [5.8] years), 8% were non-Hispanic Asian/Pacific Islander (mean [SD] age, 29.8 years), 14% were non-Hispanic Black (mean [SD] age, 24.3 [5.7] years), and 56% were non-Hispanic White (mean [SD] age, 27.0 [5.6] years) (Table 1). The majority of individuals had completed at least a high school education (88%) and had insurance coverage (92% with Medicaid or private insurance). There were 144 861 records (1.1%) missing data on education, 107 899 (0.9%) missing insurance status, 367 616 (2.9%) missing prenatal care data, and 377 230 (3.0%) missing prepregnancy BMI data.

Among non-Hispanic Asian subgroups, the mean (SD) maternal age ranged from 29.5 (4.0) years in Asian Indian individuals to 33.3 (4.7) years in Japanese individuals (eTable 2

Table 1. Maternal Characteristics by Race and Ethnicity in Individuals Aged 15 to 44 Years With Singleton First Live Births in the US, 2011-2019

Characteristic	No. (%)[a]				
	Overall (n = 12 610 235)	Hispanic/Latina (n = 2 618 571)	Non-Hispanic Asian/ Pacific Islander (n = 978 919)	Non-Hispanic Black (n = 1 774 263)	Non-Hispanic White (n = 7 035 544)
Age, mean (SD), y	26.3 (5.8)	24.4 (5.8)	29.8 (5.0)	24.3 (5.7)	27.0 (5.6)
Education					
Some high school or less	1 450 871 (11.6)	601 932 (23.2)	52 326 (5.4)	269 210 (15.3)	499 828 (7.1)
High school graduate	3 016 982 (24.2)	837 820 (32.3)	110 394 (11.4)	578 488 (32.9)	1 445 159 (20.6)
Any college	7 997 521 (64.2)	1 150 312 (44.4)	802 458 (83.1)	913 013 (51.9)	5 055 176 (72.2)
Insurance					
Medicaid	4 803 572 (38.4)	1 471 205 (56.7)	218 649 (22.5)	1 087 815 (61.8)	1 936 592 (27.8)
Private insurance	6 753 250 (54.0)	837 770 (32.3)	661 143 (68.0)	548 030 (31.2)	4 616 167 (66.2)
Self-pay	417 289 (3.3)	155 144 (6.0)	58 012 (6.0)	50 073 (2.8)	149 393 (2.1)
Other	528 225 (4.2)	130 693 (5.0)	34 626 (3.6)	73 296 (4.2)	274 315 (3.9)
Prenatal care					
Started in 1st trimester	9 549 047 (78.0)	1 829 645 (71.9)	765 279 (80.3)	1 154 476 (68.2)	5 655 660 (82.5)
Started in 2nd trimester	2 011 583 (16.4)	516 586 (20.3)	135 188 (14.2)	390 391 (23.1)	932 401 (13.6)
Started in 3rd trimester	523 193 (4.3)	146 627 (5.8)	44 104 (4.6)	108 518 (6.4)	212 681 (3.1)
None	158 796 (1.3)	51 382 (2.0)	8002 (0.8)	39 127 (2.3)	56 897 (0.8)
Pregestational BMI, median (IQR)	24.4 (21.5-29.0)	24.9 (21.9-29.3)	22.3 (20.1-25.2)	25.8 (22.1-31.2)	24.2 (21.5-28.9)
BMI ≥25	5 626 249 (46.0)	1 247 991 (49.2)	248 563 (26.3)	942 200 (55.4)	3 095 604 (45.1)
BMI ≥30	2 658 950 (21.7)	569 500 (22.4)	72 407 (7.7)	508 110 (29.9)	1 463 775 (21.3)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); IQR, interquartile range.

[a] Percentages for categorical maternal characteristics account for missing data. Characteristics in non-Hispanic Asian and Hispanic/Latina subgroups are detailed in eTables 1 and 2 in the Supplement.

in the Supplement). Among non-Hispanic Asian subgroups, 71% to 95% reported college attendance and 61% to 83% reported having private insurance. In Hispanic/Latina subgroups (eTable 3 in the Supplement), mean (SD) maternal age ranged from 23.8 (5.6) years in Mexican individuals to 27.1 (5.5) years in Cuban individuals. Cuban individuals had the highest frequency of college attendance (58%). Hispanic/Latina individuals predominantly reported having Medicaid insurance (49%-58%). From 2011 to 2019, among all individuals at first live birth overall, the mean (SD) age at delivery was 25.5 (5.9) years in 2011 and 27.0 (5.8) years in 2019, and the median (interquartile range) pregestational BMI was 24.0 (21.3-28.3) in 2011 and 25.0 (21.9-29.9) in 2019 (Table 2).

Age-Standardized Rates of Gestational Diabetes

Overall age-standardized rates of gestational diabetes in individuals with a first live birth increased significantly from 47.6 (95% CI, 47.1-48.0) to 63.5 (95% CI, 63.1-64.0) per 1000 live births from 2011 to 2019 (Figure 2). The mean APC in age-standardized rates of gestational diabetes in this population was 3.7% (95% CI, 2.8-4.6) per year (eTable 4 in the Supplement). Gestational diabetes rates in non-Hispanic White individuals at first live birth increased significantly from 44.1 (95% CI, 43.6-44.6) to 57.7 (95% CI, 57.2-58.3) per 1000 live births from 2011 to 2019 (APC, 3.5% [95% CI, 2.8%-4.3%] per year). In non-Hispanic Black individuals at first live birth, gestational diabetes rates increased significantly from 49.0 (95% CI, 47.5-50.4) to 55.7 (95% CI, 54.5-57.0) per 1000 live births from

2011 to 2019 (APC, 1.3% [95% CI, 0.6%-1.9%] per year). Relative to the 2019 gestational diabetes rate in non-Hispanic White individuals (57.7 per 1000 live births), the rate of gestational diabetes in non-Hispanic Black individuals was statistically significantly lower (55.7 per 1000 live births; RR, 0.97 [95% CI, 0.94-0.99]; Figure 3). The RRs for gestational diabetes rates by race and ethnicity groups in 2011, 2015, and 2019 are shown in eTable 5 in the Supplement.

Absolute age-standardized rates of gestational diabetes among non-Hispanic Asian/Pacific Islander individuals and non-Hispanic Asian subgroups at first live birth are shown in Figure 2. Specifically, among non-Hispanic Asian/Pacific Islander individuals in aggregate, gestational diabetes rates significantly increased from 69.9 (95% CI, 68.1-71.6) to 102.7 (95% CI, 100.7-104.7) per 1000 live births from 2011 to 2019 (APC, 5.0% [95% CI, 4.5%-5.5%] per year) (eTable 4 in the Supplement). Relative to the 2019 gestational diabetes rate among non-Hispanic White individuals, the rate of gestational diabetes among non-Hispanic Asian/Pacific Islander individuals was statistically significantly higher (102.7 per 1000 live births; RR, 1.78 [95% CI, 1.74-1.82]; Figure 3). Absolute gestational diabetes rates in nulliparous individuals at first live birth were highest among Asian Indian individuals, which increased significantly from 90.8 (95% CI, 85.9-95.9) to 129.1 (95% CI, 124.1-134.2) per 1000 live births from 2011 to 2019 (APC, 4.4% [95% CI, 3.1%-5.6%] per year). Although Japanese individuals had the fastest relative increase in absolute gestational diabetes rates, from 28.4 (95% CI, 21.4-40.8) to 53.8 (95% CI, 41.0-78.5)

Table 2. Maternal Characteristics in Individuals Aged 15 to 44 Years With Singleton First Live Births From 2011 to 2019 in the US

Characteristic	No. (%)[a]				
	2011	2013	2015	2017	2019
No.	1 312 431	1 360 253	1 459 015	1 421 125	1 395 829
Age, mean (SD), y	25.5 (5.9)	25.9 (5.8)	26.3 (5.8)	26.7 (5.8)	27.0 (5.8)
Race and ethnicity					
Hispanic	275 449 (21.0)	273 246 (20.1)	300 055 (20.6)	298 451 (21.0)	303 338 (21.7)
Central/South American	36 000 (2.7)	36 821 (2.7)	44 257 (3.0)	48 080 (3.4)	55 593 (16.1)
Cuban	7291 (0.6)	8218 (0.6)	9416 (0.6)	10 801 (0.8)	10 691 (0.8)
Mexican	163 229 (12.4)	156 756 (11.5)	170 010 (11.7)	160 156 (11.3)	162 937 (11.7)
Puerto Rican	20 159 (1.5)	21 086 (1.6)	23 865 (1.6)	25 911 (1.8)	26 444 (1.9)
Other Hispanic[b]	48 770 (3.7)	50 365 (3.7)	52 507 (3.6)	53 503 (3.8)	47 673 (3.4)
Non-Hispanic Asian/Pacific Islander	88 478 (6.7)	98 782 (7.3)	113 168 (7.8)	118 441 (8.3)	114 138 (8.2)
Asian Indian	22 917 (1.7)	26 584 (2.0)	31 921 (2.2)	35 253 (2.5)	33 030 (2.4)
Chinese	19 029 (1.4)	23 042 (1.7)	25 471 (1.7)	28 338 (2.0)	26 771 (1.9)
Filipina	11 043 (0.8)	11 286 (0.8)	12 528 (0.9)	11 782 (0.8)	11 514 (0.8)
Japanese	2673 (0.2)	2774 (0.2)	3235 (0.2)	2893 (0.2)	2525 (0.2)
Korean	6552 (0.5)	6671 (0.5)	7265 (0.5)	6843 (0.5)	6317 (0.5)
Vietnamese	7361 (0.6)	7829 (0.6)	8592 (0.6)	8588 (0.6)	8810 (0.6)
Other Asian/Pacific Islander[c]	18 903 (1.4)	20 596 (1.5)	24 156 (1.7)	24 744 (1.7)	25 171 (1.8)
Non-Hispanic Black	181 907 (13.9)	193 426 (14.2)	204 649 (14.0)	201 876 (14.2)	199 064 (14.3)
Non-Hispanic White	746 421 (56.9)	774 074 (56.9)	817 525 (56.0)	779 472 (54.8)	755 848 (54.2)
Education					
Some high school or less	197 935 (15.2)	169 767 (12.6)	165 257 (11.5)	143 029 (10.2)	128 149 (9.3)
High school graduate	317 290 (24.4)	326 004 (24.2)	347 025 (24.1)	338 756 (24.1)	339 067 (24.6)
Any college	783 205 (60.3)	850 279 (63.2)	930 107 (64.5)	922 372 (65.7)	910 090 (66.1)
Insurance					
Medicaid	536 121 (41.5)	534 672 (39.8)	554 071 (38.2)	527 789 (37.3)	500 860 (36.1)
Private insurance	652 147 (50.5)	700 608 (52.1)	786 882 (54.3)	783 544 (55.4)	789 469 (56.9)
Self-pay	41 178 (3.2)	45 054 (3.4)	48 642 (3.4)	47 302 (3.3)	46 074 (3.3)
Other	63 038 (4.9)	63 601 (4.7)	59 514 (4.1)	54 805 (3.9)	50 231 (3.6)
Prenatal care					
Started in 1st trimester	959 777 (75.4)	994 504 (75.9)	1 113 988 (78.8)	1 097 047 (79.1)	1 087 687 (79.6)
Started in 2nd trimester	244 676 (19.2)	243 032 (18.6)	222 152 (15.7)	209 961 (15.1)	199 249 (14.6)
Started in 3rd trimester	52 267 (4.1)	56 810 (4.3)	59 881 (4.2)	60 107 (4.3)	59 220 (4.3)
None	15 705 (1.2)	15 279 (1.2)	17 787 (1.3)	19 466 (1.4)	20 499 (1.5)
Pregestational BMI, median (IQR)	24.0 (21.3-28.3)	24.1 (21.3-28.3)	24.3 (21.5-28.9)	24.7 (21.6-29.3)	25.0 (21.9-29.9)
BMI ≥25	538 746 (42.7)	570 953 (43.8)	643 635 (45.4)	663 843 (47.8)	692 774 (50.7)
BMI ≥30	244 712 (19.4)	262 776 (20.2)	302 500 (21.4)	319 655 (23.0)	341 168 (24.9)

Abbreviations: BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); IQR, interquartile range.

[a] Percentages for categorical maternal characteristics account for missing data. Listed maternal characteristics data are from mothers of all race and ethnic groups.

[b] Comprises other Hispanic subgroups not individually identified and unknown Hispanic origin.

[c] Comprises Hawaiian, Guamanian, Samoan, and other Asian/Pacific Islander subgroups not individually identified, as well as non-Hispanic individuals reporting multiple races who were bridged to Asian/Pacific Islander race.

per 1000 live births from 2011 to 2019 (APC, 9.9% [95% CI, 6.4%-13.4%] per year), they had the lowest absolute gestational diabetes rates throughout most of the study period. Relative to non-Hispanic White individuals (gestational diabetes rate of 57.7 per 1000 live births in 2019), absolute gestational diabetes rates among non-Hispanic Asian subgroups ranged from not significantly different in Japanese individuals (53.8 per 1000 live births; 2019 RR, 0.93 [95% CI, 0.71-1.36]) to statistically significantly higher in Asian Indian individuals (129.1 per 1000 live births; 2019 RR, 2.24 [95% CI, 2.15-2.33]) (Figure 3).

Among Hispanic/Latina individuals at first live birth (Figure 2), age-standardized rates of gestational diabetes increased significantly from 50.0 (95% CI, 48.9-51.2) to 66.6 (95% CI, 65.6-67.7) per 1000 live births from 2011 to 2019 (APC, 3.7% [95% CI, 3.0%-4.3%] per year). Relative to the 2019 gestational diabetes rate in non-Hispanic White individuals, the rate of gestational diabetes among Hispanic/Latina individuals was statistically significantly higher (66.6 per 1000 live births; RR, 1.15 [95% CI, 1.13-1.18]) (Figure 3). Absolute gestational diabetes rates were highest in Puerto Rican individuals and increased significantly, from 57.0 (95% CI, 52.6-61.7) to 75.8

(95% CI, 71.8-79.9) per 1000 live births from 2011 to 2019, and lowest in Central/South American individuals and increased significantly, from 39.6 (95% CI, 37.4-41.9) to 52.0 (95% CI, 50.0-54.1) per 1000 live births from 2011 to 2019. Compared with non-Hispanic White individuals in 2019, gestational diabetes rates were significantly lower in Central/South American individuals (52.0 per 1000 live births; 2019 RR, 0.90 [95% CI, 0.97-0.94]), but significantly higher in Cuban (62.3 per 1000 live births; 2019 RR, 1.08 [95% CI, 1.00-1.17]), Mexican (73.7 per 1000 live births; 2019 RR, 1.27 [95% CI, 1.25-1.31]), and Puerto Rican (75.8 per 1000 live births; 2019 RR, 1.31 [95% CI, 1.24-1.39]) individuals (Figure 3). Secondary analyses showed similar magnitude and direction of gestational diabetes trends overall and in all race and ethnicity groups from 2016 to 2019 (eTable 6 in the Supplement).

Age-Specific Rates of Gestational Diabetes

Trends in age-specific rates of gestational diabetes in individuals at first live birth based on 5-year stratified age groups were calculated (eTables 7-9 in the Supplement). Overall gestational diabetes rates per 1000 live births significantly increased within all age strata from 2011 to 2019 (eTable 7 in the Supplement): from 16.0 to 22.4 (APC, 4.2% [95% CI, 3.2%-5.2%] per year) among individuals aged 15 to 19 years, 29.9 to 40.7 (APC, 4.0% [95% CI, 3.4%-4.6%] per year) among individuals aged 20 to 24 years, 46.6 to 61.1 (APC, 3.4% [95% CI, 2.5%-4.4%] per year) among individuals aged 25 to 29 years, 57.8 to 78.0 (APC, 3.8% [95% CI, 3.2%-4.4%] per year) among individuals aged 30 to 34 years, 76.9 to 100.8 (APC, 3.4% [95% CI, 2.8%-4.0%] per year) among individuals aged 35 to 39 years, and 92.5 to 127.5 (APC, 4.2% [95% CI, 3.5%-4.8%] per year) among individuals aged 40 to 44 years. Age-stratified gestational diabetes rates by race and ethnicity groups are shown in eTable 7 in the Supplement, among non-Hispanic Asian subgroups in eTable 8 in the Supplement, and among Hispanic/Latina subgroups in eTable 9 in the Supplement.

Age-Standardized Rates of Pregestational Diabetes

Pregestational diabetes rates in individuals at first live birth increased significantly from 7.3 (95% CI, 7.1-7.4) to 9.0 (95% CI, 8.9-9.2) per 1000 live births from 2011 to 2019 (APC, 2.8% [95% CI, 1.9%-3.6%] per year) (eTable 10 in the Supplement). Relative to non-Hispanic White individuals in 2019 (eTable 11 in the Supplement), in whom the rate of pregestational diabetes was 7.9 (95% CI, 7.7-8.1) per 1000 live births, rates of pregestational diabetes were significantly higher in 2019 among non-Hispanic Black individuals (14.2 per 1000 live births; RR, 1.80 [95% CI, 1.71-1.90]) and Hispanic/Latina individuals (10.8 per 1000 live births; RR, 1.38 [95% CI, 1.31-1.44]) and not statistically significantly different among non-Hispanic Asian/Pacific Islander individuals (7.6 per 1000 live births; RR 0.97 [95% CI, 0.89-1.04]). Relative to non-Hispanic White individuals in 2019, the rates of pregestational diabetes among non-Hispanic Asian subgroups were significantly higher in Filipina individuals (10.1 per 1000 live births; 2019 RR, 1.29 [95% CI, 1.04-1.59]) and the rates of pregestational diabetes in Hispanic/Latina individuals were significantly higher in
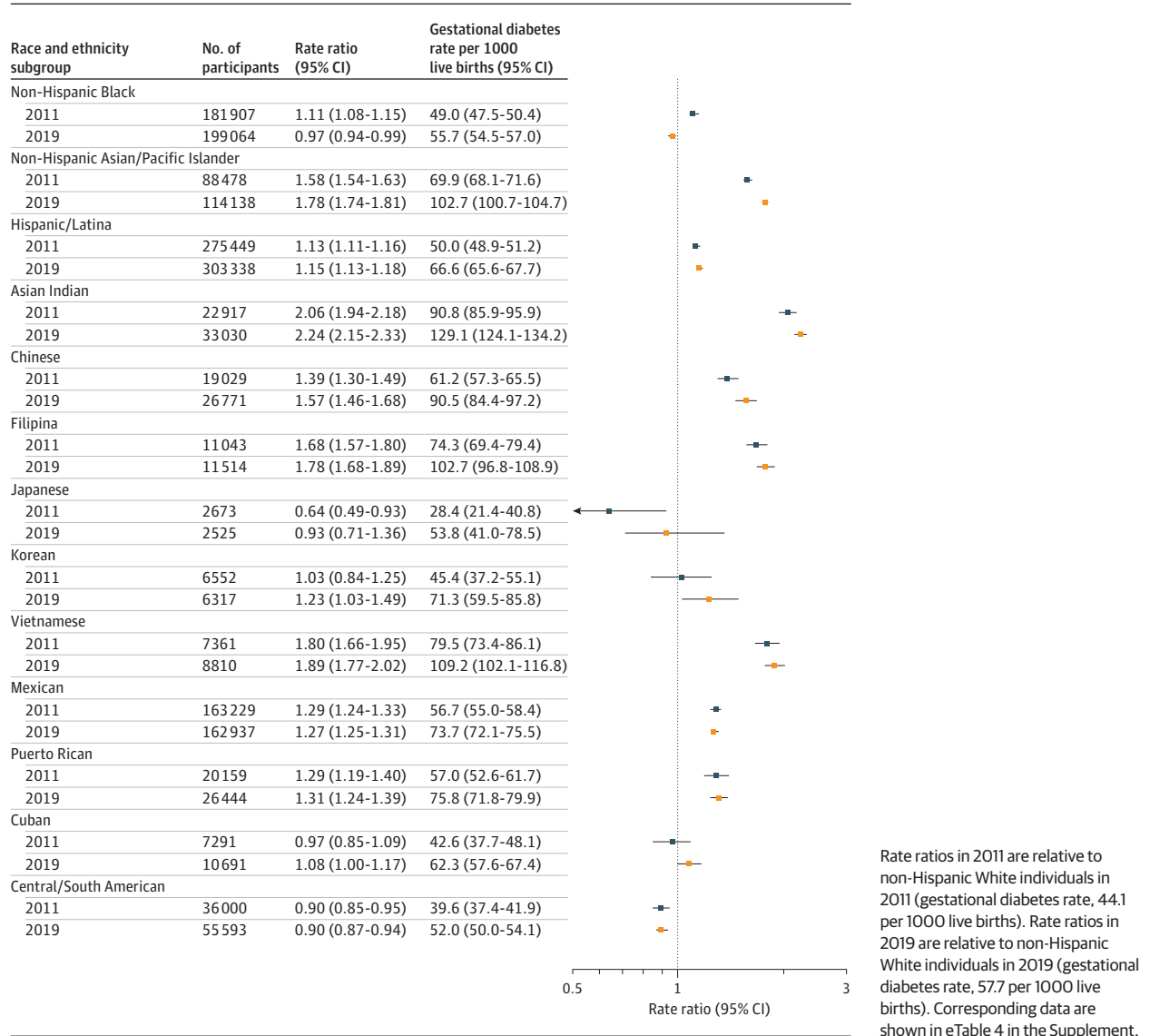
Figure 2. Age-Standardized Rates of Gestational Diabetes in Race and Ethnic Subgroups in Individuals Aged 15 to 44 Years With Singleton First Live Births in the US from 2011 to 2019

A Overall and by race and ethnicity

Non-Hispanic Asian/Pacific Islander
Hispanic/Latina
Overall
Non-Hispanic White
Non-Hispanic Black

B Non-Hispanic Asian subgroups

Asian Indian
Vietnamese
Filipina
Chinese
Korean
Non-Hispanic White
Japanese

C Hispanic/Latina subgroups

Puerto Rican
Mexican
Cuban
Non-Hispanic White
Central/South American
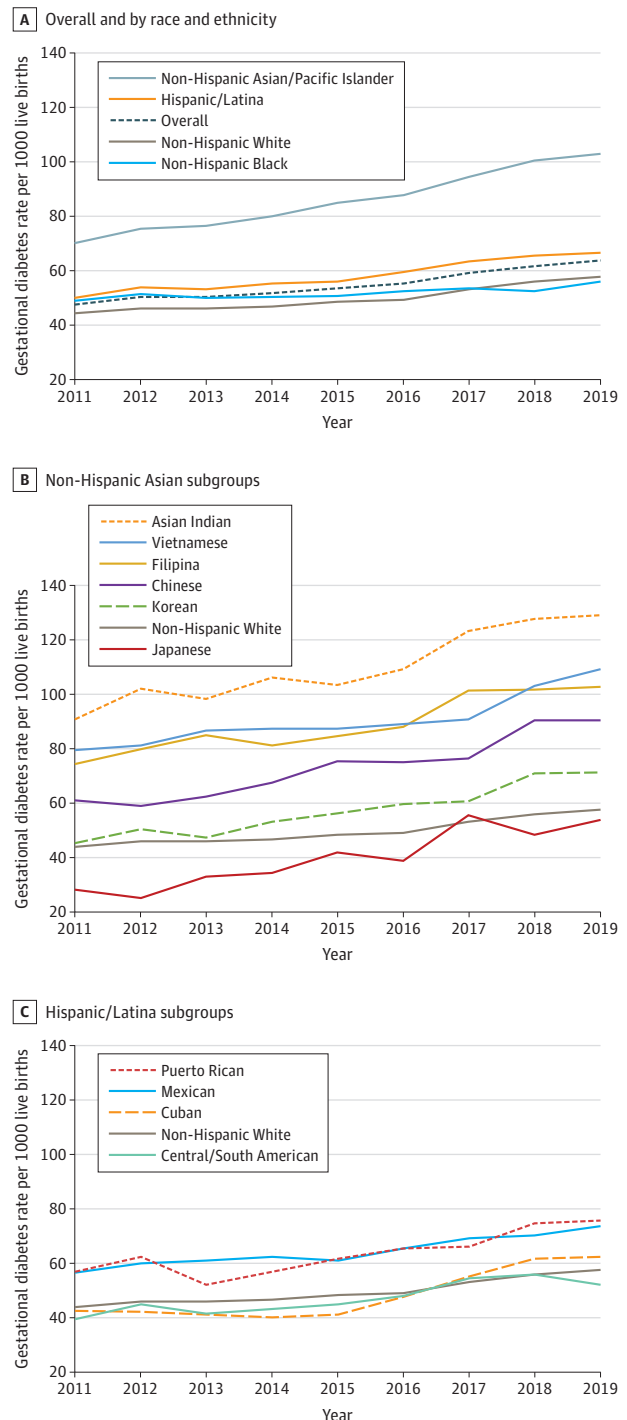
Corresponding data, including annual percent change in gestational diabetes rates, are shown in eTable 3 in the Supplement.

Mexican (12.8 [95% CI, 12.1-13.5] per 1000 live births; 2019 RR, 1.62 [95% CI, 1.53-1.73]) and Puerto Rican (14.5 [95% CI, 12.8-16.4] per 1000 live births; 2019 RR, 1.85 [95% CI, 1.62-2.09])

Figure 3. Rate Ratios of Age-Standardized Rates of Gestational Diabetes Among Individuals Aged 15 to 44 Years With Singleton First Live Births in Race and Ethnic Minority Subgroups Relative to Non-Hispanic White Individuals in the US in 2011 and 2019

Race and ethnicity subgroup	No. of participants	Rate ratio (95% CI)	Gestational diabetes rate per 1000 live births (95% CI)	
Non-Hispanic Black				
2011	181 907	1.11 (1.08-1.15)	49.0 (47.5-50.4)	
2019	199 064	0.97 (0.94-0.99)	55.7 (54.5-57.0)	
Non-Hispanic Asian/Pacific Islander				
2011	88 478	1.58 (1.54-1.63)	69.9 (68.1-71.6)	
2019	114 138	1.78 (1.74-1.81)	102.7 (100.7-104.7)	
Hispanic/Latina				
2011	275 449	1.13 (1.11-1.16)	50.0 (48.9-51.2)	
2019	303 338	1.15 (1.13-1.18)	66.6 (65.6-67.7)	
Asian Indian				
2011	22 917	2.06 (1.94-2.18)	90.8 (85.9-95.9)	
2019	33 030	2.24 (2.15-2.33)	129.1 (124.1-134.2)	
Chinese				
2011	19 029	1.39 (1.30-1.49)	61.2 (57.3-65.5)	
2019	26 771	1.57 (1.46-1.68)	90.5 (84.4-97.2)	
Filipina				
2011	11 043	1.68 (1.57-1.80)	74.3 (69.4-79.4)	
2019	11 514	1.78 (1.68-1.89)	102.7 (96.8-108.9)	
Japanese				
2011	2673	0.64 (0.49-0.93)	28.4 (21.4-40.8)	
2019	2525	0.93 (0.71-1.36)	53.8 (41.0-78.5)	
Korean				
2011	6552	1.03 (0.84-1.25)	45.4 (37.2-55.1)	
2019	6317	1.23 (1.03-1.49)	71.3 (59.5-85.8)	
Vietnamese				
2011	7361	1.80 (1.66-1.95)	79.5 (73.4-86.1)	
2019	8810	1.89 (1.77-2.02)	109.2 (102.1-116.8)	
Mexican				
2011	163 229	1.29 (1.24-1.33)	56.7 (55.0-58.4)	
2019	162 937	1.27 (1.25-1.31)	73.7 (72.1-75.5)	
Puerto Rican				
2011	20 159	1.29 (1.19-1.40)	57.0 (52.6-61.7)	
2019	26 444	1.31 (1.24-1.39)	75.8 (71.8-79.9)	
Cuban				
2011	7291	0.97 (0.85-1.09)	42.6 (37.7-48.1)	
2019	10 691	1.08 (1.00-1.17)	62.3 (57.6-67.4)	
Central/South American				
2011	36 000	0.90 (0.85-0.95)	39.6 (37.4-41.9)	
2019	55 593	0.90 (0.87-0.94)	52.0 (50.0-54.1)	

0.5   1   3
Rate ratio (95% CI)

Rate ratios in 2011 are relative to non-Hispanic White individuals in 2011 (gestational diabetes rate, 44.1 per 1000 live births). Rate ratios in 2019 are relative to non-Hispanic White individuals in 2019 (gestational diabetes rate, 57.7 per 1000 live births). Corresponding data are shown in eTable 4 in the Supplement.

individuals. Secondary analyses showed similar magnitude and direction of pregestational diabetes trends overall and in all race and ethnic groups from 2016 to 2019 (eTable 6 in the Supplement).

Discussion

Among individuals at first live birth in the US, rates of gestational diabetes increased across all race and ethnicity groups and in all age groups from 2011 to 2019. Gestational diabetes rates were significantly higher among most non-Hispanic Asian and Hispanic/Latina subgroups relative to non-Hispanic White individuals. Asian Indian individuals had the highest absolute rates of gestational diabetes throughout the study period. Although absolute rates of pregestational diabetes were low, dif-

ferences across race and ethnicity groups were present, with the highest rates in non-Hispanic Black and Hispanic/Latina individuals. Trends showed that rates of pregestational diabetes increased over time in most subgroups.

Increases in rates of gestational diabetes among individuals at first live birth of all race and ethnicity subgroups are likely multifactorial in etiology. Older maternal age during pregnancy is associated with a higher risk for gestational diabetes and may contribute, in part, to observed differences and trends; however, mean maternal age at delivery increased only modestly (<2 years) in the past decade.[14] Certain groups (eg, Mexican and Puerto Rican individuals) had higher gestational diabetes rates despite lower maternal age compared with other groups, suggesting that factors beyond maternal age likely contribute to differences in gestational diabetes burden. Further, increasing gestational diabetes

rates among individuals at first live birth were observed in all age subgroups, which suggests more widespread secular trends among all individuals.[14,15] The observed trends in rates of gestational diabetes occurred in parallel with unfavorable increases in prevalence of obesity,[16] physical inactivity,[17] and poor diet quality,[18] which are each known risk factors for gestational diabetes.[19,20]

Differences in gestational diabetes risk factors and differential exposure and vulnerability to social determinants of health between individuals by race and ethnicity group may also contribute to the wide heterogeneity in gestational diabetes rates. Differences in pregestational BMI, educational attainment, and insurance were observed that may influence risk of gestational diabetes and quality of prenatal care. Specifically, Hispanic/Latina individuals at first live birth had a relatively higher BMI and lower educational attainment than non-Hispanic White individuals. In contrast, Asian Indian individuals at first live birth had the highest rates of gestational diabetes despite lower BMI levels and higher educational attainment. Structural factors, such as access to and use of prenatal care, as well as the screening and gestational diabetes diagnostic criteria used by clinicians, have the potential to differentially influence both diagnosis and ascertainment of gestational diabetes across race and ethnicity groups.

Higher cardiometabolic risk may also be related to epigenetic and lifestyle factors as well as dysregulated visceral fat deposition at lower BMI values in Asian populations, contributing to the observed burden of gestational diabetes in non-Hispanic Asian American individuals.[21] These patterns among subgroups with higher rates of gestational diabetes are similar to the epidemiology of type 2 diabetes in the US, with highest rates of type 2 diabetes in non-Hispanic Asian (Asian Indian) and Hispanic/Latino (Mexican American) adults.[22] Known differences in behavioral, psychosocial, structural, and immigration-related factors between subgroups, such as culturally specific dietary patterns, physical activity levels, rates of depression, acculturation, and discrimination may further contribute to observed gestational diabetes differences.[23-26] Several of these determinants may also contribute to the observed differences in gestational diabetes vs pregestational diabetes trends. For example, gestational diabetes rates were significantly lower, but pregestational diabetes rates were significantly higher, in non-Hispanic Black individuals compared with non-Hispanic White individuals, indicating that more non-Hispanic Black individuals had diabetes when becoming pregnant so were not "at risk" for gestational diabetes.

Given that gestational diabetes is associated with increased short-term and long-term risks for individuals and their offspring, the observed trends and disparities may portend a greater burden of future cardiometabolic disease. Gestational diabetes is associated with up to 10-times higher odds of development of maternal type 2 diabetes or prediabetes compared with individuals with a normoglycemic pregnancy,[27,28] and an approximately 2-fold increased risk for incident cardiovascular disease.[2,29,30] Recent trends in documenting increasing rates of premature mortality related to diabetes and coronary heart disease in young adults underscore the importance of targeting the postpartum period for cardiometabolic disease prevention.[31-33] There is also evidence indicating intergenerational transmission of cardiometabolic risk related to gestational diabetes. Gestational diabetes is associated with childhood obesity and impaired glucose tolerance in offspring.[27] One large observational study identified that offspring of women with gestational diabetes had a 29% higher rate of early-onset cardiovascular disease.[6] However, further research is needed to understand the long-term cardiometabolic consequences of gestational diabetes in subgroups with the highest burden, who are less represented in previous research.

The observed heterogeneity in rates of gestational diabetes within subgroups of non-Hispanic Asian and Hispanic individuals at first live birth highlight the importance of ascertaining and reporting rates specific to these disaggregated non-Hispanic Asian and Hispanic subgroups.[34,35] The reported trends herein may also guide strategies to equitably address increasing gestational diabetes rates by investigating the determinants of gestational diabetes and interventions to address them in populations with high burden.[36] Addressing modifiable prenatal risk factors and implementing strategies to prevent gestational diabetes and postnatal diabetes in all individuals, with particular focus on groups with disproportionately high gestational diabetes rates, may help to reduce disparities in long-term cardiovascular and metabolic disease outcomes. Consideration for earlier screening prior to the universal second trimester screening for gestational diabetes (between 24 and 28 weeks) is currently recommended by the American College of Obstetrics and Gynecology in individuals with risk factors for gestational diabetes, including individuals who identify as being from racial or ethnic subgroups at increased risk.[10]

Limitations

This study has several limitations. First, it is possible that the assessment of the trends before 2016 may be affected by only including data from states that adopted the 2003 birth certificate revision. Individual-level data from birth certificates by state are not publicly available, so it was not possible to fully evaluate the degree to which staggered state-level adoption of the 2003 birth certificate revision contributed to observed trends. This issue may have particularly affected the results of the Native Hawaiian and Pacific Islander individuals, because Hawaii was not included until 2014. However, a secondary analysis showed similar magnitude and direction of trends from 2016 to 2019 (the period in which all states/regions adopted the revised certificate) as were observed from 2011 to 2019. Second, the analysis was only among individuals with singleton first live births. It is known that prior gestational diabetes is a risk factor for subsequent gestational diabetes, but the deidentified nature of this data set meant that individuals who had multiple children during the study period could not be distinguished. Because multiparity may be a risk factor for gestational diabetes, focusing on individuals at first live birth may actually underestimate total gestational diabetes rates.[37]

Third, the potential for miscoding or lack of awareness of pregestational diabetes that may be related to differences in

screening or preconception care in individuals of childbearing age is possible. Previous research has shown that the sensitivity of birth certificates for identifying gestational diabetes is 46% to 83% (median, 65%) and the specificity is greater than 98%,[38] with substantial agreement of gestational diabetes diagnosis between birth certificates and medical records.[39] This study therefore focused primarily on identifying differences and trends in gestational diabetes, acknowledging that birth certificate data may underestimate the true burden of gestational diabetes and overt type 2 diabetes may be less likely to be diagnosed prior to pregnancy in certain subgroups. However, the NCHS data are the largest, most comprehensive source of vital statistics data capturing all live births in the US. Gestational diabetes diagnosis in these records is completed by the professional birth attendant, so identification of gestational diabetes does not rely on administrative coding. But, there may be inconsistency between clinicians in how gestational diabetes is diagnosed depending on which diagnostic criteria are used (eg, American College of Obstetrics and Gynecology vs the International Association of Diabetes and Pregnancy Study Groups criteria[40]), so these findings may, in part, reflect secular trends in gestational diabetes detection related to adoption of more liberal diagnostic criteria. Fourth, these estimates do not include individuals with fetal deaths, who were excluded given inconsistencies in state-level reporting. Fetal death is an event that has been associated with gestational diabetes, but represented less than 0.7% of all pregnancy records in the study period. Fifth, lack of data on other covariates, such as diet quality or physical activity, limit assessment of key risk factors that may be contributing to observed trends at a national level. Sixth, although these data include self-identification of several subgroups, options to identify as Southeast Asian or Middle Eastern/North African groups were not available.

Conclusions

Among individuals with a singleton first live birth in the US from 2011 to 2019, rates of gestational diabetes increased across all race and ethnicity subgroups. Differences in absolute gestational diabetes rates were observed across race and ethnicity subgroups.

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