Trends in the Prevalence of Preexisting Diabetes and Gestational Diabetes Mellitus Among a Racially/Ethnically Diverse Population of Pregnant Women, 1999–2005

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OBJECTIVE — The purpose of this study was to assess changes in the prevalence of preexisting diabetes (diabetes antedating pregnancy) and gestational diabetes mellitus (GDM) from 1999 through 2005.

RESEARCH DESIGN AND METHODS — In this retrospective study of 175,249 women aged 13–58 years with 209,287 singleton deliveries of ≥20 weeks' gestation from 1999 through 2005 in all Kaiser Permanente hospitals in southern California, information from clinical databases and birth certificates was used to estimate the prevalence of preexisting diabetes and GDM.

RESULTS — Preexisting diabetes was identified in 2,784 (1.3%) of all pregnancies, rising from an age- and race/ethnicity-adjusted prevalence of 0.81 per 100 in 1999 to 1.82 per 100 in 2005 ($P_{trend} < 0.001$). Significant increases were observed in all age-groups and all racial/ethnic groups. After women with preexisting diabetes were excluded, GDM was identified in 15,121 (7.6%) of 199,298 screened pregnancies. The age- and race/ethnicity-adjusted GDM prevalence remained constant at 7.5 per 100 in 1999 to 7.4 per 100 in 2005 ($P_{trend} = 0.07$). Among all deliveries to women with either form of diabetes, 10% were due to preexisting diabetes in 1999, rising to 21% in 2005, with GDM accounting for the remainder.

CONCLUSIONS — The stable prevalence of GDM and increase in the prevalence of preexisting diabetes were independent of changes in the age and race/ethnicity of the population. The increase in preexisting diabetes, particularly among younger women early in their reproductive years, is of concern.

Diabetes Care 31:899–904, 2008

Diabetes, a common medical complication of pregnancy, can be divided into two broad categories: overt or preexisting diabetes (type 1 and type 2) and gestational diabetes mellitus (GDM). The latter is defined as glucose intolerance with onset or first recognition during pregnancy (1). GDM accounted for ~88% of all pregnancies affected by diabetes in the U.S. in 1988, with preexisting diabetes accounting for the remaining 12% (2). GDM complicates 4–14% of pregnancies in the U.S. annually, with the prevalence varying significantly with characteristics of the population studied (3).

Several studies reported increases in GDM in U.S. populations in the 1990s. An increased incidence of GDM in a northern California population was observed from 1991 (5.1%) to 1997 (7.4%), with rates leveling off from 1997 through 2000 (4). The prevalence of GDM in a Colorado cohort doubled from 1994 to 2002 (5). From 1990 to 2005, the age-adjusted prevalence of diabetes increased from 0.9 per 100 to 1.5 per 100 for women aged <44 years in the U.S (6). The SEARCH for Diabetes in Youth Study estimated that 3.1 per 1,000 girls aged 10–19 years in the U.S. had nongestational diabetes of any type in 2001 (7). Overweight and obesity are known risk factors for diabetes (8). One-third of all women aged 20–39 years in the U.S. were obese in 2003–2004, whereas more than half of black women and more than 40% of Mexican-American women were obese (9).

Given the increasing prevalence of obesity and diabetes among reproductive-age women, we examined changes in the prevalence of preexisting diabetes and GDM among a racially/ethnically diverse population of pregnant women to determine whether there were changes in prevalence over time, to identify women in racial/ethnic groups and age-groups most affected by any changes, and to assess whether preexisting diabetes or GDM may now account for a larger proportion of diabetes-exposed pregnancies than reported previously.

RESEARCH DESIGN AND METHODS

The Kaiser Permanente Southern California (KPSC) Medical Care Program is a large prepaid group practice–managed health care organization providing health care for >3 million members. Members receive their care in KPSC-owned medical offices and hospitals throughout the seven county region. Confidential health plan databases, including all hospitalizations, outpatient visits, laboratory test results, and pre-

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Received for publication 10 December 2007 and accepted in revised form 22 January 2008.
Published ahead of print at http://care.diabetesjournals.org on 25 January 2008. DOI: 10.2337/dc07-2345.
Additional information for this article can be found in an online appendix at http://dx.doi.org/10.2337/dc07-2345.
Abbreviations: GDM, gestational diabetes mellitus; KPSC, Kaiser Permanente Southern California; OGTT, oral glucose tolerance test.

scriptions dispensed by KPSC pharmacies, were used for this study.

This study was approved by the KPSC institutional review board. The study population was women who had one or more singleton births at ≥20 weeks' gestation (stillbirth or livebirth) from 1 January 1999 through 31 December 2005 in KPSC hospitals. Uniform definitions of preexisting diabetes and GDM could be applied using standardized databases and methods for this period. Maternal race/ethnicity as reported on the infant's birth certificate was categorized as Hispanic, non-Hispanic white (white), non-Hispanic black (black), Asian/Pacific Islander, and other races. Maternal age at delivery, categorized as 13–19, 20–24, 25–29, 30–44, 35–39, and ≥40 years, and parity, categorized as 0, 1, 2, and ≥3, were also obtained from the birth certificate.

Identifying women with preexisting diabetes

An algorithm was used to identify women with a high probability of having diabetes on the basis of having at least one of the following: an ICD-9 hospital diagnostic code of 250.xx (diabetes mellitus), an outpatient encounter code for diabetes, a prescription for insulin or other oral hypoglycemic agents, or A1C ≥7.0% (10). There were two exceptions. First, women taking metformin who had none of the other criteria defining diabetes were not defined as having preexisting diabetes because this drug is also used to treat polycystic ovary syndrome independent of whether or not the patient has glucose intolerance (11,12). Second, to avoid misclassifying women with a history of GDM treated with insulin or glyburide (13) as having preexisting diabetes during any future pregnancy based solely on her use of these medications during pregnancy, use of these two drugs during pregnancy was excluded from the algorithm to classify women as having preexisting diabetes.

Screening and testing women for GDM

Plasma glucose and oral glucose tolerance test (OGTT) results were obtained from KPSC laboratory databases that include all tests performed at all KPSC facilities. Women were defined as having been screened for GDM if a 50-g, 1-h OGTT was performed, as this is the standard practice in 10 of the 11 medical centers. Given that we wished to include women who had results from other laboratory tests during pregnancy that met the criteria for diagnosing GDM or diabetes, regardless of whether they had the 50-g test, we also considered women who had the 100-g, 3-h or 75-g, 2-h OGTT; a fasting plasma glucose test; or a random plasma glucose test as having been screened for GDM.

GDM was defined hierarchically as *1)* at least two abnormal plasma glucose measurements during the 100-g, 3-h OGTT greater than or equal to the Carpenter and Coustan threshold values recommended by the American Diabetes Association (fasting 5.3 mmol/l, 1 h 10 mmol/l, 2 h 8.6 mmol/l, and 3 h 7.8 mmol/l [14]; or *2)* at least two abnormal values on the 75-g obstetric OGTT greater than or equal to the threshold values (fasting 5.3 mmol/l, 1 h 10 mmol/l, and 2 h 8.6 mmol/l [14]; or *3)* a fasting plasma glucose concentration of ≥7 mmol/l [1]; or *4)* a random plasma glucose concentration of ≥11.1 mmol/l (1). One medical center did not perform the 50-g screening test but, rather, tested each pregnant woman with the 75-g OGTT; the other 10 medical centers selectively test with the 100-g OGTT contingent on the results of the 50-g glucose screen.

Categorization of diabetes status for each pregnancy

For each pregnancy, we determined whether a woman had preexisting diabetes, GDM, or neither condition. To avoid overlap of the diagnostic periods, women were defined as having preexisting diabetes if they met the criteria previously described at least 270 days before the delivery, excluding the time during any previous pregnancies. Once a woman had preexisting diabetes, she retained this status for any future pregnancies. Women who had GDM were not assumed to have GDM in future pregnancies.

Statistical analysis

Statistical analyses were performed with SAS (version 9.1; SAS Institute, Cary, NC). As the purpose of this article was to report the trends in prevalence of preexisting diabetes and GDM by year, we included all women with one or more deliveries during the study period to accurately estimate the yearly prevalence. All references to year refer to the delivery year; screening and diagnosis may have occurred in the previous calendar year. Differences were assessed using Student's *t* tests (maternal age), Wilcoxon's rank-sum test (parity), and χ^2 tests (race/ethnicity). Prevalence of preexisting diabetes was estimated by dividing the number of women with preexisting diabetes giving birth that year by the total number of women giving birth during that year. Prevalence of GDM was estimated by dividing the number of women giving birth during that year with GDM by the total number of women screened for GDM giving birth that year. Although the prevalence of diabetes is frequently reported per 1,000 and the prevalence of GDM reported per 100, we used per 100 for both conditions to facilitate the comparison of the prevalence of these conditions.

The annual age-adjusted and the age- and race/ethnicity-adjusted prevalence of preexisting diabetes and GDM and SEMs were calculated using the direct adjustment method (15). The age and race/ethnicity distribution of the entire study population of all singleton births was used as the standard population for all adjusted prevalence estimates.

We used the GENMOD procedure to develop Poisson regression models to assess the effect of time (year), controlling for race/ethnicity and maternal age and then repeating these models adding parity on prevalence of preexisting diabetes and GDM (16) by comparing the prevalence of these conditions at the beginning (1999) and the end (2005) of the study period. Rate ratios (RRs) and 95% CIs are presented. Testing for trend was conducted by fitting year as a continuous variable in the log-linear Poisson model, adjusting for age or race/ethnicity categories where appropriate. Age-specific models and race/ethnicity-specific models only included women from the specified group in the model of interest, whereas final crude, age-adjusted, and age- and race/ethnicity-adjusted trends were assessed with all women in the model (17). We considered P values < 0.05 indicative of a significant trend.

To estimate the proportions of all pregnancies affected by some degree of glucose intolerance due to preexisting diabetes and GDM each year, we used two approaches. First, we added the age- and race/ethnicity-adjusted rates for both conditions and then calculated the percentage attributed to each condition. Second, we used the total number of women with either condition as the denominator and then calculated the percentage attributed to preexisting diabetes and GDM. This second approach does not adjust for

Table 1—*Annual number of singleton births, mean maternal age, and prevalence of preexisting diabetes per 100 births by maternal age and race/ethnicity among 209,287 births by year, Kaiser Permanente Southern California, 1999–2005*

	1999	2000	2001	2002	2003	2004	2005	P_{trend}*
No. births	32,089	31,377	29,980	29,877	29,598	28,135	28,231	
Mean age (years)	28.2	28.3	28.5	28.8	29.0	29.1	29.1	
No. with diabetes†	245	333	315	377	451	526	537	
13–19 years	0.11 (0.07)	0.25 (0.10)	0.14 (0.08)	0.21 (0.11)	0.51 (0.17)	0.17 (0.10)	0.55 (0.17)	0.0106
20–24 years	0.36 (0.07)	0.48 (0.09)	0.41 (0.08)	0.58 (0.10)	0.66 (0.11)	0.87 (0.13)	0.72 (0.12)	0.0001
25–29 years	0.59 (0.08)	0.70 (0.09)	0.85 (0.10)	0.92 (0.10)	1.19 (0.12)	1.40 (0.13)	1.29 (0.13)	<0.0001
30–34 years	0.95 (0.11)	1.44 (0.13)	1.23 (0.12)	1.50 (0.13)	1.83 (0.15)	2.34 (0.17)	2.36 (0.17)	<0.0001
35–39 years	1.39 (0.18)	1.98 (0.22)	1.87 (0.21)	2.30 (0.23)	2.61 (0.24)	3.00 (0.26)	3.43 (0.27)	<0.0001
≥40 years	2.86 (0.54)	3.13 (0.57)	3.62 (0.58)	3.32 (0.54)	3.35 (0.54)	4.66 (0.66)	4.08 (0.60)	0.0425
Race/ethnicity								
Non-Hispanic white								
Crude	0.63 (0.08)	0.89 (0.10)	0.82 (0.10)	1.14 (0.12)	1.23 (0.13)	1.53 (0.14)	1.48 (0.15)	<0.0001
Age-adjusted	0.61 (0.02)	0.87 (0.02)	0.75 (0.02)	1.09 (0.02)	1.15 (0.02)	1.42 (0.03)	1.38 (0.03)	<0.0001
Hispanic								
Crude	0.75 (0.07)	1.13 (0.08)	1.05 (0.08)	1.22 (0.09)	1.66 (0.10)	1.98 (0.12)	1.92 (0.11)	<0.0001
Age-adjusted	0.89 (0.02)	1.29 (0.02)	1.15 (0.02)	1.27 (0.02)	1.72 (0.03)	2.04 (0.03)	1.95 (0.03)	<0.0001
Black								
Crude	0.87 (0.16)	1.39 (0.21)	1.44 (0.21)	1.59 (0.23)	1.66 (0.24)	2.11 (0.28)	2.59 (0.31)	<0.0001
Age-adjusted	0.96 (0.02)	1.53 (0.03)	1.52 (0.03)	1.62 (0.03)	1.68 (0.03)	2.23 (0.03)	2.77 (0.04)	<0.0001
Asian/Pacific Islander								
Crude	1.07 (0.18)	0.95 (0.17)	1.20 (0.19)	1.48 (0.21)	1.47 (0.20)	2.02 (0.24)	2.12 (0.25)	<0.0001
Age-adjusted	0.96 (0.02)	0.78 (0.02)	0.98 (0.02)	1.15 (0.02)	1.24 (0.02)	1.70 (0.03)	1.73 (0.03)	<0.0001
Other races								
Crude	0.95 (0.47)	0.26 (0.26)	1.17 (0.58)	1.04 (0.52)	1.63 (0.66)	1.08 (0.54)	1.97 (0.56)	0.0431
Age-adjusted	1.05 (0.02)	0.35 (0.01)	1.34 (0.03)	0.91 (0.02)	1.68 (0.03)	1.25 (0.02)	2.14 (0.03)	0.0710
All women								
Crude	0.76 (0.05)	1.06 (0.06)	1.05 (0.06)	1.26 (0.06)	1.52 (0.07)	1.87 (0.08)	1.90 (0.08)	<0.0001
Age-adjusted	0.81 (0.02)	1.10 (0.02)	1.06 (0.02)	1.25 (0.02)	1.50 (0.03)	1.81 (0.03)	1.83 (0.03)	<0.0001
Age- and race/ethnicity-adjusted	0.81 (0.02)	1.10 (0.02)	1.06 (0.02)	1.24 (0.02)	1.50 (0.03)	1.82 (0.03)	1.82 (0.03)	<0.0001

Data are prevalence per 100 (SEM). **P* values derived from Poisson regression models using pre-existing diabetes as the outcome variable and year as a continuous variable in the model after adjustment for other variables specified for the row. †Preexisting diabetes.

differences in age or race/ethnicity in the population over time.

RESULTS

Characteristics of study sample

There were 175,249 women aged 13–58 years (mean ± SEM 28.7 ± 6.0) with 209,287 singleton pregnancies that ended in livebirths or stillbirths at ≥20 weeks gestation from 1999 through 2005. Of these women, 144,228 (82%) had one birth and 31,021 (18%) had more than one birth in a KPSC hospital during the study period. The maternal racial/ethnic composition of the population on the basis of total number of births was 51.6% Hispanic, 25.9% white, 11.1% Asian/Pacific Islander, 9.9% black, and 1.5% other races. The mean maternal age increased from 28.2 years in 1999 to 29.1 years in 2005 ($P < 0.0001$). The median parity was 1.00 for each year of the study; the means showed no clinical difference (range 1.02–1.05) over time.

Prevalence of preexisting diabetes

Of the 209,287 deliveries in the cohort, 2,784 (1.3%) were to women with preexisting diabetes. These women tended to be older (mean age 32.2 vs. 26.6 years, $P < 0.0001$), were least likely to be white, and had higher parity (1.4 vs. 1.0 [both medians 1.0], $P < 0.0001$) than women without diabetes. The prevalence of preexisting diabetes among women giving birth doubled from an age- and race/ethnicity-adjusted prevalence of 0.81 in 1999 to 1.82 in 2005 (Table 1).

The increase in prevalence differed by maternal age, race/ethnicity, and year of delivery. From 1999 to 2005, age-specific prevalence of preexisting diabetes approximately doubled for women in the middle four age categories (20–24, 25–29, 30–34, and 35–39 years), increased fivefold for teenagers (13–19 years) from 0.11 (0.07) to 0.55 (0.17) per 100 deliveries, and increased by >40% among women >40 years of age; all trend tests were significant (Table 1). The age-adjusted prevalence doubled for Hispanic women, white women, and women of other races; almost tripled for black women, from 0.96 (0.02) to 2.77 (0.04); and increased by ~75% for Asian/Pacific Islander women during the study period.

After adjustment for maternal age and race/ethnicity, the RR for the prevalence of preexisting diabetes comparing the last year of the study (2005) to the first year (1999) was 2.26 (95% CI 1.95–2.63). After adjustments for year and maternal age, the RRs for black (1.69 [95% CI 1.47–1.93]), Hispanic (1.42 [1.29–1.57]), and Asian/Pacific Islander (1.25 [1.09–1.42]) women were significantly higher than those for white women. Further adjustment for parity had no impact on the RR, as parity remained constant over the study period.

Screening for GDM

After exclusion of the 2,784 pregnancies to women with preexisting diabetes, 96.5% (199,298) of the 206,503 remain-

Table 2—*Annual number of singleton births, mean maternal age, and prevalence of GDM per 100 births by maternal age and race/ethnicity among 199,298 births screened for GDM, Kaiser Permanente Southern California, 1999–2005*

	1999	2000	2001	2002	2003	2004	2005	$*P_{trend}$
No. births	30,576	29,903	28,474	28,443	28,308	26,815	26,779	
Mean age (years)	28.1	28.4	28.6	28.8	29.0	29.1	29.2	
No. with GDM	2,171	2,205	2,219	2,329	2,091	2,028	2,078	
13–19 years	1.8 (0.27)	1.4 (0.25)	2.0 (0.32)	1.3 (0.27)	1.4 (0.29)	2.2 (0.36)	1.7 (0.31)	0.7539
20–24 years	3.3 (0.23)	3.4 (0.24)	4.3 (0.27)	3.7 (0.26)	3.3 (0.25)	3.3 (0.27)	3.7 (0.29)	0.6778
25–29 years	6.0 (0.25)	6.5 (0.26)	6.4 (0.27)	6.8 (0.27)	5.6 (0.25)	6.2 (0.27)	6.1 (0.27)	0.4686
30–34 years	8.9 (0.32)	9.1 (0.32)	9.5 (0.34)	10.2 (0.34)	9.4 (0.33)	8.5 (0.32)	9.0 (0.32)	0.6606
35–49 years	13.0 (0.53)	13.4 (0.54)	13.2 (0.54)	13.5 (0.54)	12.2 (0.51)	12.8 (0.52)	12.8 (0.52)	0.3787
≥40 years	17.4 (1.27)	15.5 (1.22)	16.2 (1.19)	17.6 (1.18)	15.9 (1.13)	17.0 (1.21)	17.1 (1.17)	0.8138
Race/ethnicity								
Non-Hispanic white								
Crude	5.2 (0.24)	5.2 (0.25)	5.9 (0.27)	6.3 (0.28)	5.4 (0.27)	5.4 (0.27)	5.3 (0.28)	0.9306
Age-adjusted	5.1 (0.05)	5.0 (0.05)	5.6 (0.05)	5.9 (0.05)	5.2 (0.05)	5.0 (0.05)	4.9 (0.05)	0.4767
Hispanic								
Crude	7.6 (0.21)	7.8 (0.22)	8.3 (0.23)	8.6 (0.23)	7.8 (0.22)	8.0 (0.23)	8.5 (0.23)	0.0506
Age-adjusted	8.6 (0.06)	8.6 (0.06)	8.9 (0.07)	9.0 (0.07)	8.1 (0.06)	8.2 (0.06)	8.6 (0.06)	0.2552
Black								
Crude	5.6 (0.41)	6.2 (0.44)	6.1 (0.44)	6.9 (0.48)	4.6 (0.41)	5.9 (0.47)	5.0 (0.44)	0.1120
Age-adjusted	6.0 (0.05)	6.6 (0.06)	6.5 (0.06)	7.1 (0.06)	4.6 (0.05)	6.2 (0.05)	5.2 (0.05)	0.0297
Asian/Pacific Islander								
Crude	11.3 (0.57)	12.0 (0.57)	11.7 (0.58)	11.7 (0.57)	12.5 (0.57)	12.0 (0.57)	11.8 (0.57)	0.4782
Age-adjusted	10.2 (0.07)	10.8 (0.07)	10.5 (0.07)	10.2 (0.07)	10.9 (0.07)	10.8 (0.07)	10.3 (0.07)	0.5923
Other races								
Crude	5.6 (1.16)	6.5 (1.28)	6.0 (1.34)	8.3 (1.45)	4.3 (1.08)	7.4 (1.40)	8.1 (1.14)	0.2005
Age-adjusted	6.1 (0.05)	7.2 (0.06)	6.4 (0.06)	9.5 (0.07)	4.6 (0.05)	7.6 (0.06)	8.5 (0.06)	0.3224
All women								
Crude	7.1 (0.15)	7.4 (0.15)	7.8 (0.16)	8.2 (0.16)	7.4 (0.16)	7.6 (0.16)	7.8 (0.16)	0.0176
Age-adjusted	7.4 (0.06)	7.6 (0.06)	7.9 (0.06)	8.1 (0.06)	7.2 (0.06)	7.4 (0.06)	7.5 (0.06)	0.4104
Age- and race/ethnicity-adjusted	7.5 (0.06)	7.6 (0.06)	7.9 (0.06)	8.1 (0.06)	7.2 (0.06)	7.3 (0.06)	7.4 (0.06)	0.0655

Data are prevalence per 100 (SEM). *P values derived from Poisson regression models using GDM as the outcome variable and year as a continuous variable in the model after adjustment for other variables specified for the row.

ing pregnancies had been screened for GDM. The proportion screened was very high across all years and increased over time ($P < 0.001$); 96.0% were screened in 1999, the year with the lowest proportion screened, and 97.0% were screened in 2003, the year with the highest proportion screened. Women with 7,205 pregnancies who were not screened were younger (26.5 vs. 28.7 years, $P < 0.001$), less parous (1.0 vs. 1.2 [both medians 1.0], $P < 0.001$), and more likely to be of black or other race ($P < 0.001$) than those who were screened for GDM. The proportion screened by race/ethnicity ranged from 95.6% (other races) to 97.3% (Asian/Pacific Islanders).

Prevalence of GDM

We calculated the GDM prevalence by year based on the 199,298 screened pregnancies. Of these women, 15,121 (7.6%) had laboratory-identified GDM on the basis of the following criteria using the hierarchical approach: 100-g OGTT (n = 12,494; 82.6%), 75-g OGTT (n = 1,928; 12.8%), fasting plasma glucose (n = 458; 3.0%), or a random plasma glucose (n = 241; 1.6%). Women with GDM were older (mean age 31.7 vs. 28.5 years, $P < 0.001$) and of higher parity (1.23 vs. 1.00 [both medians 1.0], $P < 0.001$) and were more likely to be Asian/Pacific Islander or Hispanic than were women without GDM. Over the 7-year period, we observed almost no change in the age- and race/ethnicity-adjusted prevalence of GDM, from 7.5 per 100 in 1999 to 7.4 per 100 in 2005; the test for trend was not significant (Table 2).

After adjustment for maternal age and race/ethnicity, the RR for the prevalence of GDM comparing the last year of the study (2005) to the first year (1999) was 0.99 (95% CI 0.93–1.05). Further adjustment for parity had no effect. RRs for Asian/Pacific Islanders (1.97 [95% CI 1.86–2.08]), Hispanic (1.69 [1.62–1.77]), other (1.47 [1.26–1.72]), and black (1.26 [1.18–1.36]) women were higher than for white women after adjustment for year and maternal age.

We reran the model for GDM twice to determine whether including 7,205 unscreened pregnancies in the denominator or excluding 43,304 pregnancies from the medical center with the 75-g protocol significantly affected our findings. No significant changes were observed (data not shown).

Prevalence of preexisting diabetes compared with GDM

The cumulative prevalence of preexisting diabetes and GDM increased over the years studied. Using the first approach, we estimated that 8.3 per 100 pregnancies were affected by some form of diabetes in 1999 compared with 9.2 per 100 in 2005. The proportion of pregnancies affected by preexisting diabetes of all diabetic pregnancies (preexisting diabetes plus GDM) increased over time. In 1999, 10% of diabetic pregnant women had preexisting diabetes, whereas 90% had GDM. In 2005, 21% had preexisting diabetes and 79% had GDM. When we used the absolute number of deliveries to women with either condition as the denominator (the second approach), 11% of pregnant diabetic women had preexisting diabetes in 1999 compared with 26% in 2005.

CONCLUSIONS

Prevalence of preexisting diabetes

The age- and race/ethnicity-adjusted prevalence of preexisting diabetes during pregnancy doubled during the 7-year study period. Age-specific prevalence doubled for women in categories aged between 20 and 39 years and increased fivefold for teenagers from the first to the last year of the study. In contrast, women aged ≥40 years had a small but significant increase in the prevalence of preexisting diabetes. The increase in prevalence of preexisting diabetes among women in the younger age categories may reflect an increasing prevalence of diabetes (7) or an earlier age at diagnosis.

Although neither Ferrara et al. (4) nor Dabelea et al. (5) included women with preexisting diabetes in their studies, we calculated that 0.5% of women (1,614 of 309,440) from 1991–2000 in the northern California cohort (4) and 0.4% of women (140 of 36,403) from 1994–2002 in the Colorado cohort (5) had preexisting diabetes on the basis of their data, whereas 1.3% of pregnancies in our study from 1999–2005 were to women with preexisting diabetes. Dabelea et al. (5) noted that there was no trend in the prevalence of preexisting diabetes in their cohort, whereas Ferrara et al. (4) did not comment on the prevalence in their cohort. The estimated prevalence of preexisting diabetes from the seven states using the expanded birth certificate was 7.2 per 1,000 (0.72 per 100) in 2004, less than half of our estimate of 1.82 per 100. The larger proportion of non-Hispanic white women (72.4%) in their sample compared with ours (25.0%) and their younger age distribution may both account for the lower prevalence (18).

Prevalence of GDM

The prevalence of GDM was quite similar in 1999 and 2005. It rose until 2002 but then declined to the previous level. Similar patterns were observed across age categories and racial and ethnic groups. We can compare our GDM prevalences in 1999 and 2000 (7.5 and 7.6 per 100) to those of Ferrara et al. (4) using laboratory-identified GDM only (6.4 and 6.4 per 100, respectively). Our GDM prevalence was higher than theirs; this may be due to our population having a higher proportion of women from racial/ethnic minority groups that have a higher prevalence of GDM. Similarly, our prevalence of GDM was higher than the 3-year moving average of the race/ethnicity-specific age-adjusted prevalence reported by Dabelea et al. (5) for 1999–2001 and 2000–2002 as well as their race/ethnicity-specific estimates for all years and racial and ethnic groups. The latter study used higher screening thresholds to diagnose GDM and had a smaller proportion of minority participants than did our study. Both of these factors probably contributed to a lower prevalence of GDM in their studies. The 2004 expanded birth certificate yielded a GDM prevalence of 44.0 per 1,000 (4.4 per 100) (18), significantly less than our unadjusted GDM prevalence of 7.6 per 100 in the same year. Differences may be attributed to the different race/ethnicity and age distributions of the population as well as to our case definitions.

We chose to include only women with laboratory-identified GDM in our study. Others have relied on birth certificate data (18), self-report of the timing of diabetes in relation to pregnancy (19), ICD-9 codes exclusively (20), or combined ICD-9 codes and laboratory-identified GDM after presenting rates using laboratory-identified cases alone (4). By limiting our case definition to women with laboratory confirmation of GDM from a KPSC laboratory, we may have missed women who entered prenatal care in a KPSC facility after receiving a diagnosis of GDM in another facility, which is probably a rare occurrence. However, we are not including women who have ICD-9 codes for GDM who do not meet our objective laboratory-identified case definition of GDM.

Prevalence of preexisting diabetes compared with GDM

We found that in 1999, among pregnancies affected by some form of diabetes, 10% of diabetes cases were attributed to preexisting diabetes and 90% were attributed to GDM. This was similar to the estimate of Engelgau et al. in 1988 (2) of 12% being due to preexisting diabetes. In 2005, the proportion of all pregnancies affected by diabetes attributed to preexisting diabetes in our sample rose to 21–26%, whereas the proportion attributed to GDM had dropped to 74–79% of diabetic pregnancies, depending on which approach we used to calculate the estimate. Using data reported by Martin et al. (18) from the 2004 expanded birth certificates, we calculated that 14% of diabetic pregnancies in their sample were attributed to preexisting diabetes in 2004.

Limitations and strengths

Given the relationship of overweight/obesity with type 2 diabetes (8), the increasing prevalence of obesity/overweight in women of reproductive age (9) seems to be a likely contributor to the increase in preexisting diabetes found in our study. Unfortunately, this study, like others (4,5), lacks data on maternal height and weight to assess maternal BMI. These will be available from the 2007 California birth certificate and KPSC electronic health record in 2008. We are also unable to identify type of preexisting diabetes. A review of the inpatient and outpatient clinical encounter codes yielded missing and inconsistent information on diabetes type based on the fifth digit. Age at diagnosis of preexisting diabetes was also not available from electronic data. Although we cannot rule out the possibility that some of the increase in preexisting diabetes is due to selective enrollment into the health plan by women with impaired glucose tolerance, it may also be a harbinger of increases in impaired glucose tolerance in the population.

The availability of multiple computerized confidential databases, the use of standardized screening and diagnostic procedures over time, the application of consistent definitions over the study period, and large numbers of women in four racial/ethnic groups are significant strengths of our study. Although our findings are based on members of a managed health care plan, the findings are probably applicable to the general southern California population, as the race/ethnicity and income distribution of our insured childbearing-age women is quite similar to that of the seven-county area where our members reside on the basis of geocoded census data, as is the racial/ethnic distribution of our study cohort to women giving birth (21).

Clinical implications

Women with GDM are at high risk of recurrence of GDM and of developing type

2 diabetes (22,23). The increasing proportion of women with preexisting diabetes has implications for both maternal and infant health lasting far beyond pregnancy. Although there are negative consequences for fetal development due to GDM, maternal hyperglycemia antedating pregnancy and continuing into the period of organogenesis (5–8 gestational weeks) in women with poorly controlled preexisting diabetes exposes their fetuses to an increased risk of birth defects.

We observed a progressive increase in the prevalence of preexisting diabetes over a recent 7-year period in this population of women who had singleton births. The increase in the relative proportion of pregnant women whose diabetes antedated pregnancy is a source of great concern. In addition to the potential increased risk of fetal, neonatal, and childhood consequences of exposure to the intrauterine environment of a woman with long-standing glucose intolerance (24–26), the earlier onset and therefore longer duration of maternal diabetes suggests that these women may develop complications of diabetes at a younger age. Interventions that focus on reducing overweight and obesity as a means of preventing or delaying the onset of diabetes in all women as well as increased availability of and awareness that preconception care reduces maternal and infant complications for women with diabetes should be the focus of future culturally appropriate public health interventions.

Acknowledgments— This study was supported by a Clinical Research Award to J.M.L. from the American Diabetes Association.

Edward Wu and Vicki Chiu contributed to the analyses, and Lorena Barreda assisted with the validation.

Parts of this study were presented in abstract form at the International Diabetes Federation Meeting, Cape Town, South Africa, 3–7 December 2006, and at the 67th annual meeting of the American Diabetes Association, Chicago, Illinois, 22–26 June 2007.

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