The Epidemiology of Diabetes and Pregnancy in the U.S., 1988

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OBJECTIVE — To determine the prevalence of pregnancy complicated by diabetes in a representative sample of the U.S. population.

RESEARCH DESIGN AND METHODS — We analyzed data from a multistaged cross-sectional probability sample of live births recorded in the U.S. in 1988 for women 15–49 years of age. The main outcome measure was pregnancy complicated by diabetes.

RESULTS — Diabetes was present in ~154,000 (4%) of all pregnancies in the U.S. Gestational diabetes mellitus (GDM) accounted for 135,000 of such pregnancies (88%), non-insulin-dependent diabetes mellitus (NIDDM) for 12,000 (8%), and insulin-dependent diabetes mellitus for 7,000 (4%). On average, the mothers with NIDDM (29.6 years) and GDM (29.3 years) were older than mothers whose pregnancies were not complicated by diabetes (26.2 years; $P < 0.05$). In multivariate analyses, the odds of having a pregnancy complicated by GDM increased significantly with maternal age and body mass index.

CONCLUSIONS — Pregnancy is complicated by diabetes more often than was previously believed. More frequent testing may further increase the apparent prevalence of GDM.

Some of the adverse outcomes of pregnancy (1,2) associated with insulin-dependent diabetes mellitus (IDDM), non-insulin-dependent diabetes mellitus (NIDDM), and gestational diabetes mellitus (GDM) can be prevented. Preconception counseling for women with established diabetes (3), screening and early identification of GDM (4), maintenance of glycemic control during pregnancy (5), and a team approach to care (6) can reduce the incidence of adverse outcomes.

In the U.S., a better understanding of the epidemiology of diabetes in pregnancy is needed so that clinical and public health efforts can be appropriately directed. By using data from the 1988 National Maternal and Infant Health Survey (NMIHS), we estimated the prevalence and described the characteristics of pregnancies complicated by diabetes in the U.S.

RESEARCH DESIGN AND METHODS

— In the 1988 NMIHS, a nationally representative cross-sectional probability sample of all live births recorded during 1988 for women ages 15–49 was selected, and questionnaires were sent to the mothers and, subsequently, to the prenatal care providers and hospitals identified by the mothers (7).

We used information from four sources: *1*) birth records (maternal age at delivery, previous live births, and trimester of first prenatal care visit), 2) the mother (maternal race or ethnicity, education, marital status, height, and prepregnancy weight), 3) the health care provider (existence of maternal diabetes), and 4) the hospital medical records (existence of maternal diabetes). Maternal diabetes was determined by asking, "Did the mother have diabetes during this pregnancy?" (yes, adult-onset; yes, juvenile-onset; yes, gestational diabetes; or no). No information was available as to whether or not mothers were screened for GDM. Body mass index (BMI) was calculated as the ratio of the prepregnancy weight to the square of the height (kg/m^2). A BMI <27.3 kg/m^2 was considered nonoverweight, 27.3 kg/m^2 to <32.3 kg/m^2 as overweight, and ≥32.3 kg/m^2 as severely overweight (8).

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BMI, body mass index; CI, confidence interval; GDM, gestational diabetes mellitus; IDDM, insulin-dependent diabetes mellitus; NIDDM, non-insulin-dependent diabetes mellitus; NMIHS, National Maternal and Infant Health Survey; NNS, National Natality Survey; OR, odds ratio.

Table 1—*Characteristics of all women who gave birth in the U.S. in 1988 and of women in the 1988 NMIHS (weighted for percent distribution) by knowledge of diabetes status*

	All Women (n = 3,909,510)	Women in NMIHS		P values
		Known diabetes status (n = 7,366)	Unknown diabetes status (n = 2,587)	
Age (years)				0.42
15–24	39.6	39.8	39.0	
25–29	31.8	32.0	30.7	
30–34	20.6	20.1	22.4	
35–49	8.0	8.1	7.9	
Race				<0.01
White	77.9	79.7	70.9	
Black	17.2	15.2	24.2	
Other	4.9	5.1	5.0	
Education (years completed)				0.35
<12	20.5	18.6	20.7	
12	41.1	39.6	37.6	
13–15	20.7	24.2	23.7	
≥16	17.7	17.6	18.0	
Marital status				<0.01
Married	74.3	74.7	69.3	
Previous live births				0.19
None	40.8	41.4	41.9	
One	32.6	33.0	32.6	
Two	16.1	16.3	14.4	
Three or more	9.9	9.1	10.7	
Unknown	0.6	0.2	0.4	
Trimester of first prenatal visit				<0.01
1st	74.2	77.4	74.2	
2nd	17.5	16.2	16.6	
3rd	4.1	3.5	3.8	
None	1.9	1.1	2.6	
Unknown	2.3	1.8	2.8	
Prepregnancy BMI (kg/m^2)				0.27
<20	—	20.0	19.3	
20–24	—	48.0	48.8	
25–29	—	20.4	20.7	
≥30	—	11.7	11.2	

Data are %. The number for women in NMIHS are from an unweighted sample size. The P values are for difference between known and unknown diabetes status. Race refers to that of the child; other includes Hispanic, American Indian, Alaskan Native, Asian, Pacific Islander, and others. For marital status, women with unknown marital status were considered not married. Prepregnancy BMIs were not available for women in 1988 natality.

The sample of 9,953 mothers who participated in the NMIHS was weighted to adjust for the survey design, the probability of selection, and the mothers' response rates (7). Weighted values reflected the total number of live births to mothers 15–49 years of age in the U.S. in 1988. Information on diabetes status was available for only 7,366 mothers in the sample (74%). Characteristics of women with known and unknown diabetes status and of all women who had live births in 1988 (9) are shown in Table 1. Women with known and unknown diabetes status were similar with respect to age, level of education achieved, number of previous live births, and prepregnancy BMI. A larger proportion of women of known than that of unknown diabetes status had white infants, were married, and began prenatal care in the 1st trimester. However, women with known diabetes status tended to have similar characteristics to all women who had live births in 1988.

To estimate national counts of pregnancies where diabetes was present, we reweighted the data to adjust for non-

Table 2—*Prevalence of pregnancies complicated by diabetes, 1988 NMIHS*

Type of diabetes	Unweighted number	Weighted number	Prevalence	95% CI
IDDM	17	6,696	0.17	0.05–0.29
NIDDM	31	12,021	0.31	0.15–0.47
GDM	245	135,234	3.47	2.90–4.04
No diabetes	7,073	3,744,977	—	—
Total	7,366	3,898,918	3.95	3.36–4.54

response to the diabetes question. We performed this by: *1*) identifying a birth record item that was known for all 9,953 mothers and had a distribution that was similar for mothers with known and unknown diabetes status (we used sex of infant); 2) removing the original poststratification factor from the base weight; 3) calculating and applying to the base weight a ratio adjustment factor for each sex (sum of base weights for total sample divided by the sum of base weights for those with known diabetes status); and 4) calculating and applying a new poststratification factor (sum of the original final weight for each sampling stratum divided by the sum of the new adjusted base weights for the sampling stratum).

SUDAAN (10) was used for univariate and multivariate analyses and for calculation of standard errors of means and proportions. The χ^2 test was used to compare categorical groups, and the Student's *t* test was used to compare mean values. For women with GDM, we performed a multivariate analysis that estimated the independent effects of maternal age at delivery, race or ethnicity (as 4 categories: White, Black, Hispanic, and Other [included American Indian, Native Alaskan, Asian, Pacific Islander, and others]), level of education achieved, marital status, obesity, number of previous live births, and trimester of first prenatal visit. All data were analyzed as categorical variables, and if the covariate had a $P > 0.05$, it was eliminated from the model by using a backward stepwise procedure. Small sample size precluded a similar analysis for pregnancies complicated by established diabetes.

RESULTS — Among the 7,366 mothers in the sample, 17 had IDDM, 31 had NIDDM, and 245 had GDM. Using this sample, and applying appropriate weights, we estimate that in the U.S. in 1988, diabetes was present in ~154,000 or almost 4% of all pregnancies that resulted in live births (Table 2). This estimate includes 135,000 (88%) live births complicated by GDM, 12,000 (8%) complicated by NIDDM, and nearly 7,000 (4%) complicated by IDDM.

The mean age of women with NIDDM and GDM was over 29 years, more than 3 years older than the mean age of women whose pregnancies were not complicated by diabetes (Table 3). Compared with women without diabetes, women whose pregnancies were complicated by NIDDM and GDM tended to be nonwhite, and women with NIDDM tended to have <12 years of education. Women with NIDDM had significantly more and women with IDDM had fewer previous live births than did women without diabetes. Women with GDM had a similar number of previous live births as did women without diabetes.

Among women whose pregnancies were complicated by diabetes, 9–15% made their first prenatal visit after the 1st trimester; 22% of women whose

Table 3—*Characteristics of women and infants in pregnancies with and without diabetes, 1988 NMIHS*

Characteristic	Type of diabetes			
	IDDM	NIDDM	GDM	No diabetes
Mean age at delivery (years)	24.6	29.6*	29.3*	26.2
Race/ethnicity (%)				
White	70.8	51.9	64.1	68.2
Nonwhite	29.2	48.1	35.9	31.8
Education <12 years (%)	17.3	34.6	16.3	18.9
Married (%)	84.1	71.2	79.1	73.0
Mean number of previous live births	0.6*	2.1*	1.2	1.0
Prenatal visit during 1st trimester (%)	91.3	84.9	87.4*	78.2
Mean prepregnancy body mass index (kg/m^2)	25.1	27.9*	25.2*	22.7

For race/ethnicity, white includes non-Hispanic white; nonwhite includes Black, Hispanic, American Indian, Alaskan Native, Asian, Pacific Islander, and others. For marital status, women with unknown marital status were considered not married. Mean number of previous live births refers to sign of life shown after birth.
*$P < 0.05$ for difference between women with and without diabetes.

pregnancies were not complicated by diabetes made their first prenatal visit after the 1st trimester (Table 3). Prepregnancy BMI was greater for women whose pregnancies were complicated by diabetes than for women whose pregnancies were not and was highest for women with NIDDM.

Maternal age at delivery and prepregnancy BMI were independently and significantly ($P < 0.05$) associated with increased odds of GDM. Compared with mothers 15–24 years old, the odds for having a pregnancy complicated by GDM tended to be greater for mothers 25–29 years old (odds ratio [OR] = 1.5; 95% confidence interval [CI], 1.0–2.5), were over two times greater for mothers 30–34 years old (OR = 2.2; 95% CI, 1.4–3.6), and were over four times greater for mothers 35–49 years old (OR = 4.2; 95% CI, 2.4–7.0). Compared with nonoverweight mothers, the odds for GDM were over two times greater in overweight mothers (OR = 2.3; 95% CI, 1.4–3.4) and nearly four times greater for severely overweight mothers (OR = 3.9; 95% CI, 2.2–6.7).

CONCLUSIONS— The prevalence of pregnancy complicated by established diabetes has been reported to be 0.2 to >2% (11,12), and the prevalence of GDM has been reported to be <1 to >10% (11). In this report, we have used data from a nationwide population-based survey and estimate that nearly 4% of all pregnancies in the U.S. during 1988 were complicated by diabetes; most (88%) were complicated by GDM. Among the 12% of pregnancies complicated by established diabetes, NIDDM accounted for most (65%).

Several factors contribute to such a wide range in reported estimates (13). Hospital- or clinic-based studies may have referral bias and selectively screen high-risk groups, resulting in high estimates; while studies that rely on vital records may suffer from underreporting (14), resulting in low estimates. Our prevalence estimates are much higher than those from the 1980 National Natality Survey (NNS) and a 1979–1980 population-based survey in Washington State (11). The NNS estimated that diabetes was present in 1.2% of pregnancies, of which GDM accounted for 33% and established diabetes for 67% (IDDM and NIDDM were not distinguished). In Washington State, diabetes was present in only 0.51% of pregnancies, and GDM accounted for a much larger proportion (61%) than in the NNS. In Washington State, 39% had established diabetes and NIDDM accounted for only 24% of pregnancies complicated by established diabetes.

The increase in GDM is undoubtedly due, in part, to increased detection because of recommendations for universal GDM screening made during the 1980s (15). The trend in the U.S. toward older women giving birth (9) may also be contributing to the increased prevalence of GDM and an increased proportion of births among women with NIDDM. We found that women whose pregnancies were complicated by GDM and NIDDM were older than women whose pregnancies were not complicated by diabetes.

We found increased maternal age and obesity were independently associated with GDM. This may in part reflect bias in screening and detection of GDM among high-risk groups, although others have reported similar findings (17). In contrast to other reports (16–18), we found that when adjusted for age and obesity, the risk for GDM was not significantly different among racial or ethnic groups.

A limitation of this study was our inability to study some characteristics of pregnancies more carefully because of small numbers and large variations. Another limitation was the lack of information on the frequency with which mothers were screened for GDM. In spite of our higher prevalence estimate for GDM compared with the 1980 NNS, our estimate is probably low due to incomplete screening and detection of GDM. Nevertheless, these estimates reflect current screening practices and provide a useful measure of the current burden of diagnosed GDM in the U.S. A third limitation is the lack of diabetes information for 26% of the mothers. Mothers with known diabetes status were generally similar to those with unknown diabetes status and tended to have similar characteristics to all women who had live births in 1988. Mothers with unknown status had similar age and BMI characteristics to those with known status, two important indicators of risk factors for GDM. This suggests that the lack of information about this group probably did not affect our prevalence estimate for GDM. The identification of established diabetes was probably reliable because health care providers tend to be familiar with diagnostic criteria and women with established diabetes and their health care providers have a high level of awareness when the condition is present.

In summary, we find pregnancy complicated by diabetes to be more common that previously believed. This study shows that the burden of diabetes and pregnancy in the U.S. is substantial and greater than indicated by previous studies. Aggressive attempts should be made to reduce this burden by providing appropriate care (19).

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