

# ORIGINAL REPORTS: DIABETES

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## ETHNIC DIFFERENCES IN GESTATIONAL ORAL GLUCOSE SCREENING IN A LARGE US POPULATION

**Objective:** To estimate gestational diabetes mellitus (GDM) prevalence and hyperglycemia in a large multi-ethnic population and evaluate the differences in glucose measures by age and ethnicity.

**Participants and Setting:** All singleton births in Kaiser Permanente Hawaii (KPH) during 1995–2003.

**Measurements:** Ethnicity classifications from birth certificate data were linked to KPH's electronic medical records that included laboratory-screening results. GDM screening was performed using the 50-g, 1-hour oral glucose challenge test (GCT) and the 100-g, 3-hour oral glucose tolerance test (OGTT). GDM was ascertained by both the National Diabetes Data Group (NDDG) and the Carpenter and Coustan (C&C) thresholds.

**Results:** 21,130 (96%) of all pregnant women were screened for GDM using the 1-hour GCT: 21% had glucose levels exceeding the threshold of 140 mg/dL, with the highest rates in Filipinos and Chinese. African American and Caucasian groups had the lowest elevated glucose. Of those with elevated glucose, 1.3% had levels >200 mg/dL, were considered to have GDM, and not tested further; 88% underwent the 3-hour OGTT. Age-adjusted GDM prevalence was 4.4% (NDDG) and 6.6% (C&C). Koreans (6.2%) and Filipinos (6.1%) had the highest age-adjusted NDDG GDM. African Americans (1.5%), Caucasians (2.5%), and Vietnamese (2.8%) had the lowest.

**Conclusions:** This is the first population-based study to report GDM prevalence in a large group of ethnicities represented in Hawaii. We found very diverse rates of GDM prevalence and elevated glucose among these groups. These findings point to the need for further research along several avenues, such as maternal-child outcome differences and perhaps ethnic-specific guidelines for GDM diagnosis. (*Ethn Dis.* 2009; 414–419)

**Key Words:** Gestational Diabetes Mellitus, Ethnicity

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### INTRODUCTION

The prevalence of diabetes varies widely by ethnicity and, it is expected to increase the most in Asians over the next 20 years.<sup>1</sup> Similarly, great variability exists in prevalence rates of gestational diabetes mellitus (GDM) in pregnancy,<sup>1–5</sup> with overall GDM prevalence rates estimated to complicate at least 4 percent of all pregnancies.<sup>1</sup> Two recent US studies found that Asians have the highest reported prevalence rates of gestational diabetes compared to Caucasians, Hispanics, African Americans, and Asians.<sup>5,6</sup> Native Hawaiians also have a very high-risk of type 2 diabetes—up to four times the risk of Caucasians,<sup>7</sup> yet a recent study found that the prevalence of GDM in Native Hawaiians/Pacific Islanders is comparable to the overall US prevalence.<sup>8</sup> Because of potential risks to the fetus associated with GDM, screening is recommended.<sup>9</sup>

In the United States, screening is commonly done in pregnant women with a 50-gram glucose challenge test

(GCT) first, and if plasma glucose exceeds 140 mg/dL at 1 hour after the GCT, a full 100-gram 3-hour glucose tolerance (OGTT) is performed for diagnosis.<sup>10</sup> We found little information on how the GCT test varies by ethnicity, which could have important implications for diabetes screening in different populations. One study found that Asians as a group had the highest rates of positive GCT compared to Caucasians, African Americans, and Filipinos.<sup>11</sup> However, Asians are not a homogeneous population—and even if Pacific Islanders are not included in this group, important differences may exist in Chinese vs Japanese racial heritage in diabetes risk, for example. One study in Singapore found that Chinese had a much higher rate of abnormal GCT than people of Malay or Indian race.<sup>12</sup> A recent study in Hawaii reported GDM prevalence was greater in Filipino and Chinese women compared to Japanese.<sup>8</sup> This study also reported that the Native Hawaiian/Pacific Islanders had lower prevalence of GDM than the Asian groups that they studied. However, the Native Hawaiian group was combined with other Pacific Islanders. We found no data evaluating GDM

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*Our study examines how the rate of positive-GCT and GDM prevalence differs by ethnicity in a population that has not been well-studied.*

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prevalence differences between Native Hawaiian and other Pacific Islanders.

Hawaii has the highest proportion of non-Caucasian ethnic groups compared to other US states.<sup>13</sup> Kaiser Permanente Hawaii (KPH) has a representative membership of more than 227,000, or about 20% of the state's population.<sup>14</sup> Further, it is KPH policy to screen all pregnant women for GDM with GCT, and thus is the ideal population to evaluate ethnic differences for screening and GDM prevalence during pregnancy among Asian and Pacific Islander groups. Our study examines how the rate of positive-GCT and GDM prevalence differs by ethnicity in a population that has not been well-studied.

## METHODS

### Research setting and study population

Kaiser Permanente Hawaii was founded in 1958 and offers services on four of the Hawaiian Islands (Hawaii, Maui, Oahu, and Kauai). Its membership enrollment closely reflects the demographic and sociographic characteristics of the general population.<sup>14</sup> Low-income individuals are enrolled under the State Health Insurance Plan for Medicaid and constitute about 10% of the state and KPH population.

KPH maintains administrative and clinical electronic databases on outpatient encounters, inpatient admissions, pharmacy dispenses, chronic disease registry, laboratory tests, and outside claims/referrals. All databases are linked through each member's unique health record number.

The Institutional Review Boards of Kaiser Permanente Hawaii and the State of Hawaii Department of Health approved this study.

### Sample selection

We identified 17,042 women aged 13–39 years who were KPH members and who gave birth during 1995–2003 and who had continuous health-plan eligibility during their pregnancy and childbirth. As

it is possible that insulin resistance – and thus the response to the GCT – may differ with multiple gestation (eg, twins or triplets), we excluded 285 (1.3%) women with multiple same-pregnancy births. The remaining 16,757 women gave birth to 22,110 babies, with 12,284 women having one child during the study period, and 4,473 having two or more. Of these 22,110 births, 353 were to mothers with pre-existing diabetes mellitus.

### Classification of ethnicity

Ethnicity classification was derived from the mother's race reported on the birth certificate information from the Hawaii Department of Health. As per the Department of Health algorithm for classifying ethnicity, if the mother reported being any part Native Hawaiian, she was classified as Native Hawaiian. If Native Hawaiian was not listed, but a non-Caucasian ethnicity was reported, then she was classified into the first listed non-Caucasian group. Women were considered Caucasian only if no other ethnicity was reported. Only one individual did not report ethnicity on the birth certificate.

We separated subjects into the most precise ethnic groups possible. Samoans were considered a separate ethnicity from "Other Pacific Islander," but due to sample size, women from Fiji and Tahiti were grouped with other Pacific Islanders. The "other" ethnic group consists primarily of women from the Indian subcontinent and the Middle East.

### Glucose testing and GDM diagnosis

In KPH, GDM screening is routine in prenatal care at 24–28 weeks gestation. Pregnant women are initially screened with a 50-gram, 1-hour glucose challenge test (GCT). Women with positive GCT at a level >200 mg/dL are assumed to have GDM and are not tested further. The remaining women with positive GCT (>140 mg/dL) undergo the 100-g, 3-hour oral glucose tolerance test (OGTT). For women who had more than one glucose test

during her pregnancy, we used the test that occurred latest in the pregnancy. Although it is KPH policy to screen all pregnant women, individuals with dual insurance coverage or those who are KPH members but are not seeing a KPH physician for prenatal care may be screened outside of KPH or not at all. Our laboratory screening GCT and OGTT results are available only on those women tested in KPH facilities.

We calculated GDM rates using both the NDDG and C&C criteria. The NDDG criteria require that at least two of the OGTT glucose measures are above the following (mg/dL) thresholds: Fasting – 105; 1 hr – 190; 2 hr – 165; 3 hr – 145.<sup>2</sup> The C&C criteria have the following lower thresholds: Fasting – 95; 1 hr – 180; 2 hr – 155; 3 hr – 140.<sup>15,16</sup>

### Statistical analyses

We conducted all statistical analyses using the SAS Statistical Analysis System™ version 6.12 (SAS Institute, Cary, NC). Generalized linear mixed models that adjust for within-mother correlation were used to compare mean levels of GCT, prevalence of positive GCT and prevalence of GDM. All the statistical tests that we report are two-sided; *P* values <.05 were considered statistically significant. To allow the reader to more easily interpret *P* values, we did not adjust for multiple comparisons.

## RESULTS

A total of 22,110 pregnancies in 16,757 women were included in this study. In 353 pregnancies, the women were determined to have pre-existing diabetes mellitus. Of the remaining 21,758 pregnancies, 20,893 (96%) underwent GDM screening in KPH facilities using the 50-gram, 1-hour glucose challenge test (GCT). Age and ethnic-specific testing percents are shown in Table 1.

In general, older women were less likely to be screened (95% for aged 36+ years vs 97% for aged ≤25 years). Japanese, Samoan, Native American,

**Table 1. Mean plasma glucose levels and percent exceeding thresholds of the 50-g, 1-hour glucose challenge test for gestational diabetes by age and ethnicity in Kaiser Permanente Hawaii 1995–2003**

Age Group	Number Screened * (% of total)	50-g, 1-hour Plasma Glucose			Pre-existing Diabetes		
		Mean (SE)	% > 140 mg/dL	95% CI†	n	%	95% CI†
≤ 25 years	7791 (97%)	111.9 (0.3)	12.8	12.1, 13.5	53	0.7	0.5, 0.9
26–30 years	5710 (96%)	119.2 (0.4)	20.0	19.0, 21.1	90	1.5	1.2, 1.8
31–35 years	4765 (96%)	122.9 (0.4)	24.5	23.3, 25.8	119	2.3	2.0, 2.8
36 + years	2627 (95%)	128.3 (0.5)	31.9	30.1, 33.7	91	3.2	2.6, 3.9
Ethnicity		Age-adjusted	Age-adjusted	95% CI†		Age-adjusted	95% CI†
Native Hawaiian	6946 (96%)	119.7 (0.3)	19.6	18.7, 20.6	136	1.9	1.6, 2.2
Filipino	4326 (97%)	121.0 (0.4)	24.3	23.0, 25.7	66	1.4	1.1, 1.8
Japanese	1950 (95%)	119.1 (0.6)	25.2	23.3, 27.2	43	1.9	1.4, 2.5
Chinese	818 (97%)	121.3 (1.0)	27.5	24.5, 30.6	11	1.2	0.7, 2.2
Samoan	737 (95%)	120.0 (1.0)	22.7	19.6, 26.0	17	2.4	1.5, 3.9
Other Pacific Islander	484 (97%)	116.7 (1.2)	21.8	18.3, 25.9	11	2.4	1.3, 4.2
Korean	432 (98%)	121.1 (1.3)	25.6	21.7, 30.0	4	0.9	0.3, 2.3
African-American	195 (98%)	111.4 (1.9)	11.4	7.5, 16.8	0	0.0	
Vietnamese	187 (98%)	116.9 (2.0)	20.3	15.1, 26.8	1	0.5	0.1, 3.7
Puerto Rican	191 (97%)	119.1 (2.0)	18.6	13.5, 25.1	6	3.4	1.5, 7.4
Native American	151 (95%)	118.0 (2.2)	18.1	12.6, 25.2	4	2.6	1.0, 6.7
Other Hispanic	372 (97%)	118.9 (1.4)	22.0	17.9, 26.6	2	0.6	0.1, 2.1
Other	188 (98%)	114.5 (2.0)	11.9	7.9, 17.6	2	1.1	0.3, 4.3
Caucasian	3915 (95%)	112.8 (0.4)	16.0	14.9, 17.2	50	1.2	0.8, 1.6
<b>TOTAL</b>	20893 (96%)	118.5 (0.7)	20.9	20.6, 21.7		1.6	1.2, 2.2

\* Women with preexisting diabetes are not included in the screening analyses.

† Confidence intervals are calculated using generalized linear mixed models that adjust for within-mother correlation.

and Caucasian had the lowest proportions screened (95%) whereas Korean, African American, and Vietnamese had the highest proportion screened (98%). Eighty-three women who were not screened delivered prior to 26 weeks gestation and may not have had the opportunity to receive the GCT as it is administered at 24–28 weeks gestation. However, 857 of the screened group also delivered prior to 26 weeks gestation, yet still received the GCT. Moreover, excluding these women who may not have had the opportunity to take the GCT due to early delivery did not change the relationships between screened and unscreened women.

Table 1 also shows the average plasma glucose level for the 20,893 screened pregnancies, the percent with positive GCT (>140 mg/dL), and the percent who had pre-existing diabetes. Mean glucose levels, percent with positive GCT, and pre-existing diabetes all increased significantly with age ( $P<.001$ ). In age-adjusted analyses, average glucose levels were notably higher

for Filipino, Chinese, Korean, and Samoan women. All were significantly greater ( $P<.001$ ) than the Caucasian average (SE) of 112.8 (0.4) mg/dL.

Overall, 20.9% of pregnancies were to women with positive GCT (Table 1). Consistent with the high average level of plasma glucose, Filipino, Chinese, Korean, and Samoan women were more likely than other groups to have positive GCT; all had >22% age-adjusted abnormal screen. While mean plasma glucose for Japanese women was similar to the overall average of 119.1 mg/dL, more than 25% of these women had positive GCT, a rate exceeded only by the Samoan and Chinese women. African American women had the lowest proportion of positive GCT with an age-adjusted rate of 11.4% (95% confidence interval (CI): 7.5, 16.8).

Age-adjusted prevalence of pre-existing diabetes was 1.1% (95% CI: 1.2, 2.2). Puerto Rican women had the highest prevalence of pre-existing diabetes of 3.4% (95% CI: 1.5, 7.4).

Of the 4354 women with positive GCT, 3665 (84%) underwent the 100-g, 3-hour OGTT. Of the 689 women who had positive GCT and did not continue on to the 3-hour OGTT, 180 had screen values >200 mg/dL and were considered to have GDM without further testing. Thus, 12% (509) of those with positive GCT did not complete the 3-hr OGTT. Samoan women were least likely to complete the 3-hour OGTT (24%), followed by the Native Hawaiian women (18%).

Age-adjusted prevalence of GDM by NDDG criteria was 4.2% (95% CI: 3.8, 5.0) and by C&C criteria was 6.7% (95% CI: 6.5, 7.8). (Table 2). After adjusting for age, prevalence of NDDG-GDM was greatest in the Korean and Puerto Rican women. The lowest rates of NDDG-GDM were seen in the African Americans with only four of the 195 with positive GCT testing positive for NDDG-GDM, yielding an age-adjusted prevalence of 2.2% (95% CI: 0.8, 5.7). In relation to the

**Table 2. Prevalence of gestational diabetes mellitus detected by National Diabetes Data Group (NDDG) or Carpenter and Coustan (C&C) diagnostic plasma glucose thresholds by age and ethnicity in Kaiser Permanente Hawaii 1995–2003**

Age Group	Number screened	GDM by NDDG			GDM by C&C		
		Number abnormal	%	95% CI*	Number abnormal	%	95% CI*
≤25 years	7791	135	1.8	1.5, 2.1	237	2.8	2.5, 3.2
26–30 years	5710	236	3.4	3.0, 3.9	359	5.5	5.0, 6.2
31–35 years	4765	301	5.2	4.6, 5.9	458	8.4	7.6, 9.2
36 + years	2627	235	7.4	6.4, 8.5	333	10.8	9.6, 12.0
<b>Ethnicity</b>			<b>Age-adjusted</b>		<b>Age-adjusted</b>		
Native Hawaiian	6946	263	3.8	3.3, 4.2	386	6.5	6.4, 7.6
Filipino	4326	265	5.8	5.1, 6.5	375	8.3	7.5, 9.2
Japanese	1950	102	4.5	3.7, 5.5	150	6.9	5.9, 8.1
Chinese	818	51	5.6	4.2, 7.3	88	9.8	8.0, 12.0
Samoan	737	28	4.3	3.0, 6.1	49	7.5	5.7, 9.8
Other Pacific Islander	484	23	5.1	3.4, 7.6	38	8.5	6.2, 11.4
Korean	432	30	6.4	4.5, 9.1	46	10.1	7.6, 13.3
African-American	195	4	2.2	0.8, 5.7	6	3.3	1.5, 7.1
Vietnamese	187	7	3.9	1.9, 7.9	11	6.1	3.4, 10.6
Puerto Rican	191	12	7.4	4.3, 12.6	13	7.9	4.6, 13.1
Native American	151	5	3.5	1.5, 8.1	6	4.2	1.9, 9.1
Other Hispanic	372	11	3.2	1.8, 5.6	18	5.2	3.3, 8.1
Other	188	7	4.1	2.0, 8.3	10	5.8	3.1, 10.4
Caucasian	3915	110	2.5	2.1, 3.1	171	4.2	3.6, 4.9
<b>All Women</b>	<b>20893</b>	<b>927</b>	<b>4.2</b>	<b>3.8, 5.0</b>	<b>1387</b>	<b>6.7</b>	<b>6.5, 7.8</b>

\* Confidence intervals are calculated using generalized linear mixed models that adjust for within-mother correlation.

Caucasian group, Native Hawaiians, Filipinos, Japanese, Chinese, Koreans, Puerto Ricans, and Other Pacific Islanders had significantly higher age-adjusted prevalence of NDDG-GDM ( $P < .05$ ). Age-adjusted absolute prevalence of GDM was about 1.5% greater using the C&C thresholds (~ 50% relative increase) compared to the NDDG-GDM for all ethnic groups except the Puerto Rican group. In the Puerto Rican group, only one additional woman, out of 196 screened, met the C&C criteria, but not the NDDG.

Figure 1 displays the prevalence of hyperglycemia among persons reporting Native Hawaiian ethnicity only, or

Native Hawaiian ethnicity in addition to one other ethnicity ( $n=2543$ ). This figure details the contribution of pre-existing diabetes and GDM to the overall prevalence of hyperglycemia in these groups. Women reporting Native Hawaiian plus Asian ethnic mixture have significantly higher prevalence of positive GCT compared to women with other Native Hawaiian admixtures ( $p < .05$ ). However, prevalence of GDM and pre-existing diabetes mellitus did not differ among the groups.

There was no association between year of birth and prevalence of either hyperglycemia or GDM.

Among the Asian groups, Filipinos and Koreans had the highest prevalence of GDM, whereas Japanese had a markedly lower prevalence despite having comparable proportion of abnormal GCT. The Vietnamese had lower prevalence of both abnormal GCT and GDM.

Puerto Rican women had the highest age-adjusted prevalence of GDM by NDDG criteria. However, when we used the C&C criteria, their prevalence of GDM was only slightly higher than that of the entire study population.

The higher age-adjusted GDM prevalence we found in Puerto Ricans compared to the “Other Hispanic” group has been suggested elsewhere.<sup>17</sup> We did not have sufficient sample size of any other Hispanic group to evaluate them individually for comparison.

The diverse rates that we found among the Asian groups are noteworthy. In many studies, it is still common to combine all Asians into a single ethnic group regardless of country of origin. In fact, only recently has the US Census separated Asians from Pacific Islanders. Prevalence of NDDG-GDM in our

*In this study of more than 20,000 singleton births in Hawaii, 20.9% of the mothers had positive GCT (>140 mg/dL).*

## DISCUSSION

In this study of more than 20,000 singleton births in Hawaii, 20.9% of the mothers had positive GCT (>140 mg/dL), 4.2% were determined to have GDM according to NDDG criteria and 6.7% according to the C&C criteria. Importantly, prevalence of positive GCT and GDM ranged substantially by ethnicity.



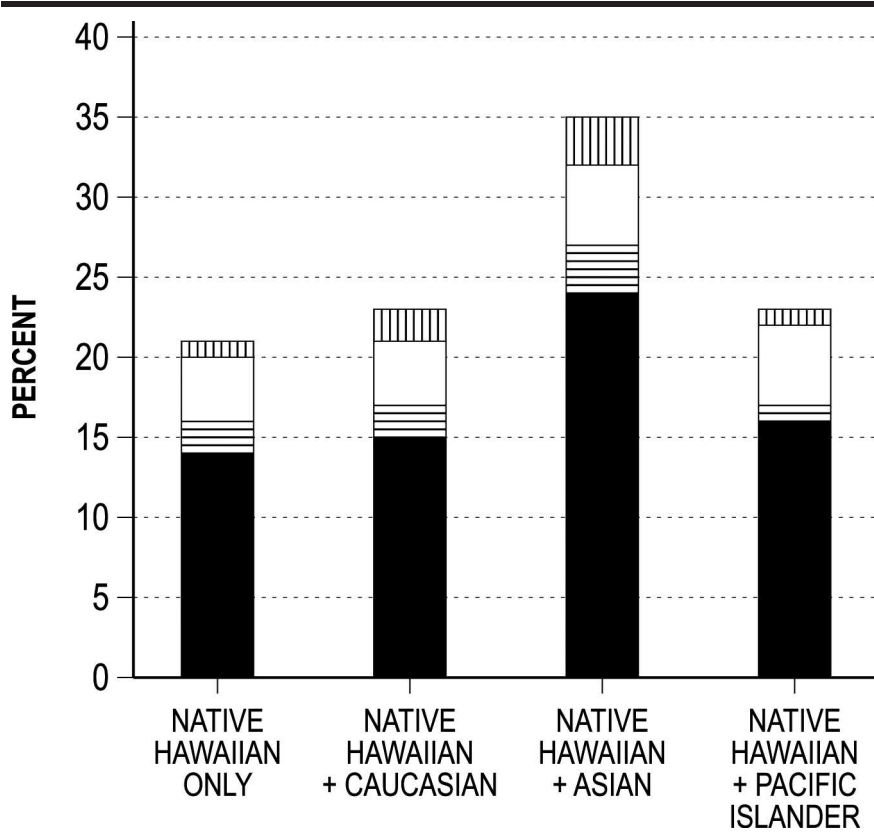


Fig 1. Burden of Hyperglycemia within Native Hawaiian ethnic mixtures

The prevalence of overall burden of hyperglycemia during pregnancy is stratified by Native Hawaiian admixture groups. Women with an abnormal (>140 mg/dL) 50-gram glucose challenge test (GCT) screen for gestational diabetes (GDM) and who were also <200 mg/dL on the GCT are divided by those who had a normal follow-up 3-hour 100-gram oral glucose tolerance test (OGTT) (black bar) and those who did not have the follow-up OGTT diagnostic test performed (horizontal stripe). GDM (white bar) is defined either per Carpenter & Coustan criteria for the OGTT<sup>15,16</sup> or a GCT >200 mg/dL (and presumed diabetes, so OGTT not done; 1.3% of total GDM). Pre-existing type 1 or type 2 diabetes is also shown (vertical stripe)

study ranged from 3.9% for Vietnamese (one of the lowest rates in this study), to 5.8% for Filipinos and 6.4% for Koreans. The ethnic-specific GDM prevalence rates that we found are comparable to those reported in studies that included these ethnic groupings.<sup>5,8,11,17-20</sup> Yet, only a limited number of studies separated the Asian groups into more specific ethnic classifications.

Strengths of this study include the large sample size, the relatively high proportion of GDM screening practiced in KPH, and the ability to compare GDM and screening rates for a diverse

group of ethnicities which could be derived from Hawaii Department of Health birth certificate records. Our study also has a few limitations. Despite internal guidelines of KPH to screen all pregnant women, 4% of women did not have a GCT. We hypothesize that since many of these women delivered at non-KPH hospitals, that they also received their health care, including their prenatal care and screening, outside of the HMO, possibly as a result of dual coverage.

We used similar procedures as the US Census for classifying women into ethnic groups. However, as per the classification of

the Hawaii Department of Health, anyone who listed Native Hawaiian as an ethnic group regardless of order and number of other ethnicities listed, were classified as Native Hawaiians. It is likely that this group represents a very diverse group of women, some who have no mixture and others who have very little Native Hawaiian in their ethnic makeup. This may explain why we didn't find a similarly high prevalence of GDM in this group despite their known high rates of obesity and type 2 diabetes. However we think this grouping is still justified because Native Hawaiians have nearly four times the rate of diabetes compared to non-Hispanic Caucasians, regardless of admixture.<sup>7</sup>

In conclusion, this population-based study reports prevalence rates of hyperglycemia and GDM for a large number of ethnic groups represented in the state of Hawaii. These findings point to the need for further research along several avenues, such as maternal-child outcome differences and perhaps ethnic-specific guidelines for GDM diagnosis.

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REFERENCES

1. King H. Epidemiology of glucose intolerance and gestational diabetes in women of child-bearing age. *Diabetes Care*. 1998;21(Suppl 2):B9-3-B9-13.
2. Coustan DR. Gestational Diabetes. In: National Diabetes Data Group, editor. *Diabetes in America*. Bethesda, Maryland: National Institutes of Health; 1995:703-734.
3. Rodrigues S, Robinson E, Gray-Donald K. Prevalence of gestational diabetes mellitus

- among James Bay Cree women in northern Quebec. *CMAJ*. 1999;160(9):1293-1297.
4. Weijers RN, Bekedam DJ, Oosting H. The prevalence of type 2 diabetes and gestational diabetes mellitus in an inner city multi-ethnic population. *Eur J Epidemiol*. 1998;14(7):693-699.
  5. Ferrara A, Hedderon MM, Quesenberry CP, et al. Prevalence of gestational diabetes mellitus detected by the National Diabetes Data Group or the Carpenter and Coustan plasma glucose thresholds. *Diabetes Care*. 2002;25(9):1625-1630.
  6. Dabelea D, Snell-Bergeon JK, Hartsfield CL, et al. Increasing prevalence of gestational diabetes mellitus (GDM) over time and by birth cohort: Kaiser Permanente of Colorado GDM Screening Program. *Diabetes Care*. 2005;28(3):579-584.
  7. Grandinetti A, Chang HK, Mau MK, et al. Prevalence of glucose intolerance among Native Hawaiians in two rural communities. Native Hawaiian Health Research (NHHR) Project. *Diabetes Care*. 1998;21(4):549-554.
  8. Silva JK, Kaholokula JK, Ratner R, et al. Ethnic differences in perinatal outcome of gestational diabetes mellitus. *Diabetes Care*. 2006;29(9):2058-2063.
  9. Coustan DR, Carpenter MW. The diagnosis of gestational diabetes. *Diabetes Care*. 1998; 21(Suppl 2):B5-8.
  10. Carr SR. Screening for gestational diabetes mellitus. A perspective in 1998. *Diabetes Care*. 1998;21(Suppl 2):B14-B18.
  11. Nahum GG, Huffaker BJ. Racial differences in oral glucose screening test results: establishing race-specific criteria for abnormality in pregnancy. *Obstet Gynecol*. 1993;81(4):517-522.
  12. Ray R, Heng BH, Lim C, et al. Gestational diabetes in Singaporean women: use of the glucose challenge test as a screening test and identification of high risk factors. *Ann Acad Med Singapore*. 1996;25(4):504-508.
  13. US Census Bureau PD. *Annual Estimates of the Population by Race Alone and Hispanic or Latino Origin for the United States and States: July 1, 2003* (SC-EST2003-04). US Census Bureau. 9-30-2004.
  14. US Census Bureau PD. *Annual Estimates of the Population by Sex and Age for Hawaii: April 1, 2000 to July 1, 2003* (SC-EST2003-02-15). US Census Bureau. 9-30-2004.
  15. Carpenter MW, Coustan DR. Criteria for screening tests for gestational diabetes. *Am J Obstet Gynecol*. 1982;144(7):768-73.
  16. Metzger BE, Coustan DR. Summary and recommendations of the Fourth International Workshop-Conference on Gestational Diabetes Mellitus. The Organizing Committee. *Diabetes Care*. 1998;21(Suppl 2):B161-7.
  17. Berkowitz GS, Lapinski RH, Wein R, et al. Race/ethnicity and other risk factors for gestational diabetes. *Am J Epidemiol*. 1992;135(9):965-973.
  18. Dornhorst A, Paterson CM, Nicholls JS, et al. High prevalence of gestational diabetes in women from ethnic minority groups. *Diabet Med*. 1992;9(9):820-825.
  19. Yue DK, Molyneux LM, Ross GP, et al. Why does ethnicity affect prevalence of gestational diabetes? The underwater volcano theory. *Diabet Med*. 1996;13(8):748-752.
  20. Henry OA, Beischer NA, Sheedy MT, et al. Gestational diabetes and follow-up among immigrant Vietnam-born women. *Aust N Z J Obstet Gynaecol*. 1993;33(2):109-114.

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