Ethnic Differences in Perinatal Outcome of Gestational Diabetes Mellitus

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OBJECTIVE — Despite the high rates of gestational diabetes mellitus (GDM) among certain Pacific Islander and Asian ethnic groups in the U.S., little is known about the risk for adverse perinatal outcomes in these populations. We sought to examine ethnic differences in perinatal outcome among Asian and Pacific-Islander women with GDM.

RESEARCH DESIGN AND METHODS — A retrospective review of all women referred to the largest outpatient GDM program in the state of Hawai'i from 1995 to 2005 was conducted. Patients of Native-Hawaiian/Pacific-Islander, Japanese, Chinese, Filipino, and Caucasian ethnicity were included (n = 2,155). Treatment of all patients consisted of an outpatient education class, dietary management, self-monitoring of blood glucose, and insulin instruction (if indicated). Demographics, maternal and neonatal characteristics, and delivery information were evaluated.

RESULTS — Neonates born to Native-Hawaiian/Pacific-Islander mothers and Filipino mothers had 4 and 2 times the prevalence of macrosomia, respectively, compared with neonates born to Japanese, Chinese, and Caucasian mothers. These differences persisted after adjustment for other statistically significant maternal and fetal characteristics. Ethnic differences were not observed for other neonatal or maternal complications associated with GDM, with the exception of neonatal hypoglycemia and hyperbilirubinemia.

CONCLUSIONS — Significant ethnic differences in perinatal outcomes exist across Asian and Pacific-Islander women with GDM. This finding emphasizes the need to better understand ethnic-specific factors in GDM management and the importance of developing ethnic-tailored GDM interventions to address these disparities.

Diabetes Care 29:2058–2063, 2006

Data from the nonpregnant population in Hawai'i, a state that has a large population of Asian Americans and Pacific Islanders (including Native Hawaiians), have yielded an estimated statewide diabetes prevalence of 6–9% (1), with population-based studies of native Hawaiians reporting an age-adjusted diabetes prevalence of 20.4% (2,3). Compared with all other ethnic groups in the state of Hawai'i, Native Hawaiians are reported to have the highest number of new diabetes cases (4). Native Hawaiians and Pacific Islanders (e.g., Samoan) are also known to have a higher prevalence of risk factors associated with diabetes, such as obesity and physical inactivity (2,3).

Although no published report on the prevalence of gestational diabetes mellitus (GDM) in Hawai'i is yet available, it has been reported that the prevalence of GDM varies in direct proportion to the prevalence of type 2 diabetes in other given populations or ethnic groups (5). Therefore, the increasing emergence of type 2 diabetes in Hawai'i and the Pacific region correlates with a concomitant increase in the number of women of childbearing age with diabetes during pregnancy (2,6).

GDM, as defined by the American Diabetes Association, occurs in ~14% of pregnancies in the U.S. (7,8). Women of ethnic minority populations are known to be at increased risk for developing GDM and, thus, are at increased risk for developing associated adverse outcomes such as neonatal macrosomia and hypoglycemia and subsequent type 2 diabetes later in life (8).

Although the relationship between GDM and perinatal outcome has been documented in other ethnic groups such as African Americans and Hispanics, no study to date has examined these outcomes in offspring of Native Hawaiian and Pacific Islanders (9–12), nor are there any studies comparing these ethnic groups with Asian ethnic groups such as Japanese, Chinese, and Filipinos. Historically, Native Hawaiian/Pacific Islanders and Asian Americans have been aggregated into a single ethnic group; however, ethnic influences on perinatal outcome of each specific ethnic group may be masked when the data are aggregated.

Consequently, we examined ethnic differences in perinatal outcome of GDM among women from five major ethnic groups of Hawai'i: Native Hawaiian/Pacific Islanders, Japanese, Chinese, Filipinos, and Caucasians. Specifically, we sought to *1*) estimate the prevalence of GDM by ethnicity, *2*) examine ethnic differences in perinatal outcome, and *3*) identify maternal and fetal factors independently associated with fetal macrosomia, including ethnicity.

RESEARCH DESIGN AND METHODS

— This study was approved by the Hawai'i Pacific Health Institutional Review Board for retrospective review of patients with GDM treated in the Sweeter Choice outpatient diabetes program at Kapi'olani Medical Center between 1995 and 2005 (n = 4,492). Diagnosis of GDM was made before program referral by each patient's primary obstetrician by either an abnormal 3-h glucose tolerance test using the Carpenter and Coustan criteria or by a 1-h glucose value of ≥200 mg/dl (13).

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Received for publication 27 February 2006 and accepted in revised form 23 May 2006.

The content of this article is solely the responsibility of the authors and does not necessarily represent the official views of the National Institutes of Health or the Kapi'olani Medical Center for Women and Children.

Abbreviations: GDM, gestational diabetes mellitus.

A table elsewhere in this issue shows conventional and Système International (SI) units and conversion factors for many substances.

DOI: 10.2337/dc06-0458

The study population was limited to those delivering at term (>37 weeks). Patients with pregestational diabetes (n = 585), multiple gestation (n = 29), coexisting medical conditions such as hypertension (n = 291), lupus (n = 15), thyroid disease (n = 49), and asthma (n = 228), and those delivering at a facility other than Kapi'olani Medical Center were excluded. Patients with incomplete information for dependent variables of interest (neonatal weight [n = 261] and neonatal hypoglycemia [n = 429]) were excluded from the analyses. The remaining patients were grouped by ethnicity into Native Hawaiian/Pacific Islander, Japanese, Chinese, Filipino, and Caucasian based on self-report, which is the standard ethnic classification schema used in Hawai'i (14). Self-report of ethnicity is thought to be superior to administrative data because responses are based on self-perception and are, by definition, accurate unless intentionally misreported (15). Patients with ethnic classifications other than the above were also excluded (n = 450). The total sample size for this study after all exclusions was 2,155 patients.

Patients in this program received comprehensive consultation with a maternal-fetal medicine specialist that incorporated an interview, a physical examination, education about the pathophysiology and possible neonatal complications of diabetes in pregnancy, and group or individual instruction by a registered dietitian and certified diabetes nurse educator regarding dietary management, home glucose monitoring, and insulin therapy (as needed). Each patient was given the necessary equipment and supplies to perform home glucose monitoring throughout the pregnancy. Home glucose monitoring results were communicated to the program nurse by phone or facsimile every 3–5 days and were reviewed by a physician. Recommended adjustments in diet and/or insulin were communicated to the patient by phone. Patients with persistent fasting glucose ≥95 mg/dl and/or 2-h postprandial glucose >120 mg/dl were given insulin therapy, and adjustments were made to maintain fingerstick glucose values below those thresholds.

Data were collected on type of delivery (i.e., vaginal, assisted vaginal [vacuum extraction or forceps], and cesarean section), neonatal hypoglycemia (<40 mg/dl), special care admissions (e.g., intermediate or intensive care nursery admission after delivery), family history of diabetes, and diabetes treatment type (i.e., diet controlled, insulin requiring, and insulin before 20 weeks of gestation). Maternal weight (in pounds) before pregnancy, at intake, and at delivery were recorded, and prepregnancy BMI was calculated (weight in kilograms divided by the square of height in meters). Neonatal weights were recorded in grams, and neonates weighing ≥4,000 g were defined as having macrosomia. Other neonatal outcomes assessed included fetal demise, fetal anomalies, shoulder dystocia, fetal distress, birth asphyxia, polycythemia, hyperbilirubinemia, respiratory distress syndrome, and sepsis. Data concerning maternal complications such as preeclampsia, chorioamnionitis, and labor disorders (arrest of dilation and decent) were also collected.

Data reduction and analyses

The unadjusted GDM prevalence was calculated for each ethnic group. ANOVA was used to examine the statistical associations of ethnic groups and fetal macrosomia with continuous data, and Tukey-Kramer honestly significant difference post hoc analysis was used to further elucidate specific between-group differences. χ^2 analysis was used to examine statistical associations of ethnic groups and fetal macrosomia with other categorical data. An α level of ≤0.05 was used to determine statistical significance for all analyses. All statistical analyses were done using JMP statistical software, version 5.1.

It was decided a priori that continuous and categorical data found to have a significant association with fetal macrosomia would be further analyzed in a single logistic regression model, along with ethnicity, to determine independent predictors of fetal macrosomia. To make the interpretation of odds ratios (ORs) and CIs meaningful, continuous data (i.e., age and maternal weights) were transformed into categorical data based on quartiles. The following categories were created: age in years (quartile 1 = 15–28, quartile 2 = 29–32, quartile 3 = 33–36, and quartile 4 = 37–51), maternal weight in pounds at intake (quartile 1 = 82–142, quartile 2 = 143–162, quartile 3 = 163–192.2, and quartile 4 = 192.3–411), and maternal weight in pounds at delivery (quartile 1 = 96–146, quartile 2 = 147–167, quartile 3 = 168–197.7, and quartile 4 = 197.8–411). Because of a large number of missing data for family history of diabetes (1,016 missing) and HbA_{1c} (A1C) (836 missing), these variables were not entered in the logistic regression model to preserve statistical power. Prepregnancy weight and prepregnancy BMI were also not entered into the model for parsimony, given that these were based on self-report and that two other measures of weight were included.

RESULTS

GDM prevalence

Of the 44,878 women who delivered at Kapi'olani Medical Center between 1995 and 2005, 2,155 (4.8%) women had GDM. The unadjusted prevalence of GDM by ethnicity was 3.6% for Native-Hawaiian/Pacific-Islander women, 6.5% for Filipino women, 6.4% for Chinese women, 5.5% for Japanese women, and 2.3% for Caucasian women.

Antepartum characteristics

Native-Hawaiian/Pacific-Islander and Filipino women comprised 65% of the total subjects with GDM enrolled in this study (Table 1). Age, prepregnancy weight, prepregnancy BMI, maternal weight at intake and delivery, A1C at intake, diabetes treatment type, and family history of diabetes were all significantly different among ethnic groups. Native-Hawaiian/Pacific-Islander women were significantly younger and weighed more before pregnancy, at the time of referral to the program, and at the time of delivery. A1C at time of referral to the program, family history of diabetes, and percentage of women requiring insulin were all significantly higher in Native-Hawaiian/Pacific-Islander women compared with women from the other ethnic groups ($P < 0.0001$).

Intrapartum and neonatal characteristics

The intrapartum and neonatal characteristics by ethnic groups and combined sample are summarized in Table 2. Statistically significant differences in type of delivery, neonatal weight/macrosomia, hypoglycemia, and hyperbilirubinemia were found among ethnic groups. Neonates born to Native-Hawaiian/Pacific-Islander and Caucasian women were more likely to have hypoglycemia whereas neonates born to Native-Hawaiian/Pacific-Islander, Filipino, and Caucasian women were more likely to have hyperbilirubinemia than neonates from other ethnic groups. Native-Hawaiian/Pacific-Islander women were also more likely to have neonates with macrosomia than women from the other

Table 1—*Maternal antepartum characteristics by ethnicity and combined sample*

	Native Hawaiian/ Pacific Islander	Japanese	Chinese	Filipino	Caucasian	Combined
n	614	432	163	797	149	2,155
Age (years)*	29.4 ± 6.1[c]	33.4 ± 4.9[a]	32.8 ± 4.9[a]	31.4 ± 5.8[b]	32.3 ± 5.4[a,b]	31.4 ± 5.8
Prepregnancy weight (lb)*	184.6 ± 47.9[a]	135.7 ± 26.7[c]	131.6 ± 27.3[c]	136.8 ± 27.4[c]	164.1 ± 43.4[b]	151.6 ± 41.8
Prepregnancy BMI (kg/m^2)*	32.1 ± 7.6[a]	25.0 ± 4.4[c]	24.3 ± 4.2[c]	25.8 ± 5.1[c]	28.1 ± 6.9[b]	27.6 ± 6.7
Maternal weight (lb) at intake*	207.4 ± 47.2[a]	152.4 ± 25.8[c]	150.9 ± 28.7[c]	156.2 ± 28.3[c]	185.5 ± 41.1[b]	171.7 ± 42.6
Maternal weight (lb) at delivery*	213.7 ± 48.4[a]	156.2 ± 25.2[d]	156.0 ± 27.1[c,d]	162.0 ± 29.0[c]	190.3 ± 41.6[b]	176.9 ± 43.3
A1C at intake (%)*	5.6 ± 0.8[a]	5.4 ± 0.7[b,c]	5.3 ± 0.5[b,c]	5.5 ± 0.8[b]	5.2 ± 0.5[c]	5.4 ± 0.8
Gestational age (weeks) at diagnosis	29.1 ± 6.6	28.2 ± 5.9	28.9 ± 5.4	28.7 ± 5.7	29.4 ± 4.2	28.8 ± 5.9
Diabetes treatment type*						
Diet controlled	432 (70.4)	365 (84.5)	143 (88.3)	675 (84.7)	112 (75.2)	1,727 (80.2)
Insulin required	169 (27.5)	62 (14.4)	18 (11.1)	113 (14.2)	34 (22.8)	396 (18.4)
Insulin prior to 20 weeks of gestation	13 (2.1)	5 (1.1)	1 (0.6)	9 (1.1)	9 (2.0)	31 (1.4)
Family history of diabetes*						
Yes	204 (66.7)	117 (59.0)	34 (45.3)	182 (48.8)	35 (55.6)	572 (56.4)
No	102 (33.3)	82 (41.0)	41 (54.7)	191 (51.2)	28 (44.4)	444 (43.6)

Data are means ± SD or *n* (%). *$P < 0.0001$ based on ANOVA comparing the maternal antepartum characteristic across ethnic groups. Levels that do not share the same letter are significantly different based on Tukey-Kramer honestly significant difference post hoc analysis.

ethnic groups. Chinese women were more likely to have assisted vaginal delivery (vacuum extraction or forceps) but were least likely to have had cesarean section compared with women from the other ethnic groups. There were no ethnic differences observed in the prevalence of fetal demise, fetal anomalies, shoulder dystocia, fetal distress, birth asphyxia, polycythemia, respiratory distress syndrome, or sepsis in the neonates, nor were there any ethnic differences in the maternal prevalence of preeclampsia, chorioamnionitis, or labor disorders. Fetal anomalies observed included deviated penile tip ($n = 1$), umbilical hernia ($n = 1$), single umbilical artery ($n = 1$), undescended testes ($n = 1$), amniotic band syndrome ($n = 1$), trisomy 21 ($n = 1$), patent ductus arteriosus ($n = 3$), hypospadias ($n = 1$), extra digit ($n = 1$), micrognathia ($n = 1$), and cystic adenomatoid malformation ($n = 1$).

Because of changes in the diagnostic criteria for GDM (i.e., the adoption of the Carpenter and Coustan criteria) in the early years of this study, we examined the effects of mothers' enrollment date into the study on fetal macrosomia, but no statistically significant association was observed (data not shown). The other neonatal and maternal conditions were not further assessed because of small numbers and the lack of significance noted among ethnic groups in the initial analysis.

Bivariate analysis of fetal macrosomia by maternal and fetal characteristics

The bivariate associations of maternal and fetal characteristics with fetal macrosomia in the combined sample are summarized in Table 3. Statistically significant associations were observed between fetal macrosomia and younger maternal age, higher prepregnancy weight and BMI, higher maternal weight at intake and delivery, higher A1C at intake, family history of diabetes, diabetes treatment type, and male neonate sex. No statistically significant association was observed between fetal macrosomia and family history of diabetes.

Logistic regression analysis predicting fetal macrosomia

Statistically significant predictors of fetal macrosomia were Native-Hawaiian/Pacific-Islander (OR 4.35 [95% CI 2.19–9.16]) and Filipino (2.82 [1.37–6.08]) ethnicity compared with Caucasian ethnicity, maternal weights from 197.8 to 411 lb (quartile 4) (34.75 [10.25–119.40]) and from 168 to 197.7 lb (quartile 3) (6.31 [CI 2.38–16.97]) at delivery compared with those who weighed from 96 to 146 lb at delivery (quartile 1), and male neonate sex (1.38 [1.01–1.90]) compared with female neonate sex. Maternal age, maternal weight at intake, and diabetes treatment type were not statistically significant independent predictors of fetal macrosomia.

CONCLUSIONS — GDM occurs as a result of insulin resistance similarly to type 2 diabetes and may indeed represent sub- or preclinical type 2 diabetes that is unmasked by the hormonal influence of pregnancy (16). Fetal and newborn morbidity associated with GDM, however, is disproportionate in that compared with weight-matched control subjects, infants of mothers with GDM are at increased risk of serious birth injury and neonatal intensive care admission (17–20). Studies indicate that the magnitude of fetal-neonatal risks is proportional to the severity of maternal hyperglycemia (21–23). Fetal macrosomia and hypoglycemia are the most common risks identified and are thought to arise as a result of maternal hyperglycemia and resultant fetal hyperinsulinemia (21). Despite adequate treatment, however, the incidence of macrosomia remains increased in pregnant women with GDM.

The purpose of this study was to examine ethnic differences in perinatal outcome among Native-Hawaiian/Pacific-Islander, Japanese, Chinese, Filipino, and Caucasian women with GDM. The strengths of this study are the inclusion of women from high-risk ethnic groups, disaggregation of data from distinct Asian and Pacific-Islander ethnic groups, and a large clinical sample spanning 10 years. To

Table 2—*Intrapartum and neonatal characteristics by ethnicity and combined sample*

	Native Hawaiian/ Pacific Islander	Japanese	Chinese	Filipino	Caucasian	Combined
Preeclampsia						
Yes	30 (7.1)	12 (4.2)	3 (2.8)	34 (6.2)	3 (2.8)	82 (5.6)
No	395 (92.9)	272 (95.8)	106 (97.2)	519 (93.8)	103 (97.2)	1,395 (94.4)
Chorioamnionitis						
Yes	7 (1.2)	7 (1.7)	2 (1.2)	10 (1.3)	2 (1.4)	28 (1.4)
No	594 (98.8)	416 (98.2)	159 (98.8)	772 (98.7)	144 (98.6)	2,085 (98.6)
Arrest of dilation						
Yes	28 (4.7)	21 (5.0)	6 (13.7)	36 (4.7)	7 (4.8)	98 (4.7)
No	573 (95.3)	402 (95.0)	155 (96.3)	745 (95.3)	139 (95.2)	2,015 (95.3)
Arrest of descent						
Yes	33 (5.5)	22 (5.2)	9 (5.6)	37 (4.7)	8 (5.4)	109 (5.2)
No	568 (94.5)	401 (94.8)	152 (94.4)	745 (95.3)	139 (94.6)	2,005 (94.8)
Shoulder dystocia						
Yes	6 (1.0)	2 (0.5)	2 (1.2)	10 (1.3)	1 (0.7)	21 (1.0)
No	595 (99.0)	421 (99.5)	159 (98.8)	772 (98.7)	146 (99.3)	2,093 (99.0)
Fetal distress						
Yes	45 (7.5)	15 (3.6)	12 (7.5)	53 (6.8)	9 (6.2)	134 (6.4)
No	553 (92.5)	405 (96.4)	148 (92.5)	726 (93.1)	137 (93.8)	1,969 (93.5)
Type of delivery*						
Vaginal	418 (68.3)	307 (71.1)	115 (70.6)	527 (66.2)	100 (67.1)	1,467 (68.1)
Assisted vaginal	14 (2.3)	16 (3.7)	15 (9.2)	43 (5.4)	6 (4.0)	94 (4.4)
Cesarean section	180 (29.4)	109 (25.2)	33 (20.2)	226 (28.4)	43 (28.9)	591 (27.5)
Neonatal weight (g)†	3,573.4 ± 552.1[a]	3,218.9 ± 430.1[c]	3,262.7 ± 424.7[b,c]	3,274.9 ± 472.6[c]	3,399.1 ± 486.1[b]	3,356.4 ± 506.8
<4,000	487 (79.3)	416 (96.3)	157 (96.3)	737 (92.5)	144 (96.6)	1,941 (90.0)
≥4,000	127 (20.7)	16 (3.7)	6 (3.7)	60 (7.5)	5 (3.4)	214 (10.0)
Neonatal hypoglycemia†						
Yes	44 (7.2)	7 (1.6)	3 (1.8)	29 (3.6)	11 (7.0)	94 (4.0)
No	570 (92.8)	425 (98.4)	160 (98.2)	768 (96.4)	138 (93.0)	2,061 (96.0)
Neonatal hyperbilirubinemia*						
Yes	29 (4.8)	6 (1.4)	3 (1.9)	34 (4.3)	8 (5.6)	80 (3.8)
No	577 (95.2)	418 (98.6)	159 (98.1)	750 (95.7)	136 (94.4)	2,040 (96.2)
Sepsis						
Yes	8 (1.3)	3 (0.7)	1 (0.6)	12 (1.6)	0 (0)	24 (1.1)
No	598 (98.7)	421 (99.3)	161 (99.4)	771 (98.4)	143 (100)	2,094 (98.9)
Asphyxia						
Yes	0 (0)	1 (0.2)	0 (0)	2 (0.3)	0 (0)	3 (0.2)
No	611 (100)	430 (99.8)	163 (100)	793 (99.7)	148 (100)	2,145 (99.8)
Polycythemia						
Yes	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.04)
No	611 (99.8)	431 (100)	163 (100)	795 (100)	148 (100)	2,148 (99.96)
Respiratory distress syndrome						
Yes	15 (3.8)	7 (2.3)	1 (0.9)	10 (1.9)	5 (4.8)	38 (2.6)
No	381 (96.2)	299 (97.7)	114 (99.1)	530 (98.1)	99 (95.2)	1,423 (97.4)
Fetal demise						
Yes	1 (0.2)	0 (0)	0 (0)	0 (0)	0 (0)	1 (0.05)
No	611 (99.8)	432 (100)	1,623 (100)	796 (100)	148 (100)	2,149 (99.95)
Special care admission						
Yes	30 (4.9)	9 (2.1)	3 (1.8)	29 (3.6)	7 (4.7)	78 (3.6)
No	584 (95.1)	423 (97.9)	160 (98.2)	767 (96.4)	142 (95.3)	2,076 (96.4)

Data are *n* (%) or means ± SD. *$P < 0.05$; †$P < 0.0001$, based on ANOVA comparing the intrapartum or neonatal characteristic across ethnic groups. Levels that do not share the same letter are significantly different based on Tukey-Kramer honestly significant difference post hoc analysis.

date, this is the only study to report on ethnic differences in GDM and perinatal outcome among Asian and Pacific Islanders.

Increased incidence of macrosomia and neonatal hypoglycemia has been described in offspring of women with GDM from other ethnic groups; however, these outcomes have not been extensively studied in the Native-Hawaiian/Pacific-Islander population nor has this population been compared with other Asian groups. Although these findings are

Table 3—*Bivariate analysis of the association between fetal macrosomia (≥4,000 g) and maternal and fetal characteristics*

	<4000 g	≥4,000 g	*P* value
Age (years)	31.5 ± 5.8	29.9 ± 5.6	<0.0001
Prepregnancy weight (lb)	147.6 ± 38.4	188.5 ± 51.2	<0.0001
Prepregnancy BMI (kg/m^2)	27.1 ± 6.3	32.6 ± 8.1	<0.0001
Maternal weight (lb) at intake	167.3 ± 39.0	211.9 ± 51.9	<0.0001
Maternal weight (lb) at delivery	171.9 ± 39.2	222.5 ± 51.0	<0.0001
A1C at intake	5.4 ± 0.7	5.8 ± 1.0	<0.0001
Family history of diabetes			
Yes	509 (55.3)	63 (67.0)	0.0260
No	412 (44.7)	31 (33.0)	
Diabetes treatment type			
Diet controlled	1,582 (81.6)	144 (67.3)	<0.0001
Insulin requiring	330 (17.0)	66 (30.8)	
Insulin before 20 weeks of gestation	27 (1.4)	4 (1.9)	
Fetal sex			
Male	983 (51.8)	130 (61.6)	0.0066
Female	914 (48.2)	81 (38.4)	

Data are means ± SD or *n* (%). Associations between continuous characteristics and fetal macrosomia were analyzed by *t* test, and associations between categorical characteristics and fetal macrosomia were analyzed by χ^2 analysis.

an important first step toward addressing the antenatal needs of this at-risk population, ethnicity is probably only one component in the complex etiology underlying these outcomes. Prepregnancy weight and BMI are also associated with neonatal macrosomia, suggesting that obese women of Native-Hawaiian/Pacific-Islander ethnicities who gain further weight during pregnancy are at particular risk of delivering an infant with macrosomia (10,24). Although Caucasian women did not have a particularly high risk of delivering an infant with macrosomia, their risk of neonatal hyperbilirubinemia was higher than that of Native-Hawaiian/Pacific-Islander women, and their risk of cesarean section and neonatal hypoglycemia was the second highest. Caucasian women also weighed more than Japanese, Chinese, and Filipino women before pregnancy, at time of intake into the Sweeter Choice program, and at delivery. Furthermore, they were more likely than women of those ethnicities to not only require insulin for glycemic control but also to require insulin at <20 weeks of gestation. Therefore, even though the prevalence of GDM is lower in Caucasians than in other ethnic groups, Caucasian women who have GDM probably represent a heavier cohort prone to similar perinatal complications.

Our data also show, however, that the influence of maternal weight on macrosomia may have differential effects across ethnic groups. The Filipinos in our study, for example, had 2.82 greater odds of having an infant with macrosomia compared with Caucasians, even though their prepregnancy, intake, and delivery weights were not significantly different from those of the Japanese or Chinese. This finding emphasizes the importance of evaluating these Asian and Pacific-Islander groups separately if we want to have an impact on accurate identification of ethnic groups at risk and, ultimately, appropriate intervention and improved outcome.

Although the gestational age at diagnosis was not significantly different among ethnic groups, the higher percentage of Native-Hawaiian/Pacific-Islander women requiring insulin during pregnancy and those requiring insulin before 20 weeks of gestation, suggests that there may be a larger subset of Native-Hawaiian/Pacific-Islander women with preexisting undiagnosed diabetes. The higher A1C in Native Hawaiian/Pacific Islanders in this study, the known high prevalence of type 2 diabetes in Native Hawaiian/Pacific Islanders, and the parallel association between prevalence of GDM and type 2 diabetes support this hypothesis (2–4). Offspring of these women might have had prolonged exposure to higher levels of glycemia compared with offspring of women with "pure" GDM. Although mean fasting and 2-h postprandial glucose values were not analyzed in this study, patients requiring insulin for glycemic control during pregnancy seemed to be an acceptable proxy.

Unfortunately, once pregnancy occurs, glycemic control is the sole independent variable that can be manipulated to improve perinatal outcome. Therefore, these findings illustrate the value of early detection of abnormalities in glucose regulation as a means to primary prevention. The integration of ethnic-specific approaches to health care delivery often is cited as a means to improve health outcome; however, the most effective technique and optimal means of implementation, particularly for those of Native-Hawaiian/Pacific-Islander and Filipino descent, have yet to be determined (25–27).

Other potential risk factors such as socioeconomic differences involving income inequality, education, and discrimination have been reported to influence perinatal outcome independent of ethnicity (28). By contrast, several studies have found ethnicity to be an independent risk factor for GDM and related outcomes (10,11,29). Results found in this retrospective study also support prior studies indicating ethnicity as an independent risk factor for perinatal outcomes such as macrosomia. However, this study was limited by the lack of data on other mediating factors such as socioeconomic status (i.e., income and education), social support, or other cultural factors (i.e., language, traditional beliefs, and others). For example, the Sweeter Choice outpatient program has not been validated across ethnic groups and, therefore, some of the findings may be due to the lack of cultural relevance of this program rather than to true biological differences. Furthermore, it would have been ideal to include smoking status as a confounder because smoking reduces birth weight, but data on this variable were not available.

Although it has been reported that the prevalence of GDM varies in direct proportion to the prevalence of type 2 diabetes in other ethnic groups (5), our unadjusted prevalence estimates of GDM by ethnicity did not support this assumption. However, there are several methodological limitations to the prevalence estimates in our study. First, the method of ethnic classification differed between the Sweeter Choice program (from which our data originate) and the hospital records. For example, we classified ethnicity based on patients' self-report, whereas the hospital's ethnic classification is determined by the admissions staff

and is based on assumed physical characteristics. Second, the exclusion of participants in our study is not accounted for in the hospital database. For example, we excluded women with multiple gestations, those with deliveries at <37 weeks, and those who had comorbidities, whereas these women were all counted in the hospital records from which we calculated the prevalence of GDM.

The discrepancy between the reported prevalence of type 2 diabetes and the estimated prevalence of GDM among Native Hawaiians in this study may also be due to large age differences among ethnic groups in our sample. For example, the teenage pregnancy rate among Native-Hawaiian women is the highest in the state of Hawai'i and, therefore, the hospital sample of Native-Hawaiian women could be skewed toward a younger age-group who have not yet developed a risk factor profile for GDM (30). Furthermore, the current disparate prevalence ratio of GDM to type 2 diabetes may also represent a temporal phenomenon and a harbinger of future epidemics of type 2 diabetes among the Filipino and Chinese communities.

Future prospective studies designed to control for variables independent of ethnicity that are also known to affect perinatal outcome (such as maternal parity, smoking habits, and others) will provide critical information to design and tailor interventions to improve perinatal outcome in high-risk ethnic minority groups such as Native-Hawaiian/Pacific-Islanders, Filipinos, and other Asian-American populations, which could help to inform the development of outpatient diabetic programs that are culturally relevant and acceptable to women from all ethnic groups.

Acknowledgments— This project/study was supported by a grant (P20MD000173) from the National Center for Minority Health and Health Disparities, National Institutes of Health. J.K.S. was funded in part by a grant (HP03013-09) from the Department of Health and Human Services, Health Resources Services Administration, Bureau of Health Professions, Division of Health Careers, Diversity and Development.

We acknowledge The Sweeter Choice Program at Kapi'olani Medical Center, Teresa Brink-Wong, RN, CDE, for assistance in patient education and data management, Lynnae K. Millar, MD, for developing the concept, and Erin Saito for assistance.

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