Type 1 and Type 2 Diabetes in Asian and Pacific Islander U.S. Youth

The SEARCH for Diabetes in Youth Study

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OBJECTIVE — Given limited reports on diabetes among U.S. Asian and Pacific Islander youth, we describe the clinical characteristics, incidence, and prevalence of diabetes among Asian, Pacific Islander, and mixed Asian–Pacific Islander youth.

RESEARCH DESIGN AND METHODS — Data were collected from 245 Asian, Pacific Islander, and Asian–Pacific Islander participants in the SEARCH for Diabetes in Youth Study, a population-based study of diabetes in youth (aged <20 years). Additionally, we estimated the incidence and prevalence of type 1 and type 2 diabetes for Asian, Pacific Islander, and Asian–Pacific Islander youth combined.

RESULTS — Most participants with type 2 diabetes were obese (range Asian 71% to Pacific Islander 100%) with mean BMI >33 kg/m^2. In those with type 1 diabetes, Pacific Islanders were more likely to be obese, with a mean BMI of 26 vs. 20 kg/m^2 for Asian and Asian–Pacific Islander youth ($P < 0.0001$). The incidence of type 1 diabetes for youth aged 0–9 years was 6.4 per 100,000 person-years and 7.4 per 100,000 person-years for youth aged 10–19 years. The incidence of type 2 diabetes was 12.1 per 100,000 person-years for youth aged 10–19 years.

CONCLUSIONS — While Asian and Asian–Pacific Islanders with type 1 and type 2 diabetes had lower mean BMIs than Pacific Islanders, all Asian, Pacific Islander, and Asian–Pacific Islanders with type 2 diabetes had mean BMIs above adult ethnicity-specific definitions of obesity. While the majority of Asian, Pacific Islander, and Asian–Pacific Islander youth had type 1 diabetes, older Asian, Pacific Islander, and Asian–Pacific Islander youth (aged 10–19 years) have an incidence of type 2 diabetes almost double that of type 1 diabetes. Public health efforts to prevent type 2 diabetes and obesity in Asian, Pacific Islander, and Asian–Pacific Islander adolescents are needed.

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In Asian and Pacific Islander youth, obesity is increasing, raising concerns that type 2 diabetes will also emerge as an epidemic in this age-group as it has in Asian and Pacific Islander adults (1,2). In an earlier report, the SEARCH for Diabetes in Youth Study (SEARCH study) reported that the incidence of type 2 diabetes was considerably higher among Asian and Pacific Islander youth compared with non-Hispanic white (NHW) youth (3). The SEARCH study also reported a lower incidence of type 1 diabetes in Asian and Pacific Islanders than NHWs, a finding consistent with generally low incidence rates from Asian countries participating in the Diabetes Mondiale Project (3,4). To date, however, no manuscript has described the clinical and biochemical phenotypes associated with type 1 and type 2 diabetes in Asian and Pacific Islander youth.

In this report, we describe demographic and clinical characteristics, including adiposity, of U.S. Asian and Pacific Islander youth with type 1 or type 2 diabetes. Given the heterogeneity between Asian and Pacific Islander populations and the importance of body weight as a risk factor for diabetes, coupled with different adult BMI criteria (5) for overweight and obesity for these groups, we report demographic and clinical results for Asian, Pacific Islander, and mixed Asian–Pacific Islander youth separately. We also report the overall prevalence and incidence of type 1 and type 2 diabetes for all Asian, Pacific Islander, and Asian–Pacific Islander youth combined.

RESEARCH DESIGN AND METHODS

— Data for this analysis derive from the SEARCH study. A detailed description of SEARCH study methods has been published elsewhere (6). The SEARCH study is a multicenter, observational study that began conducting population-based ascertainment of cases of nongestational diabetes in youth aged <20 years beginning in 2001 and continuing through the present. The SEARCH study has six clinical centers, lo-

cated in Ohio, Colorado, Washington, South Carolina, Hawaii, and California.

The SEARCH study sought to identify all existing (prevalent) cases of diabetes in 2001 and all newly diagnosed (incident) cases in subsequent calendar years. Diabetes cases were considered valid if diagnosed by a health care provider. Analyses herein include prevalent (for 2001) and incident cases for calendar years 2002–2005. Before implementation of the protocol, the study was reviewed and approved by the institutional review board(s) that had jurisdiction over the local study population, and compliance with Health Insurance Portability and Accountability Act regulations was ensured. All study personnel were trained in study procedures before initiation of data collection and then recertified annually.

Youth with diabetes or their parent/guardian were asked to complete a short initial survey that collected information on race, ethnicity, and diabetes-related factors. Self-reported race and ethnicity were collected using the 2000 U.S. Census questions (7). All youth who replied to the initial survey, excluding those whose diabetes was secondary to other conditions, were invited to a study visit.

Written informed consent and assent were obtained according to the guidelines established by the local institutional review board at the beginning of the study visit. During this visit, additional survey information was collected, including symptoms at presentation, medications, medical care utilization, perceptions of care, and family history. For all participants, blood was drawn for measurement of diabetes autoantibodies, glycohemoglobin (GHb), fasting glucose, C-peptide, and lipids. Specific laboratory methods for these tests have been previously described (6,8). For youth aged ≥3 years, a brief physical examination included height, weight, waist circumference, evaluation for acanthosis nigricans, and measurement of systolic and diastolic blood pressure (6).

Categorization of key variables

Diabetes type was reported by the health care professional or abstracted from the medical records as type 1, type 1a, type 1b, type 2, maturity-onset diabetes of the young, hybrid, or other type. We have previously shown that using provider-diagnosed diabetes type results in grouping youth with a clinical diagnosis of type 1 diabetes who are much more likely to have a positive diabetes autoantibody, with much lower fasting C-peptide concentrations, than youth with a clinical diagnosis of type 2 diabetes (3). For a small proportion of youth, we could confirm their diabetes diagnosis but could not find diabetes type reported. For this report, we have restricted our analyses to youth with type 1 (including type 1a and type 1b) or type 2 diabetes. Case subjects with maturity-onset diabetes of the young, hybrid, other types, or missing type were excluded (2.5% of all registered case subjects). Three youth aged <10 years with type 2 diabetes were excluded due to too much missing data and insufficient data (e.g., labs, medication use) to confirm their diabetes type.

Race/ethnicity was categorized somewhat differently for the prevalence and incidence estimates, which used all registered youth, and for the analysis of respondent characteristics, which was based on the subset of youth who had a study visit. For both analyses, all participants who reported Hispanic ethnicity were categorized as Hispanic, regardless of their responses to race questions. For the prevalence and incidence estimates, participants with multiple race categories were race bridged using methods developed by the National Center for Health Statistics (9). Participants with missing race and ethnicity data or who were classified as "other race" were geocoded (7.6% of all registered case subjects were either geocoded or race bridged).

For analyses of characteristics of youth with diabetes among the non-Hispanic participants, those who reported multiple races were sorted into a race category using the plurality approach (9). For example, using this approach a participant who self-identified as African American and Asian (or Pacific Islander) would be placed in the African American category; participants who self-identified as Asian (or Pacific Islander) and NHW would be in the Asian/Pacific Islander category. Subjects who could not be classified to one race group using the plurality approach, such as those participants that only report "other" race (0.5% of study visit case subjects) and those with missing data (0.02% of study-visit case subjects) were excluded.

This report includes all participants assigned to the Asian/Pacific Islander race category by the plurality approach (n = 245). Approximately one-third of Asian and Pacific Islander youth (42 Asian and 12 Pacific Islander) and one-half of Asian–Pacific Islander youth (n = 37) also reported NHW race. In addition, two youth were Asian–NHW–Native American and three were Asian–Pacific Islander–NHW–Native American.

We further separated the entire Asian/Pacific Islander race category into three ethnic subgroups: Asian, Pacific Islander, or mixed Asian–Pacific Islander, given that 25% of the SEARCH study Asian and Pacific Islander case subjects reported mixed Asian and Pacific Islander ethnicity. Youth (or their parents) were also able to self-report more than one ethnicity (e.g., Japanese, Samoan, etc.).

BMI was calculated using measured weight (in kilograms) divided by the square of measured height (in meters). Percentiles for BMI were determined to be specific to sex and month of age using algorithms prepared by the U.S. Centers for Disease Control and Prevention based on the 2000 Centers for Disease Control and Prevention Growth Charts (10,11). Overweight was defined as a BMI in the 85th to <95th percentile, and obesity was defined as a BMI in the ≥95th percentile (12). High waist circumference was defined as ≥90th percentile for age and sex.

Hypertension was defined based on either systolic or diastolic blood pressure more than or equal to age-, sex-, and height-specific 95th percentile (13). A1C was categorized using the American Diabetes Association guidelines as good (<8.0%), marginal (8.0–9.4%), or poor (≥9.5%) (14). Diabetic ketoacidosis (DKA) at diagnosis was reported for incident cases only and is based on having at least one of the following criteria noted in the medical record: *1*) blood bicarbonate <15 mmol/l or pH <7.25 (venous) or <7.30 (arterial or capillary), *2*) ICD-9 code 250.1 at discharge, or *3*) diagnosis of DKA mentioned in the medical records (15).

Estimation of prevalence

Methods for estimating diabetes prevalence in 2001 have been previously reported (16). Briefly, the numerator for the analysis included all case subjects with nongestational diabetes prevalent in 2001 who were aged <20 years on 31 December 2001 and a resident of the defined population in 2001 (geographically based centers) or a member of the participating health plan in 2001 (membership-based centers). Age is based on the subject's age on 31 December 2001. The denominators included youth aged <20 years who were civilian residents of the study areas cov-

Table 1—*Racial and ethnic breakdown of SEARCH study Asian, Pacific Islander, and mixed Asian–Pacific Islander youth

Ethnicity*	Asian	Pacific Islander	Mixed Asian–Pacific Islander
n	150	34	61
Filipino	63		29
Japanese	42		20
Chinese	23		40
Asian Indian	16		
Korean	8		1
Vietnamese	3		
Other Asian	12		1
Native Hawaiian		16	51
Samoan		15	12
Guamanian or Chamorro		2	2
Other Pacific Islander		6	4

*More than one response category allowed.

ered by the geographic centers or were members of the specific health plans in 2001. The prevalence of diabetes was expressed as cases per 1,000 youth using data pooled across all SEARCH study centers, with 95% CIs calculated by using an inverted-score test from the binomial distribution (17). Since the estimates used for the denominator pool Asians, Pacific Islanders, and Asian–Pacific Islanders into one heterogeneous group, both prevalence estimates and incidence rates are reported for Asian/Pacific Islander/Asian–Pacific Islander combined.

Estimation of incidence rates

Annual incidence rates for 2002 and 2003 were published previously (3). Here, we present more detailed, race/ethnic-specific incidence rates using diabetes cases ascertained with newly diagnosed diabetes over a 4-year period (2002–2005). Because the 2000 U.S. Census projections for youth residing in the participating areas were similar in 2002 and 2003 (−0.2% change overall), for simplicity, the 2002 denominator was multiplied by four and used as the total denominator for cases ascertained over the 4-year period of 2002–2005. The larger numbers made available for numerators and denominators by this approach allowed greater stability of the rate estimation within subgroups of race/ethnicity, age, sex, and clinically diagnosed diabetes type. Sensitivity analyses were conducted that demonstrated that this approach was unlikely to result in any quantitatively meaningful bias, even if the true denominator changed by as much as 5% per year, representing a cumulative change up to 16% over 4 years. Based on the current census reports, there is very little evidence that any race/ethnic or other subgroup studied in the SEARCH study would have shown such a large change. If such a dramatic change did occur, the impact on the estimation of annual incidence rates (per 100,000) would be <1.0 to 3, for low (<10/100,000) or high (35/100,000) incidence rates, respectively. The study covered 20,063,776 person-years at risk, which represents ~6% of the U.S. population aged <20 years. Annual incidence rates were estimated per 100,000 youth, and 95% CIs were calculated by using an inverted-score test from the binomial distribution (17). As for prevalence, lack of ethnic-specific denominator data precluded ethnic-specific incidence rate estimation.

Statistical analyses

Statistical testing was conducted across Asian, Pacific Islander, and mixed Asian–Pacific Islander subgroups using χ^2 tests for categorical variables, *t* tests, or ANOVA, as appropriate. Linear or logistic regression was used to adjust for differences in age and diabetes duration between Asian, Pacific Islander, and Asian–Pacific Islander subgroups for continuous and dichotomous outcomes. Despite the number of comparisons made, given the descriptive and hypothesis-generating nature of these analyses, we retained use of the traditional α of 0.05 to declare statistical significance.

Table 2—*Demographic characteristics of SEARCH study youth by Asian, Pacific Islander, and mixed Asian–Pacific Islander ethnicity*

	Asian	Pacific Islander	Mixed Asian–Pacific Islander	Overall *P* value*
n	150	34	61	
Diabetes type				
Type 1	105 (70)	25 (73.5)	47 (77)	0.5749
Type 2	45 (30)	9 (26.5)	14 (23)	
Age (years)				
0–9	45 (30)	6 (17.6)	16 (26.2)	0.3362
10–19	105 (70)	28 (82.4)	45 (73.8)	
Sex				
Male	68 (45.3)	12 (35.3)	28 (45.9)	0.5373
Female	82 (54.7)	22 (64.7)	33 (54.1)	
Income ($)				
<25,000	23 (18.3)	13 (50)	17 (32.1)	0.0192
25, 000–49,999	32 (25.4)	6 (23.1)	9 (17)	
50,000–74,999	20 (15.9)	4 (15.4)	12 (22.6)	
75,000–99,999	26 (20.6)	2 (7.7)	6 (11.3)	
≥100,000	25 (19.8)	1 (3.9)	9 (17)	
Education				
Less than high school	5 (3.4)	3 (9.4)	1 (1.7)	<0.0001
High school	19 (12.8)	13 (40.6)	21 (35)	
More than high school	125 (83.9)	16 (50)	38 (63.3)	

Data are *n* (%). **P* value for categorical variables using χ^2 test for the association between variable levels and Asian, Pacific Islander, and mixed Asian–Pacific Islander groups.

RESULTS

Ethnicity

Asian, Pacific Islander, and mixed Asian–Pacific Islander subgroups encompassed numerous ethnicities (Table 1). Asians were primarily Filipino, Japanese, and Chinese (in descending order). The Pacific Islander subgroup was predominantly Native Hawaiian and Samoan. All five groups were well represented among the mixed Asian–Pacific Islander youth.

Demographic characteristics

Demographic characteristics of all youth with diabetes are displayed in Table 2 for the 245 diabetic youth who completed a study visit. The majority of Asian, Pacific Islander, and Asian–Pacific Islander youth had type 1 diabetes. Only 23–30% of youth had type 2 diabetes, and the distribution by type did not differ by ethnic subgroups. Approximately 70% of youth were aged 10–19 years, and 55% were female. There were no significant differences by age or sex between the Asian, Pacific Islander, and Asian–Pacific Islander subgroups. The income distribution differed significantly by ethnic subgroups, with 40% of Asians reporting annual household incomes of at least $75,000, compared with 12% of Pacific Islanders and 28% of Asian–Pacific Islanders ($P = 0.019$). Of note, half of the Pacific Islander group had annual household incomes <$25,000. Highest parental education paralleled the income distribution, with Asians having 84% with more than a high school education, compared with 50% of Pacific Islanders and 63% of Asian–Pacific Islanders ($P < 0.0001$).

Clinical characteristics of youth with type 1 diabetes

Clinical characteristics are presented in Table 3, stratified by diabetes type and ethnic subgroup (Asian, Pacific Islander, and Asian–Pacific Islander). Youth with type 1 diabetes had significantly different weight-related measures across the ethnic subgroups ($P < 0.0001$ for all comparisons). Asians had the lowest rates of overweight and obesity (24.5 and 9.6%, respectively) and corresponding low mean BMI (19.7 kg/m^2) and BMI *z* score (0.4). Pacific Islander youth with type 1 diabetes had the highest rates of overweight and obesity (29.2 and 50.0%, respectively) with high mean BMI (25.9 kg/m^2) and BMI *z* score (1.5). Mixed Asian–Pacific Islander youth had values slightly higher than Asians and much lower than Pacific Islanders (overweight 25.0%, obesity 11.1%, mean BMI 20.7 kg/m^2, and BMI *z* score 0.7). Similar patterns were seen with the waist measures, with Asians having the lowest, Pacific Islanders the highest, and Asian–Pacific Islanders intermediate waist measures ($P < 0.0001$). Of note, 54.5% of Pacific Islander youth with type 1 diabetes had a high waist circumference.

Looking at other clinical characteristics among youth with type 1 diabetes, the mean diabetes duration ranged from 39.2 (Asian) to 52.9 (Pacific Islander) months (Table 3). Having a positive family history of diabetes ranged from 15.4% (Asian–Pacific Islander) to 30.4% (Pacific Islander). Fasting C-peptide differed across the three ethnic subgroups. Asian and Asian–Pacific Islander youth had lower values (0.5 and 0.4, respectively), and Pacific Islander youth had the highest (0.9) ($P = 0.048$). GAD65 positivity and stimulated C-peptide and DKA at diabetes onset (incident cases only) were not significantly different across the ethnic subgroups.

Diabetes treatment regimens differed, with almost all Asian and Asian–Pacific Islander youth with type 1 diabetes (99–100%) using insulin compared with 84% of Pacific Islander youth ($P = 0.002$). Glycemic control categorized by A1C% or mean A1C (adjusted for age and duration) varied, with Asians having the lowest A1C values (8.3%), Pacific Islanders having the highest (8.9%), and Asian–Pacific Islanders having intermediate (8.7%); but neither variable was statistically significant between subgroups. Hypertension, total cholesterol, LDL cholesterol, triglycerides, and apolipoprotein B also did not differ by subgroup. However, Pacific Islander youth had significantly lower mean HDL cholesterol (mean 47.7) compared with Asian and Asian–Pacific Islander youth (mean 56), after adjustment for age and diabetes duration ($P = 0.007$).

Clinical characteristics of youth with type 2 diabetes

As expected, the majority of youth with type 2 diabetes were obese, ranging from 71% of Asians to 100% of Pacific Islanders, with mean BMI ranging from 33.7 kg/m^2 in Asians to 42.4 kg/m^2 in Pacific Islanders (Table 3). As with other variables, Asian–Pacific Islander youth had intermediate obesity rates and BMI measures. Among youth with type 2 diabetes, there were no significant differences by ethnic subgroup for any of the weight or waist measures.

Mean duration of type 2 diabetes varied significantly among subgroups, ranging from 19.6 months (Asians) to 40.8 months (Asian–Pacific Islanders) ($P = 0.011$) (Table 3). The majority of youth with type 2 diabetes had a positive family history of diabetes. GAD65 positivity and fasting and stimulated C-peptide levels were not significantly different between subgroups. Only two participants (both Asian) with type 2 diabetes had DKA at onset. Current therapy differed significantly between subgroups; 71.4% of Asian youth with type 2 diabetes were on metformin only (compared with 42.9% of Pacific Islanders and 37.5% of Asian–Pacific Islanders), 5.7% of Asian youth were taking insulin (compared with 14.3% of Pacific Islanders and 50% of Asian–Pacific Islanders), and 14.3% of Asian youth were not on any medication (compared with 28.6% of Pacific Islanders and 12.5% of Asian–Pacific Islanders) ($P = 0.049$). Glycemic control varied, with Asians having the lower A1C values (8.1%) and Pacific Islanders having higher (9.4%), but neither A1C% category nor mean A1C was statistically significant between subgroups. The percent with hypertension ranged from 12.5% (Pacific Islanders) to 36.4% (Asian–Pacific Islanders). Total cholesterol, LDL cholesterol, HDL cholesterol, triglycerides, and apolipoprotein B levels did not differ by subgroup and were all relatively high (except HDL cholesterol, which was low) as expected given their obesity.

Prevalence and incidence

Prevalence and incidence rates for type 1 and type 2 diabetes for all Asian, Pacific Islander, and mixed Asian–Pacific Islander youth combined are presented in Table 4. The prevalence of type 1 diabetes among Asian, Pacific Islander, and Asian–Pacific Islander youth combined was 0.26 per 1,000 youth aged 0–9 years and 0.77 per 1,000 youth aged 10–19 years (Table 4). The prevalence of type 2 diabetes was 0.52 per 1,000 youth aged 10–19 years. The incidence of type 1 diabetes among Asian, Pacific Islander, and Asian–Pacific Islander youth combined was 6.4 per 100,000 person-years for youth aged 0–9 years and 7.4 per 100,000 person-years among youth aged 10–19 years. The incidence of type 2 diabetes was 12.1 per 100,000 person-years among youth aged 10–19 years. The incidence of type 2 di-

Table 3—*Clinical characteristics of SEARCH study youth by diabetes type and by Asian, Pacific Islander, and mixed Asian–Pacific Islander ethnicity*

	Type 1 diabetes				Type 2 diabetes			
	Asian	Pacific Islander	Asian–Pacific Islander	Overall *P* value*	Asian	Pacific Islander	Asian–Pacific Islander	Overall *P* value*
n	105	25	47		45	9	14	
Weight categories†								
Overweight	23 (24.5)	7 (29.2)	9 (25.0)	<0.0001	6 (19.4)		2 (18.2)	0.6597‡
Obese	9 (9.6)	12 (50.0)	4 (11.1)		22 (71)	8 (100)	8 (72.7)	
BMI (means ± SD)	19.7 ± 3.9	25.9 ± 6	20.7 ± 3.3	<0.0001	33.7 ± 12.4	42.4 ± 19.3	35.2 ± 10.3	0.2599
BMI *z* score (means ± SD)	0.4 ± 1.1	1.5 ± 0.7	0.7 ± 0.8	<0.0001	1.9 ± 0.8	2.3 ± 0.5	1.9 ± 0.7	0.4299
Waist measures								
Waist circumference (cm) (means ± SD)	68.5 ± 13.3	85.3 ± 17	72.9 ± 12.3	<0.0001	103 ± 17.4	110.5 ± 13.9	104 ± 17.8	0.5398
High waist circumference [*n* (%)]§	10 (11.4)	12 (54.5)	4 (11.1)	<0.0001	25 (80.6)	7 (87.5)	8 (72.7)	0.7215
Diabetes duration (months) (means ± SD)	39.2 ± 41.6	52.9 ± 48.6	41.9 ± 44.7	0.3668	19.6 ± 16.7	20.8 ± 20.8	40.8 ± 36.7	0.0114
Family history of diabetes [*n* (% yes)]‖	27 (27.6)	7 (30.4)	6 (15.4)	0.2691	24 (64.9)	4 (57.1)	8 (72.7)	0.7879
GAD65 [*n* (% positive)]	37 (49.3)	10 (45.5)	15 (55.6)	0.7678	4 (15.4)	2 (25)	1 (11.1)	0.7269
Fasting C-peptide (means ± SE)¶	0.5 ± 0.08	0.9 ± 0.1	0.4 ± 0.1	0.0479	3.3 ± 0.4	4.4 ± 0.7	3.2 ± 0.7	0.3479
Stimulated C-peptide (means ± SE)¶	6.3 ± 1.3	9.1 ± 2.5	2.6 ± 1.8	0.1480	17.2 ± 2.9	16.3 ± 6.2	13.8 ± 6.5	0.8955
DKA at onset [*n* (%)]**	12 (27.9)	3 (33.3)	6 (26.1)	0.9190	2 (6.3)			0.6537
Current therapy [*n* (%)]								
Insulin	103 (99)	21 (84)	47 (100)	0.0018	2 (5.7)	1 (14.3)	4 (50)	0.0493
Metformin	1 (1)	1 (4)			25 (71.4)	3 (42.9)	3 (37.5)	
Both		2 (8)			3 (8.6)	1 (14.3)		
None		1 (4)			5 (14.3)	2 (28.6)	1 (12.5)	
A1C (means ± SE)¶	8.3 ± 0.2	8.9 ± 0.4	8.7 ± 0.3	0.2757	8.1 ± 0.4	9.4 ± 0.8	8 ± 0.8	0.3192
A1C category [*n* (%)] (%)				0.4360				0.3855
<8.0	35 (45.4)	6 (27.3)	11 (39.3)		17 (65.4)	3 (37.5)	4 (44.4)	
8.0–9.5	26 (33.8)	8 (36.4)	8 (28.6)		2 (7.7)	0	1 (11.1)	
>9.5	16 (20.8)	8 (36.4)	9 (32.1)		7 (26.9)	5 (62.5)	4 (44.4)	
Hypertension [*n* (% yes)]†‡	15 (16.1)	1 (4.2)	2 (5.6)	0.1120	8 (27.6)	1 (12.5)	4 (36.4)	0.5104
Total cholesterol (means ± SE)¶	174.3 ± 3.8	174.7 ± 7	160.5 ± 6.3	0.1561	193.4 ± 8.7	207.1 ± 16.2	194.5 ± 15.6	0.7519
LDL cholesterol (means ± SE)¶	100.5 ± 3.2	99.5 ± 5.5	90.1 ± 4.8	0.1890	106.5 ± 7.2	104.1 ± 13.2	109.6 ± 12.7	0.9552
HDL cholesterol (means ± SE)¶	56.7 ± 1.4	47.7 ± 2.5	56.5 ± 2.3	0.0072	44.5 ± 2	36.8 ± 3.8	44 ± 3.6	0.1959
Triglycerides (geometric means ± SE)¶	68.9 ± 1.1	84 ± 1.1	61.2 ± 1.1	0.1618	136 ± 1.2	241.4 ± 1.4	199 ± 1.3	0.2256
Apolipoprotein B (geometric means ± SE)¶	73.6 ± 1.0	82.9 ± 1.1	69.7 ± 1.1	0.1108	90.4 ± 1.1	124.5 ± 1.2	105.8 ± 1.2	0.2626

*P value for categorical variables using χ^2 test for the association between variable levels and Asian/Pacific Islander/Asian–Pacific Islander groups or continuous variables using ANOVA for the overall effect of Asian/Pacific Islander/Asian–Pacific Islander groups. P value for adjusted variables using logistic regression (categorical variables) or linear regression (continuous variables) for the overall effect of Asian/Pacific Islander/Asian–Pacific Islander groups. †Overweight: BMI 85th to 95th percentile for age and sex; obese: BMI ≥95th percentile for age and sex. ‡Overweight and obese categories are combined for type 2 diabetes statistical analyses. §≥90th percentile for age and sex. ‖Yes, if positive for mother, father, or sibling. ¶Adjusted for age and duration.**For incident cases only. ††Systolic or diastolic blood pressure ≥95th percentile for age, sex, and height.

Table 4—*Prevalence and incidence rates of type 1 and type 2 diabetes by age-group among all Asian, Pacific Islander, and mixed Asian–Pacific Islander youth combined*

	Type 1 diabetes		Type 2 diabetes	
	Aged 0–9 years*	Aged 10–19 years*	Aged 0–9 years*	Aged 10–19 years*
Denominator	154,899	165,504	154,899	165,504
Cases	40	127	2	86
Prevalence (per 1,000) (95% CI)	0.26 (0.19–0.35)	0.77 (0.65–0.92)	†	0.52 (0.42–0.64)
Denominator	753,299	806,921	753,299	806,921
Cases	48	59	5	98
Incidence (per 100,000) (95% CI)	6.4 (4.8–8.5)	7.4 (5.8–9.6)	†	12.1 (9.9–14.8)

*Age at the time of diagnosis for incident cases and age in the year 2001 for prevalent cases. †Rate not presented due to small numerator size.

abetes was almost double that of type 1 diabetes in youth aged 10–19 years. Rates of type 2 diabetes for those aged 0–9 years are not presented, given the small numerator size and subsequent imprecision of the estimate. There were no significant differences in the incidence or prevalence of diabetes by sex for any of the age categories.

CONCLUSIONS — An important factor in the etiopathogenesis of diabetes is body weight and increasing body fat content. Risk of obesity-related diseases increases with greater BMI. Despite the lack of widely accepted reference ranges with which to compare different body weight measures among the diverse Asian and Pacific Islander ethnicities and very little data in relation to cut points that predict disease, reports in the literature suggest that body standards are different in Asian and Pacific Islander populations. Thus, lower BMI cut points have been recommended in Asians for overweight ($\geq$23 kg/m^2) and obesity ($\geq$25 kg/m^2) than for non-Asians ($\geq$25 and $\geq$30 kg/m^2, respectively) (5).

The evidence in support of these BMI recommendations comes from studies showing that morbidity and mortality occur in Asians with lower BMI than non-Asians (18,19). For a given percent body fat, Asians have been reported to have lower BMI (20). The lower BMI cutoff points in Asians may be related to a greater propensity for accumulation of adipose tissue centrally. For example, Asians have a more centralized distribution of body fat for a given level of BMI compared with NHWs (21). Moreover, studies have shown that this may be due to increased susceptibility to accumulate visceral adipose tissue in Asians (22,23).

On the other hand, Pacific Islanders tend to be large and muscular and have high BMI. Thus, the BMI cut points recommended for Asians do not apply to Pacific Islanders. In these populations, different BMI cut points are more appropriate, resulting in the recommendation of higher BMI values to define overweight ($\geq$26 kg/m^2) and obesity ($\geq$32 kg/m^2), although the data to support these are still rather sparse (5,24). Based upon these reports, as well as others, it seems inappropriate to group Asians and Pacific Islanders together. As children are still growing, the adult BMI cut points may not be appropriate. However, as with adults, ethnic-specific BMI cut points need to be considered for Asian and Pacific Islander youth.

A recent report (1) of diabetes prevalence in the U.S. supports that the relationship of BMI to risk for diabetes should be race and ethnic specific. Data from the 2001 Behavioral Risk Factor Surveillance Survey was used to determine that among adults at least 30 years of age, the prevalence of self-reported diabetes in Asians was 5.0%, Pacific Islanders 13.8%, and NHWs 6.9%. Following adjustment for age, sex, and, most importantly, BMI, thereby accounting for the lower BMI of Asians, the risk of diabetes was 60% higher in Asians than in NHWs. Furthermore, adjusting for age and sex but not for BMI, risk of diabetes was threefold higher in Pacific Islanders than NHWs. However, after further adjusting for BMI to account for the higher BMI of Pacific Islanders, the risk of diabetes was similar to Asians.

Given this background from adult Asian and Pacific Islander populations, we found that Asian, Pacific Islander, and mixed Asian–Pacific Islander youth with both type 1 and type 2 diabetes had high rates of overweight and obesity. As expected, Pacific Islander youth had higher weight- and waist-related measures than Asian or mixed Asian–Pacific Islander youth. Almost 80% of Pacific Islander youth with type 1 diabetes were overweight or obese. Furthermore, Asian, Pacific Islander, and Asian–Pacific Islander youth with type 2 diabetes all had mean BMIs above World Health Organization adult Pacific Islander–specific definitions of obesity (BMI $\geq$32 kg/m^2), with Pacific Islander youth having mean BMI of 42 kg/m^2. Given the known increased morbidity associated with increasing BMI, these youth are at significant risk for other obesity-related comorbidities (e.g., sleep apnea, nonalcoholic steatohepatitis, etc.) in addition to type 2 diabetes.

Sociodemographic characteristics such as income and education levels differed significantly between the three subgroups, with Asians reporting the highest, Asian–Pacific Islanders intermediate, and Pacific Islanders the lowest levels of household income and parental education. The demographics of these SEARCH study participants generally reflect the findings in a recent U.S. Census Bureau publication that reported Asians having the highest median household income ($64,238) of all race groups and 49% having a Bachelor's degree or higher compared with the lower median household income ($49,361) and Bachelor's degree or higher (14%) for Native Hawaiians and Pacific Islanders (25). In addition, a recent report (26) by the Kaiser Family Foundation found that despite the common belief that individuals categorized as Asians and Pacific Islanders are generally healthier than individuals from other minority groups, certain subgroups of U.S. Asian American, Native Hawaiian, and Pacific Islander populations are less likely to have health insurance coverage and access to health care. For example, the proportion of nonelderly individuals who are uninsured varies widely, ranging from 31% of Koreans, 24% of Native Hawaiians and Pacific Islanders, and 12% of Jap-

anese and Asian Indians. In comparison, 12% of nonelderly NHWs are uninsured.

Our study was not able to separate Asians from Pacific Islanders to report diabetes incidence rates or prevalence estimates. However, we found that Asian and Pacific Islander youth in the U.S. have a higher type 1 diabetes incidence rate than youth aged 0–14 years in several Asian countries (time period ranging from the 1970s to 2001). For example, rates of type 1 diabetes for youth in Japan (27–29), Korea (30), Shanghai (31), Taiwan (32), Thailand (33), and Singapore (34) ranged from <1.0/100,000 (Thailand, Korea) to 3.3/100,000 (Japan), making our rates at least twofold higher than the highest rates reported in these countries.

Incidence of type 2 diabetes in the U.S. was also high compared with youth aged 6–18 years from Japan and Taiwan (28,32,35–37). Among these studies, the highest incidence was 13.9/100,000 reported for youth aged 12–15 years in Japan from 1991 to 1995 (35). In all other reports from Asia, incidence was much lower than found in the SEARCH study Asian and Pacific Islander youth, ranging from 2.6 (Japan, aged 6–15 years, 1974–2004 [37]) to 6.5 (Taiwan, aged 6–18 years, 1992–1999 [32]). Given the high rates of obesity in the SEARCH study Asian, Pacific Islander, and mixed Asian–Pacific Islander youth, obesity prevention and treatment efforts in these populations are needed in order to decrease risk for type 2 diabetes and other obesity-related morbidities.

The Asian, Pacific Islander, and Asian–Pacific Islander participants in this study represented 4.7% of the entire SEARCH study population, in comparison with the U.S. population (7): 4.2% Asian and 0.3% Native Hawaiian/Pacific Islander (38). However, SEARCH study sites were specifically selected to oversample minority groups, thereby selecting sites in California, Hawaii, and Washington, where Asian/Pacific Islander populations are concentrated. Over half of Asians and three-quarters of Pacific Islanders live in the western U.S. (39,40). With regard to ethnic subgroups, the SEARCH study Pacific Islander group paralleled the U.S. Pacific Islander population with Native Hawaiians as the largest ethnic subgroup followed by Samoan (40). However, SEARCH study Asian participants were more likely to be Filipino or Japanese in contrast to the broader U.S. Asian population, where Chinese are the largest subgroup, followed by Filipinos and Asian Indians (39).

The SEARCH study was designed to identify youth with physician-diagnosed diabetes. The study protocol does not include a component to screen for undiagnosed diabetes. While the accuracy of our prevalence estimates and incidence rates are dependent on case ascertainment, completeness of case ascertainment has been estimated to be 93% (3,16).

Despite the fact that this report contains the largest cohort of U.S. Asian and Pacific Islander youth with diabetes, the study is limited by having only 245 participants. When stratified into the three categories (Asian, Pacific Islander, and Asian–Pacific Islander), the number of subjects limits statistical power to identify differences. In addition, although we emphasize the need to separate Asians from Pacific Islanders, we were unable to present incidence or prevalence rates by ethnic subgroup due to our current denominators, which combine all groups. Future efforts to separate these groups will be important since diabetes rates differ widely among countries in the Asia-Pacific region (41).

In conclusion, while Asian and Asian–Pacific Islander youth with type 1 and type 2 diabetes had lower mean BMI than Pacific Islanders, all Asians, Pacific Islanders, and Asian–Pacific Islanders with type 2 diabetes had mean BMI above adult ethnicity-specific definitions of obesity. Asian, Pacific Islander, and Asian–Pacific Islander youth aged 10–19 years have an incidence of type 2 diabetes almost double that of type 1 diabetes. Public health efforts to address the high incidence of type 2 diabetes in Asian and Pacific Islander youth as well as the high prevalence of obesity in these youth are needed. In addition, more data and research is needed within Asian and Pacific Islander youth subgroups to examine obesity cut points for diabetes risk in order to develop prevention and assessment strategies for Asian and Pacific Islander populations.

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