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# Prevalence of Childhood Obesity among Young Multiethnic Children from a Health Maintenance Organization in Hawaii

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## Abstract

***Background:*** Pacific Islander, Asian, and mixed-ethnicity children are not described in national nutrition and health surveys.

***Methods:*** Data on BMI values of 4608 5- to 8-year-old children available from Kaiser Permanente Hawaii electronic medical records in 2010 were analyzed for prevalence of overweight and obesity and for ethnic differences in BMI and risk for overweight and obesity, controlling for age, sex, neighborhood education level, and on a subset ($n = 2169$) that further controlled for maternal education and maternal age. Kaiser Permanente data allow for reporting of multiple ethnicities.

***Results:*** Data revealed that 33% of this child population was of mixed ethnic ancestry. Prevalence of overweight and obesity was 32.6% (12.9% overweight and 19.7% obese). However, Samoan children and children of Native Hawaiian, Filipino, and mixed ethnic ancestries had higher levels of overweight and obesity than whites or Asians. Higher neighborhood education level, higher maternal education level, and older maternal age were associated with decreased risk of overweight and obesity, except for children whose mothers were between 21 and 30 years old, who had a higher risk for obesity than those whose mothers were under 20 years of age (odds ratio = 1.34).

***Conclusions:*** Populations of mixed ethnicities in the Pacific region deserve further study related to healthy body size and acculturation to environment and lifestyle.

## Introduction

Few population-based data are available on overweight and obesity of children in the Pacific Region, and obesity is a major threat to the future health of our population. In US data from the 48 contiguous states, it has been estimated that approximately 60% of 5- to 10-year-old overweight children will develop type 2 diabetes at some point in their lives, whereas in the total population of those children, one-third will develop diabetes.[1] Obese children are more likely than their peers to experience negative social and psychological consequences, including discrimination, stigmatization, and low self-esteem.[2–5] Orthopedic,[6,7] neurological,[8,9] pulmonary,[10,11] digestive,[12,13] and endocrine systems[14–16] are all negatively affected by obesity in children. National data are not provided on obesity of Native Hawaiians, other Pacific Islanders, or Asians, nor has the state of Hawaii been selected for measurement in the National Health and Nutrition Examination Surveys (NHANES).[17]

A previous study showed that the average BMI and the risk for overweight and obesity in Hawaii varied by ethnic group in the preschool-age population, using data from the Supplemental Feeding Program for Women, Infants and Children (WIC)[18]; the prevalence of obesity among preschoolers was 9% and varied from 2% in Asian children to 17% in Samoan children. A study of children in Hawaii based on parent telephone report of weight, height, health, and socioeconomic factors showed a 31.8% prevalence of overweight and obesity among 10 to 13 year olds.[19] In that study, Native Hawaiian and Pacific Islander children (10–17 years) had a greater prevalence of obesity (38.6%) than whites, as did children of mixed ethnicity (30.9%). Prevalence was higher among children of younger mothers, and among children whose mothers had less education. Overweight and obesity prevalence was higher among children of poorer health (46.5%) than among those of very good health (25.8%). The relationship between socioeconomic status (SES) and childhood obesity has been shown

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to vary among ethnic groups where SES was inversely related to obesity in whites, but not in Hispanics or African Americans.[20] In national data, the mean prevalence of obesity was 18% among 6 to 11 year olds.[21] In a study of the adult hotel worker population in Hawaii,[22] obesity prevalence among males and females was, respectively, 51% and 46% among Pacific Islanders, 17% and 13% among Filipinos, 19% and 8% among other Asians, and 27% and 19% among whites. A study by Novotny et al. showed that acculturation level of the population accounted for some of the disparity in BMI in adults.[23,24]

Hawaii's population has a high rate of intermarriage, and 23.6% of the population reports mixed ethnicity.[25] For those reporting at least two ethnic groups, the largest mixed ethnic group was a combination of Asian with Native Hawaiian and other Pacific Islanders, comprising 5.3% of the state's population. Those identifying with three or more ethnic groups totaled 113,640 people, or 8.4% of the population. A study by Albright et al.[26] showed that mixed-ethnicity adults had higher BMI values than would be expected from the mean of the component ethnic groups.

The objectives of this study are to examine the BMI of 5- to 8-year-old children from Kaiser Permanente Hawaii (KPH) electronic medical records for prevalence of overweight and obesity, for ethnic differences in BMI, and for risk for overweight and obesity, with adjustment for important covariates (child age and sex, maternal age and education, and neighborhood education level). Of particular interest is the comparison of the Asian and Pacific Islander ethnic groups prevalent in Hawaii, and the large Native Hawaiian-Asian mixed ethnic group, compared to the white population living in the same Hawaii environment.

## Methods and Procedures

The study used a cross-sectional study design and electronic medical record (EMR) data from KPH. The sample included the 8984 5- to 8-year-old children with a parent who was a member of KPH Health Maintenance Organization (HMO); 145 had a missing weight or height, yielding $n = 8839$ available for BMI analyses. Data include children born between January 1, 2002, and December 31, 2005 (data were extracted in 2010). Both KPH and the University of Hawaii reviewed and approved the study for use of human subjects.

### *BMI Data from the HMO*

Because children visit the HMO at varying ages, multiple EMR entries were often available for each child. Thus, for this analysis, weights and heights from the last EMR entry were extracted. BMI was calculated as weight in kilograms divided by height in meters squared.

BMI percentiles and *z*-scores were determined for each child based on age and sex according to CDC methods.[27] Biologically implausible BMI *z*-scores were determined by the CDC algorithm and excluded from the analyses (14 low, 87 high; $n = 101$), yielding $n = 8738$ for analyses. By the CDC method, the following BMI *z*-score ranges are considered biologically implausible: By the CDC method, less than $-4.0$ and greater than $+5.0$ BMI *z*-scores were considered biologically implausible. Overweight is defined as the $\geq 85^{th}$–$95^{th}$ percentile for age and sex and obese as the $\geq 95^{th}$ percentile for age and sex, compared to the CDC reference data.

### *Ethnicity*

At KPH, ethnic information is collected from one of three sources: (1) Inpatient admission via interview, (2) personal history sheet completed by the patient (or by the parent, for children), used at all (outpatient) clinics, and (3) physician notes, sometimes used in the tumor registry. Although the data source is not recorded in the database, most ethnic information is captured through the ''personal history sheet'' (especially for children), which was implemented in the last decade to capture this information at outpatient visits. The KPH personal history sheet provides the opportunity to identify 29 ethnic categories; the EMR data contain up to five ethnic entries per child. For children, this information is obtained predominantly by parental report. Ethnic data were available on approximately 60% of the membership.

We collapsed the different ethnic categories and their combinations into eight categories for the present analysis: White, Asian, Filipino, Native Hawaiian, Samoan, Hawaiian-Asian, other mixed, other. The ''Asian group'' included those whose entries were: Chinese (68), Japanese (138), Korean (13), Asian Indian/Pakistani (11), Vietnamese (11), Laotian (4), Kampuchean (1), other Asian (without other detail, $n = 185$). A child of a mixed ethnicity involving Native Hawaiian and Asian (but no other group) was assigned to a Hawaiian-Asian mixed-ethnicity group; this group was retained separately because it was the predominant mixed ethnic category (41% of children of mixed ethnicity fell into this group). All other individuals with mixed ethnicity were combined into one mixed ethnicity group. The mixed ethnic group included: Asian-mixed (other than Hawaiian-Asian) (512), Filipino-mixed (140), Hawaiian-mixed (other than Hawaiian-Asian) (646), other-mixed (202), and Samoan-mixed (22). The 'other' ethnic group included black (35), American Indian/Aleutian/Eskimo (5), other Pacific Islander (272), and other (144). In all, 4608 (52.8%) of the 8738 children had ethnic data available for analysis, which is similar to the overall percentage of KPH membership with ethnicity data available.

### *Neighborhood Education Level*

SES data were not collected in the KPH EMR. To understand the extent to which ethnic differences were explained by SES, the year 2000 census data were attached to the data to provide information on neighborhood education level based on the zip code of the child's address (children were born between 2002 and 2005) as an indicator of SES. The census data provide the percentage of adults, 25 years

or older, by education category. We computed an average number of years of education for zip code (neighborhood) using the midpoint of completed years of education for each category. Category of neighborhood educational level was then assigned based on the average as: 1 = high school or less, 2 = some college, 3 = Associate degree, 4 = greater than Associate degree. These data were missing for 9 children, leaving 4599 for this analysis.

### *Subsample with Vital Records Data*

Maternal age (years) and maternal education (in years) were also available in a subsample of children ($n = 2169$). These variables were included in analysis as more proximal, individual-level indicators of SES. These data were made available on a subsample from a special linkage done with vital records from the Hawaii State Department of Health at the request of the Kaiser Permanente Center for Health Research Hawaii. The data on maternal education were grouped in the same levels given above, and maternal age groups used were <20 years (reference), 21–30 years, 31–40 years, and >40 years.

### *Statistical Analysis*

Descriptive statistics and regression analyses were calculated using SAS, v. 9.2 (Cary, NC). The population of children was first described by age, ethnicity, and neighborhood education level. The younger ages of 5 and 6 years were found to be overrepresented due to younger children being more likely to have visits to KPH for recommended well-child visits than older children. Because we wished to provide results that are reflective of the child population aged 5–8 years found in the state of Hawaii, a weighting scheme was created based on the age distribution of 5 to 8 year olds in the 2000 state census data[25] (where each of the four age groups was approximately equal in size), such that the sum of the weights equals the overall sample size of 4599. The weighting was applied to all analyses except the initial description of the population (Tables 1 and 2). Regression was used to model BMI continuously or as overweight or obese.

Because neighborhood education level was assigned within zip code, a correlation structure was imposed on the data that had to be accounted for in the analysis. Therefore, mixed regression models were used to account for the imposed clustering of data into the 83 zip codes via a compound symmetric covariance matrix. Independent variables in all models included sex, age, neighborhood education level, and ethnic group. Models on the subsample also included maternal age and maternal education. Interaction between neighborhood education level and ethnic group was tested using cross-product terms. Mixed linear models were used where the outcome was BMI percentiles of children, and covariate-adjusted means were computed by ethnic group. The model assumptions were checked and found generally to be met. Mixed logistic models were used where the outcome was the category of overweight and obesity, with the odds ratio (OR) and 95% confidence intervals (CI) as the measures of association.

**Table 1. Demographic Distribution by Child Sex ($n = 4599$)**

| | Males (2458) *n* | Females (2141) *n* | All (4599) *n* |
|---|---|---|---|
| Age, years | | | |
| 5 | 925 (37.6) | 842 (39.3) | 1762 (38.4) |
| 6 | 821 (33.4) | 693 (32.4) | 1514 (32.9) |
| 7 | 463 (18.9) | 380 (17.8) | 843 (18.3) |
| 8 | 249 (10.1) | 226 (10.6) | 475 (10.4) |
| Ethnicity | | | |
| White | 339 (13.8) | 286 (13.5) | 625 (13.6) |
| Asian[a] | 228 (9.3) | 203 (9.5) | 431 (9.4) |
| Filipino | 243 (9.9) | 211 (9.9) | 454 (9.9) |
| Native Hawaiian | 177 (7.2) | 150 (7.0) | 327 (7.1) |
| Hawaiian-Asian | 348 (14.2) | 349 (16.3) | 697 (15.2) |
| Samoan | 41 (1.7) | 46 (2.2) | 87 (1.9) |
| Other mixed[b] | 818 (33.3) | 704 (32.9) | 1522 (33.1) |
| Other[c] | 264 (10.7) | 192 (9.0) | 456 (9.8) |
| Neighborhood education level[d] | | | |
| High school or less | 233 (9.5) | 201 (9.4) | 434 (9.4) |
| Some college | 794 (32.3) | 664 (31.0) | 1458 (31.7) |
| Associate degree | 1144 (46.5) | 1016 (47.5) | 2160 (47.0) |
| Greater than Associate degree | 287 (11.7) | 260 (12.1) | 547 (11.9) |

[a]Asian includes Chinese (68), Japanese (138), Korean (13), Asian Indian/Pakistani (11), Vietnamese (11), Laotian (4), Kampuchean (1), other Asian (185).

[b]'Mixed' includes Asian-mixed (512), Filipino-mixed (140), other Native Hawaiian-mixed (646), other-mixed (202), Samoan-mixed (22).

[c]'Other' ethnic group includes black (35), American Indian/Aleutian/Eskimo (5), other Pacific Islander (272), other (144).

[d]Year 2000 census educational attainment based on the zip code of the child's address, as an indicator of socioeconomic status.

Because data were derived from Kaiser Permanente records, an insurance company, to assure an estimate of overweight and obesity that was reflective of the child population found in the state of Hawaii, a weighting scheme was applied to the data that was based on the age distribution of 5 to 8 year olds in the 2000 state census data,[25] and that retained the overall sample size of 4599.

## Results

### *Age, Ethnic Group, and Neighborhood Education Level Distribution by Sex*

Frequencies of child age, ethnic group and neighborhood education level by sex, prior to weighting, are

**Table 2. Neighborhood Education Level[a] Differs by Child Ethnic Group (Chi-Squared, $p < 0.0001$), *n* (%)**

| | Asian[b] | Filipino | Hawaiian-Asian | Native Hawaiian | Mixed[c] | Other[d] | Samoan | White | Total |
|---|---|---|---|---|---|---|---|---|---|
| High school or less | 34 (7.9) | 79 (17.4) | 61 (8.8) | 34 (10.4) | 119 (7.8) | 61 (13.4) | 24 (27.6) | 22 (3.5) | 434 (9.4) |
| Some college | 104 (24.1) | 204 (44.9) | 246 (35.3) | 117 (35.8) | 455 (29.9) | 167 (36.6) | 34 (39.1) | 131 (21.0) | 1458 (31.7) |
| Associate degree | 200 (46.4) | 154 (33.9) | 334 (47.9) | 150 (45.9) | 772 (50.7) | 193 (42.3) | 27 (31.0) | 330 (52.8) | 2160 (47.0) |
| Greater than Associate degree | 93 (21.6) | 17 (3.7) | 56 (8.0) | 26 (8.0) | 176 (11.6) | 35 (7.7) | 2 (2.3) | 142 (22.7) | 547 (11.9) |
| Total | 431 | 454 | 697 | 327 | 1522 | 456 | 87 | 625 | 4599 |

[a]Year 2000 census educational attainment based on the zip code of the child's address, as an indicator of socioeconomic status.

[b]Asian includes Chinese (68), Japanese (138), Korean (13), Asian Indian/Pakistani (11), Vietnamese (11), Laotian (4), Kampuchean (1), other Asian (185).

[c]'Mixed' includes Asian-mixed (512), Filipino-mixed (140), other Hawaiian-mixed (646), other-mixed (202), Samoan-mixed (22).

[d]'Other' ethnic group includes black (35), American Indian/Aleutian/Eskimo (5), other Pacific Islander (272), other (144).

provided in Table 1. There were more males than females, and there was a greater frequency of younger than older children in the data set.

### *Ethnic Distribution*

Thirty-three percent of children ($n = 1522$) had two or more ethnic groups, of which 15% was mixed Hawaiian-Asian ethnicity ($n = 697$). The distribution by ethnic group was generally unchanged after applying the weighting scheme.

### *Neighborhood Education Level*

The children generally lived in neighborhoods (defined by zip code) where most adults, 25 years and older, had an Associate of Arts or Science degree or some college education (Table 2). There were no differences in neighborhood education level by child sex (data not shown). A significant association between ethnic group and neighborhood education level was found (chi-squared, $p < 0.0001$; Table 2). Of particular note is the lower neighborhood educational level of Samoan (27.6% had high school or less) and Filipino (17.4% had high school or less) children, as compared with whites (3.5%) and Asians (7.9%).

### *Overweight and Obesity*

The estimated prevalence of overweight ($\geq 85^{th}$–$95^{th}$ percentile BMI) was 12.9%, and obesity ($\geq 95^{th}$ percentile BMI) was 19.7%, among this 5- to 8-year-old sample with ethnic information ($n = 4608$), after weighting to the year 2000 census age distribution. The overweight plus obesity prevalence of 32.6% is similar to the estimate of 30% for children with ethnic data but with no weighting to the census age distribution. The prevalence of overweight and obesity among children with no ethnic information was 28.7%, and combining children with and without ethnic information, the prevalence was 29.4%.

All children except Asians were significantly more likely to be overweight or obese in comparison with white children ($p < 0.05$) (Fig. 1). The excess risk varied by ethnic group: Samoan (OR = 9.4), Native Hawaiian (OR = 2.5), Filipino (OR = 1.7), Hawaiian-Asian mixed (OR = 1.9), other mixed (OR = 1.8), and other (OR = 2.3) children.

Figure 2 shows the mean child BMI by ethnic group and by neighborhood education level, adjusted for age and sex. The BMIs were significantly different for both variables (F test, $p < 0.0001$). Higher neighborhood education level was associated with lower BMI. Relationships between BMI, the ethnic groups, and the neighborhood education levels remained the same when not adjusted for age and sex (data not shown). Figure 3 shows the age- and sex-adjusted odds ratios, for overweight and obesity by neighborhood education levels within ethnic group. The interaction between these two variables was significant ($p < 0.0147$). Within each group, the highest levels of education were associated with lower levels of overweight/obesity, although the association was not consistent at the lower education levels. For Samoans and others, children living in neighborhoods with the lowest level of education (high school or less) were the most likely to be overweight or obese. For all other ethnic groups, the children living in neighborhoods with the lowest level of education were generally less likely to be overweight/obese compared to children from neighborhoods in the next highest education level.

### *Subsample with Vital Records Data*

In the subsample with vital records data ($n = 2169$), mothers averaged $28.8 \pm 6.3$ years of age and $13.6 \pm 2.2$ years of education at the birth of the child. The correlation between maternal years of education and neighborhood education level was 0.26. We found that the older maternal age groups ($p < 0.04$) and higher education levels ($p = 0.0001$) were associated with lower BMIs among children.

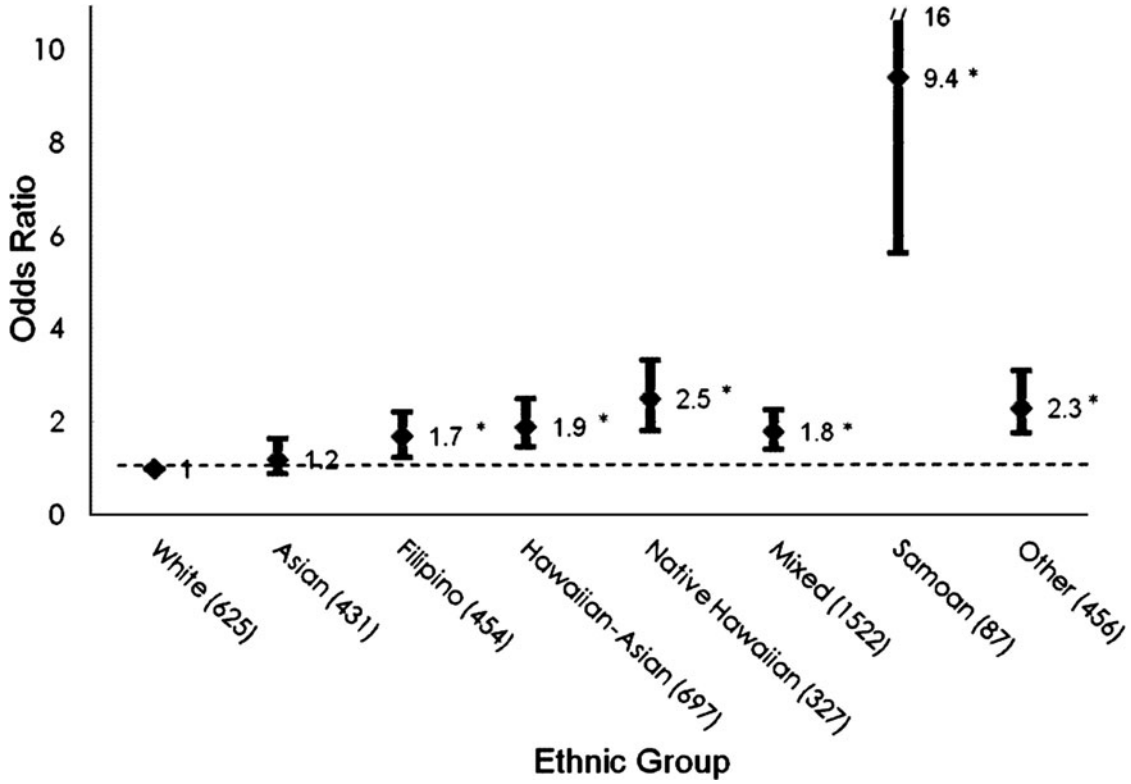


**Figure 1. Risk of overweight and obesity[a] by ethnic group[b] in children 5–8 years old. Odds ratios (adjusted for age, sex, and neighborhood education level) ($n = 4599$). (*) $p < 0.05$.**

[a]Overweight and obesity $\geq 85^{th}$ percentile.[27]

[b]Asian includes Chinese (68), Japanese (138), Korean (13), Asian Indian/Pakistani (11), Vietnamese (11), Laotian (4), Kampuchean (1), other Asian (185); 'mixed' includes Asian-mixed (512), Filipino-mixed (140), other Hawaiian-mixed (646), other-mixed (202), Samoan-mixed (22); 'other' ethnic group includes black (35), American Indian/Aleutian/Eskimo (5), other Pacific Islander (272), other (144).

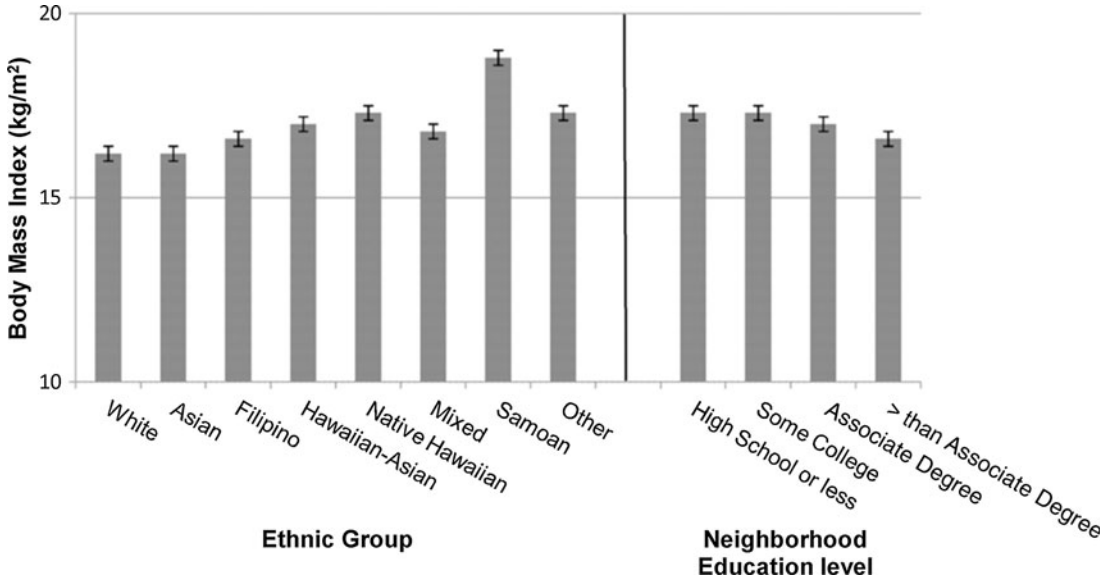


**Figure 2. Age- and sex-adjusted mean child BMI[a,b] by ethnic group[c] and neighborhood education level,[d] 5–8 years old ($n = 4599$).**

[a]Covariates are age and sex for ethnicity model and age, sex and ethnicity for neighborhood education level model.

[b]$p < 0.0001$ for both models based on global F test across categories.

[c]Asian includes Chinese (68), Japanese (138), Korean (13), Asian Indian/Pakistani (11), Vietnamese (11), Laotian (4), Kampuchean (1), other Asian (185); 'mixed' includes Asian-mixed (512), Filipino-mixed (140), other Hawaiian-mixed (646), other-mixed (202), Samoan-mixed (22); 'other' ethnic group includes black (35), American Indian/Aleutian/Eskimo (5), other Pacific Islander (272), Other (144).

[d]Year 2000 census educational attainment based on the zip code of the child's address, as an indicator of socioeconomic status.

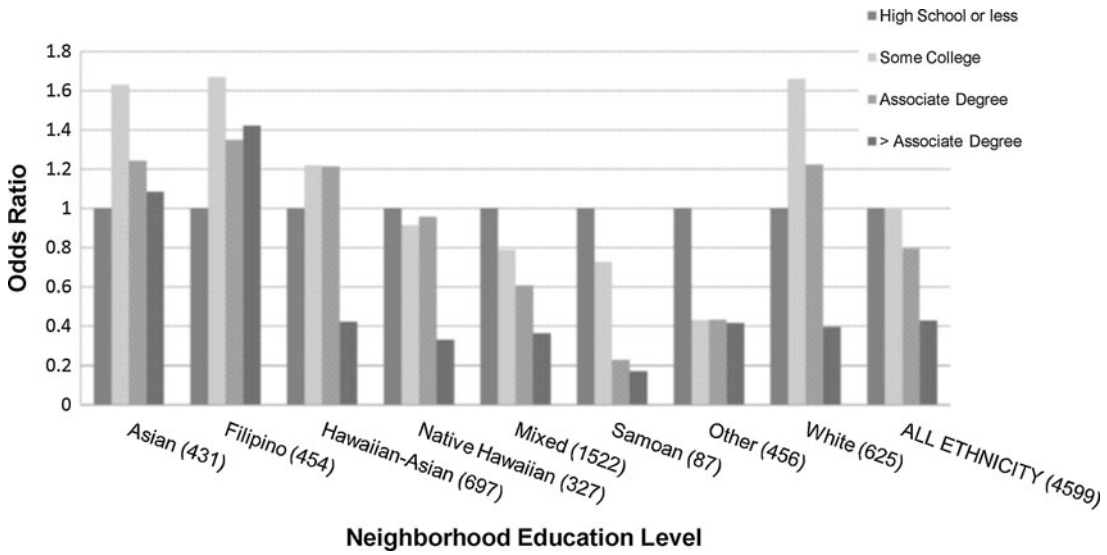


**Figure 3. Age- and sex-adjusted odds ratios[a] of overweight and obesity[b] by child ethnic group[c] and neighborhood education level,[d] 5– 8 years old ($n = 4599$).**

[a]Odds ratios adjusted for age and sex.

[b]Overweight and obesity $\geq 85^{th}$ percentile.[27]

[c]Asian includes Chinese (68), Japanese (138), Korean (13), Asian Indian/Pakistani (11), Vietnamese (11), Laotian (4), Kampuchean (1), other Asian (185); 'mixed' includes Asian-mixed (512), Filipino-mixed (140), other Hawaiian-mixed (646), other-mixed (202), Samoan-mixed (22); 'other' ethnic group includes black (35), American Indian/Aleutian/Eskimo (5), other Pacific Islander (272), other (144).

[d]Year 2000 census educational attainment based on the zip code of the child's address, as an indicator of socioeconomic status. Interaction of ethnic group and neighborhood education level was significant ($F = 4.42$, $p < 0.0147$).

Compared to mothers under 20 years of age, risk of overweight and obesity of children was increased in 21 to 30 year olds (OR = 1.34), was similar among 31 to 40 year olds (OR = 1.07), and was decreased among those 40 years of age or older (OR = 0.74).

Compared to children of mothers with less than or equal to high school education, children whose mothers had some college education had an increased risk of overweight and obesity (OR = 1.14); those whose mothers had an Associate degree had a decreased risk (OR = 0.95), and those whose mothers had more than an Associate degree had a further decreased risk (OR = 0.52).

When both neighborhood education level (F test, $p = 0.002$) and maternal education level (F test, $p = 0.046$) were included in one logistic model of child overweight/obesity (adjusting for maternal age, child ethnic group, child sex, and child age), both variables were significant.

## Discussion

The prevalence of obesity ($\geq 95^{th}$ percentile BMI for age and sex) was 19.7% in this population of 5 to 8 year olds (data were extracted in 2010), higher than the level found in the 48 contiguous US states among children 2–19 years old (16.9% prevalence); among those 6–11 years old, the prevalence in these national data was 18%.[21] These national data showed ethnic differences in obesity prevalence with white children at 13.9% and prevalence among non-Hispanic black children at 28.6%.

There were significant ethnic differences in the likelihood of overweight and obesity among our 5- to 8-year-old children. Most children (*i.e.*, Samoan, Native Hawaiian, Filipino, Hawaiian-Asian mixed, other mixed, and other children) were more likely to be overweight and obese in comparison with white children, except Asians. Samoan risk was notably higher (OR = 9.4) for overweight and obesity as compared with risk among whites. Another study by Stark et al.[28] examined 554 randomly selected 2- to 10-year-old children who received well-child care at KPH in 2003. The prevalence of overweight was 13% and of obesity was 19%, for a combined prevalence of 32%, close to that of the current study. They found more boys to be overweight when compared to girls; and more Pacific Islanders were overweight compared to other ethnic groups, followed by Native Hawaiians (including mixed Hawaiian). Place of residence was also related to risk of overweight and obesity.

In a Hawaii preschool-age WIC sample from a slightly earlier time period (1997–1998), risk for obesity was also significantly elevated for Samoan children compared to whites (OR = 3.9).[18] However, in that study, Native Hawaiian ethnicity was not associated with increased risk, and Asian ethnicity was protective (OR = 0.42), whereas in our study Native Hawaiian children also had increased risk, but Asians were similar to whites in risk. Possibly, these disparities in risk have increased with age, as children moved from preschool to early elementary school, and also over time.

Samoans, Native Hawaiians, Hawaiian-Asians, mixed, Filipinos, and other ethnic groups also had a higher risk of overweight and obesity compared to whites and Asians. Samoans and Filipinos are newly acculturated to Hawaii, which may increase risk. The environment and lifestyle in Hawaii continues to westernize from traditional native practices, which also may increase risk. We accounted for mixed ethnicity, prevalent especially among Native Hawaiians, which may account for differences in findings as compared to other studies; nonetheless, both mixed and Native Hawaiian–only reported ancestry had an increased risk of obesity compared to whites in this older sample of children.

Appropriate reference data and cutoff points to determine overweight and obesity are debated. We used the CDC cutoff points for overweight and obesity. It has been suggested that ethnic-specific cutoff points would be more appropriate. Other BMI cutoff points for overweight and obesity could be compared to these CDC cutoff points in further study. Although lower cutoff points for overweight and obesity have been proposed for Asian adults and higher ones for Pacific Islander adults, mixed Asian and Pacific Islander ethnicity in Hawaii complicates choice of cutoff points.[29] Selecting appropriate cutoff points for children also requires further study, such as by relating values to health conditions.

Mean BMI-for-age and sex percentiles for Hawaiian-Asian mixed children were more similar to Native Hawaiian than to Asian percentiles. This may reflect a tendency to adopt the host (Native Hawaiian) culture, or may reflect bicultural adaptation to ethnic mixing, which is prevalent in Hawaii. Ethnic mixing would be expected to favor retention of favored cultural attributes, such as ceremonial foods that are likely more energy dense[30] and could explain higher BMI percentiles. Actual proportion of ethnic group for children with mixed ethnicity would require information on parental ethnicity, which is currently unavailable. There could be important body composition differences between children of different ethnic groups which might partially explain BMI differences and be associated with different health risks,[30–32] but this is outside the scope of this study.

There was a monotonic relationship between neighborhood education level and risk of overweight/obesity for two ethnic groups with a lower level of neighborhood education level (Samoans and other ethnic group); for other ethnic groups, an elevated risk was only observed for the second lowest neighborhood education level. This may be due to a livelihood and lifestyle based on more physical activity among those with a lower neighborhood education level among ethnic groups other than Samoans and others. Lower SES and education have been found to be associated with greater obesity in other studies, and such obesity is expected to be due to poor-quality, energy-dense diets among lower-income children.[33]

Neighborhood educational level was used because we did not have individual data on parent's education on all children, which could be a limitation of the study. However, our findings were similar whether using neighborhood education level or maternal education level when available; indeed, both variables contributed to models, suggesting importance of both neighborhood and family SES. Ideally the 2010 American Community Survey zip code data would be used in the analysis; however, zip code–level information for 2010 was not available at the time of the data extraction. Nonetheless, we found that the association between neighborhood education level from census 2000 zip code data and child overweight/obesity differed by ethnic group. Our power was adequate despite the misclassification, because we found that the associations for neighborhood education level explain the findings. Our study is based on a sample of insured children in Hawaii. Although the ethnic distribution is similar to the state average, the sample of insured children may not represent the most underserved children in the state.

In the subsample analysis, we found that younger maternal age was associated with higher child overweight and obesity. Mothers who are young may still be going to school, which may result in a lifestyle for children that is more sedentary and includes more fast food. Unfortunately, we do not have data on maternal occupation. Household income level might also be expected to explain findings, but was not available for our analysis.

## Conclusion

This study provides new information on little-documented ethnic disparity in child overweight and obesity, and on mixed ethnicity, which has behavioral, clinical, and public health implications. Samoan, Native Hawaiian, Hawaiian-Asian, mixed, Filipino and children of other ethnicity were more overweight and obese than white or Asian children in Hawaii. We found that higher neighborhood education level was associated with lower BMI levels and interacted with ethnic group, and that younger maternal age and lower maternal education were associated with child overweight and obesity. Populations of mixed Pacific ethnic groups deserve further study related to acculturation to environment and lifestyle and determination of healthy body size.

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### Author Disclosure Statement

No competing financial interests exist.

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