DIETARY “ADDED SUGAR” and OVERWEIGHT AND OBESITY AMONG MULTIETHNIC CHILDREN IN HAWAIʻI

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ABSTRACT

The high prevalence of overweight and obesity in children is a public health concern. A single component of total dietary intake, such as added sugar, has been questioned as a primary factor in risk of obesity. This study aimed to examine dietary added sugar intake in Hawaii and its association with the prevalence of overweight and obesity among multiethnic children accounting for demographic and behavioral factors. Weighted two-day food records were obtained from 85, 5- to 8- year-old children, and were completed with the assistance of parents, at the baseline measure of the Pacific Kids DASH for Health (PacDASH) study. This study found that added sugar intake expressed in percentage was inversely associated with age and body mass index (BMI) status in children after accounting for sex, ethnicity, education, income, and age (for BMI). The younger age group was particularly vulnerable to diets with high added sugar intake.

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LIST OF ABBREVIATIONS AND SYMBOLS

PacDASH – Pacific Kids DASH for health
BMI – Body Mass Index
USDA – United States Department of Agriculture
SES – Socioeconomic status
SSB(s) – Sugar-sweetened beverages
HHS – Health and Human Services
FDA – Food and Drug Administration
ERS –Economic Research Service, US Department of Agriculture
FNB – Food and Nutrition Board
IOM – Institute of Medicine
DRIs – Dietary Reference Intakes
UL –Upper Limit
NNS – Nonnutritive Sweeteners
Kcal – kilocalories
Tsp – teaspoon
NHANES – National Health and Nutrition Examination Survey
FAM – Female Adolescent Maturation Study
NIFA – National Institute for Food and Agriculture
CSREES – Cooperative State Research, Education, and Extension Service
NRI – National Research Initiative
UH-CC – University of Hawaii Cancer Center
UH-CRC – University of Hawaii-Clinical Research Center
UH-JABSOM – University of Hawaii-John A. Burns School of Medicine
KP-CHRH – Kaiser Permanente Center for Health Research Hawaii
KPH – Kaiser Permanente Hawaii
EMR – Electronic Medical Record
RAS – Research Assistants
RD – Registered Dietitian
PA – Physical Activity
PacTrac2 – Pacific Tracker version 2.0
MPED – MyPyramid Equivalents Database
NAP – Nutritional Assessment of Populations Program
HNFAS – Human Nutrition, Food, and Animal Sciences Department

CHAPTER 1. CHILDHOOD OBESITY

Childhood obesity (measured as body mass index [BMI] of $\geq 95^{th}$ percentile) (Kuczmarski et al., 2000) has become a public health concern and epidemiologic studies have shown that children who are obese are more likely to be obese as adults (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997), regardless of whether the parents are obese. In the 48 contiguous United States, which excludes Hawaii, 16.9% of children and adolescents from 2 through 19 years of age were obese in the cross sectional analyses of National Health and Nutrition Examination Survey 2009 – 2010 (Ogden, Carroll, Kit, & Flegal, 2012).

1. 1 ASSOCIATED MORBIDITY

The increasing prevalence of childhood obesity has resulted in a higher prevalence of co-morbid conditions. Immediate health risks associated with childhood obesity including cardiovascular disease (CVD) (Freedman, Mei, Srinivasan, Berenson, & Dietz, 2007), pre-diabetes (Whitlock, Williams, Gold, Smith, & Shipman, 2005), metabolic syndrome, non-alcoholic fatty liver disease (NAFLD), and chronic inflammation (Han, Lawlor, & Kimm, 2010). Obese children have a greater risk of social and psychological problems (Schwartz & Puhl, 2003). Long-term health risks of childhood obesity including adult obesity (Biro & Wien, 2010), and serious health problems associated with adult obesity including heart disease, diabetes, and several types of cancers (breast, colon, endometrium, esophagus) (Harvey, Lashinger, & Hursting, 2011).

1.2 PROBLEM STATEMENT

The fundamental cause of childhood obesity is the imbalance between energy intake and energy expenditure. Consumption of energy, regardless of source, is necessary for normal growth and development. Obesity is developed over a period of time and is influenced by many factors including diet, sedentary lifestyle, genetic variation, and other environmental factors. Childhood is a stage of life that can influence the child's weight-related behaviors in adulthood, and is a predictor of long-term health and well-being (Han, et al., 2010).

Dietary patterns and physical inactivity are the leading factors that explain why children are heavier today than they were 30 or so years ago. Current children's diets, although generally varied, typically consist of energy-dense foods, often low in nutrients. Sugar-sweetened beverages (SSBs), which are low in essential nutrients, are the leading contributor of empty calories in many children's diet (Reedy & Krebs-Smith, 2010). Children's lack of physical activity also contributes to the prevalence of childhood obesity. Television watching, playing inactive video games, and other popular children's gadgets perpetuate physical inactivity, which contributes to the problem (Prentice-Dunn & Prentice-Dunn, 2012).

Early exposure to over consuming of added sugar, defined as sugars that are eaten separately or used as ingredients in processed or prepared foods by the US Department of Agriculture (USDA) and Health and Human Services Food Guide Pyramid, such as high-fructose corn syrup, corn syrup, fruit juice concentrate, and caloric sweeteners, may predisposed the diet of children in later adult life (Liem & Mennella, 2002). Many foods found in the market today consist of added sugar, and are generally high in calories, and

provide little to no essential nutrients in children's diets. The Institute of Medicine reported that people whose diets are in high added sugars have lower intakes of essential nutrients, such as calcium, magnesium, iron, zinc, vitamin A and E (Trumbo et al., 2002). "Added sugar" is a variable that is available from computerized dietary analyses and is one way to measure sugar intake.

PURPOSE

The purpose of this study is to examine the intake of "added sugar" in young multiethnic children and its relationship to overweight and obesity in these children while accounting for demographic factors such as age, sex, ethnicity, socioeconomic status (SES), and the key behavioral factors of physical activity and food energy.

1.3 LITERATURE REVIEW

The literature review highlights what has been published in the past 10 years, concerning the relationship of added sugar, diet quality and overall health or obesity in either children, adolescents or the adult population. In addition, recommendations for added sugar intake, and the utilization of sugars in the human body are also considered in this review.

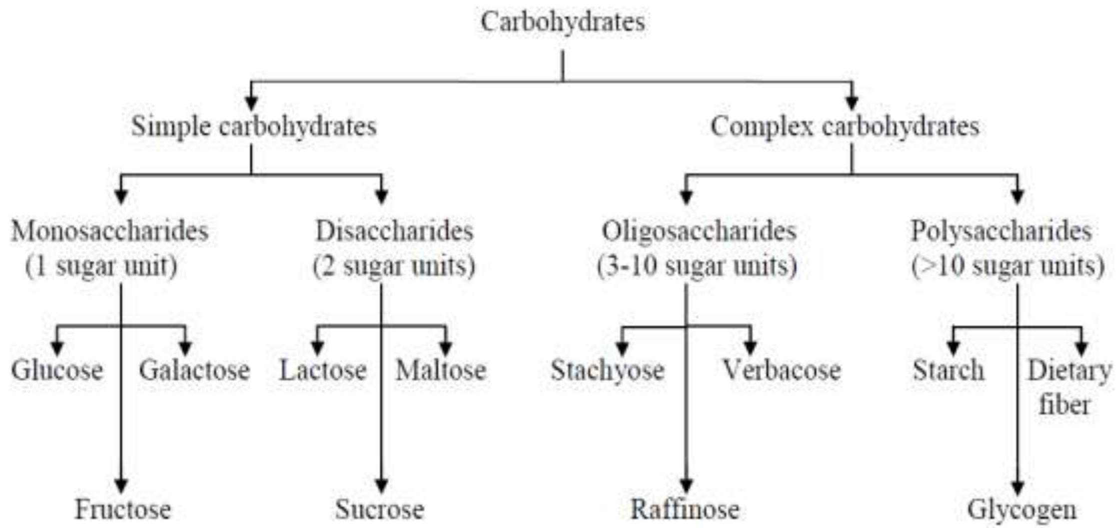
1.3.1 Carbohydrates

Dietary energy is obtained mainly from carbohydrates. Carbohydrate energy is provided by simple carbohydrates (simple sugars) and complex carbohydrates (starches and fibers) (Figure 1). Chemically, the term "sugars" refer to a group of compounds comprising carbon, hydrogen, and oxygen atoms. Sugars are the simplest types of carbohydrates and, structurally, can be one of two types:

- Monosaccharides (simple sugars)—such as glucose, galactose and fructose, or
- Disaccharides—such as lactose (glucose and galactose) and sucrose (glucose and fructose), and maltose (2 molecules of glucose)

Sugars are the primary monosaccharides and disaccharides in the human diet. Syrups contain a third group, the oligosaccharides (composed of sugar molecules containing 3-9 monomers). Sugars occur naturally (intrinsic) in some unprocessed foods that are staples of a healthy diet – fruits, vegetables, milk and some grains. Sugar in various forms that is added to foods and beverages is known as *added sugars*. All sugars, whether natural (intrinsic) or added (extrinsic), are a type of simple carbohydrates that our body uses for energy. (Gray, 2003)

Figure 1.3.1.1. Major Dietary Carbohydrates[a]



[a] (Gropper, Smith, & Groff, 2009)

1.3.2 Sugar Digestion

Carbohydrates are the largest energy source in an individual's diet. Carbohydrates contribute to the improvement of the nutritional status, depending on the type and amount of carbohydrates eaten, and to the maintenance of metabolic homeostasis associated with energy balance. Of the major classifications of carbohydrates, from Figure 1, nutritionally, most are dietary sugars consumed as polysaccharides (>10 sugar units) and disaccharides (2 sugar units). Polysaccharides and disaccharides are hydrolyzed in the gastrointestinal tract into their monosaccharide units—simple sugars (Gropper, Smith, & Groff, 2009).

The human body makes no physiological distinction between added and naturally occurring sugars (Palou, Bonet, & Pico, 2009). All carbohydrates, whether consumed as "natural" or "added", are hydrolyzed to single sugar units—glucose, fructose, and

galactose. Glucose is the preferred fuel of the brain. A difference is observed in the absorption, transportation, distribution, and metabolism of these single-sugar units in the body. Glucose and fructose are transported by carriers to different tissues for metabolism. Glucose is distributed, metabolized, and utilized in different tissues, but fructose is only metabolized in the liver. The reason for this is that fructose has a specific carrier protein for metabolism that is only found in the liver.

Fructose has been implicated in the relationship between the high consumption of sugar-sweetened beverages (SSBs) and obesity and its co-morbidities (Lustig, 2010). Sugar-sweetened beverages contain a high level of high-fructose corn syrup, which is produced from corn syrup and is composed of 55% fructose and 45% glucose. A review by Lustig (2010) described fructose metabolism as similar to ethanol metabolism in the liver. Overconsumption of high-fructose corn syrup from sugar-sweetened beverages is hypothesized to be toxic—putting pressure on the liver for metabolism of fructose because it's only metabolized there. However, several meta-analyses summarizing studies of fructose concluded that the fructose is not harmful, unless it provides excess energy (Sievenpiper et al., 2012). Thus, the harm is likely excess energy rather than any metabolic trait of fructose. Further, glucose and galactose are absorbed into the same mucosal cells, and the absorption capacity of the human intestine has been estimated to amount to about 5,400 g/day for glucose and 4,800 g/day for fructose, and this volume could not possibly be reached in a normal diet (Gropper, et al., 2009).

1.3.3 Added Sugar

There is no universally accepted definition of the phrase "added sugar". However, the definition from MyPyramid Equivalents Database, 2.0 for the US

Department of Agriculture (USDA) Survey Foods, 2003-2004 is an appropriate reference, where "Added sugar" is defined as sugars that are eaten separately or used as ingredients in processed or prepared foods (Bowman, Friday, & Moshfegh, 2008). There are other terms for sugar used by different government agencies (Table 1.3.1). This thesis will interchangeably use the terms "added sugar" and "sugars". The USDA has provided the amount of added sugar in each food item in its two food composition databases; this variable omits naturally occurring sugars, such as those in fruits and dairy products. Since there is no analytical method for distinguishing between added sugar and naturally occurring sugars, the "added sugar" values were calculated from sugars listed as label ingredients and nutrient values for total sugars and total carbohydrates for processed foods.

Table 1.3.3.1. Summary of sugars and their definitions[a]

Term	Source	Definition	Measurement
Added sugar	MyPyramid (USDA[b])	Eaten separately or used as ingredients in processed or prepared foods.	Teaspoon
Sugars	Food Label—Nutrition Facts Panel (FDA[c])	All monosaccharides and disaccharides (includes natural occurring sugars and added sugars)	Grams
Sugar	Food Label—Ingredients Statement (FDA)	Sucrose	None
Caloric Sweetener	Food Disappearance Data (ERS[d])	Sweeteners consumed directly and as food ingredients	Grams/Teaspoons

[a](Sigman-Grant & Morita, 2003)
[b]US Department of Agriculture and Health and Human Services
[c]Food and Drug Administration
[d]Economic Research Service, US Department of Agriculture

1.3.3.1 Food Ingredients

Sugars, in various forms, provide a wide variety of favorable qualities to foods. Specific to baked goods and other processed foods, sugars provide several properties essential to product quality and safety, which are characterized as biological [substrate for the fermentation required for baking (leavening and texture) or antimicrobial preservation through the selective binding of water used in food recipes], sensory (taste, aroma, texture, appearance, and sweetness), physical [viscosity, ability to retain water, osmotic pressure, crumb tenderness, grain size, distribution (for texture control), consistency, and dryness], chemical caramelization, Maillard browning, and product anti-oxidation. Sugars are added to processed foods because of their role in preservation; high concentrations of sugars inhibit the growth of food spoilage bacteria.

Sugars in various forms are added to foods and beverages because they boost flavors; help preserve foods such as jams and jellies; fuel fermentation, which enables bread to rise; serve as a bulking agent in baked goods and ice cream; balance the acidity of foods containing vinegar and tomatoes; and are involved in many other food manufacturing methods (Gurr, 1995).

Table 1.3.3.1.1 provides a list of added sugars that commonly appear on the ingredient list of a food label. Nutrition facts labels only provide total carbohydrates (sugars or alcohol sugars) and do not provide information about whether the sugars are naturally occurring (intrinsic) or are added to the prepared or processed foods consumed by individuals (Figure 1.3.3.1.1).

Table 1.3.3.1.1. Names for added sugar that appear in the ingredient list on food labels

White sugar	Brown sugar
Corn sweetener	Malt syrup
High-fructose corn syrup	Molasses
Corn syrup	Raw sugar
Corn syrup solids	Sucrose
Glucose	Lactose
Dextrose	Syrup
Fructose	Sugar
Honey	Invert sugar
Fruit juice concentrates	

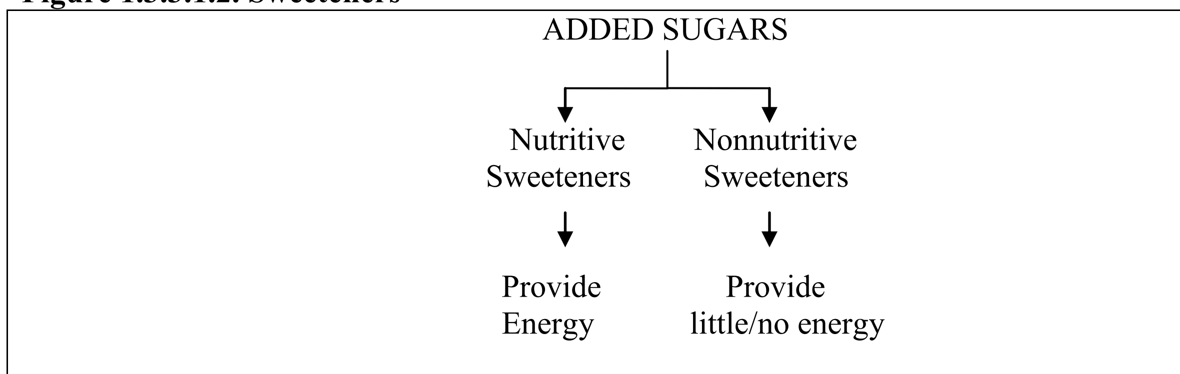
Figure 1.3.3.1.1. Nutrition Facts Label[a]

[a]Food and Drug Administration

Added sugar commonly found in food ingredients can be grouped in terms of providing energy or not: Nutritive and Non-nutritive sweeteners (Figure 1.3.3.1.2) (Fitch

& Keim, 2012). Added sugar and polyols (sugar alcohols) are nutritive sweeteners. They provide energy, an average of 4 kcal/gram and 2 kcal/gram, respectively, when they are ingested. Non-nutritive sweeteners (NNS) provide little to no energy when ingested. Commonly used NNS that are approved in the United States by the Food and Drug Administration include Acesulfame K, Aspartame, Neotame, Saccharin and Stevia (Gardner et al., 2012).

Figure 1.3.3.1.2. Sweeteners[a]



[a]Fitch & Keim, 2012

1.3.3.2 Recommendations for Added Sugar Intake

The Dietary Reference Intakes (DRIs) recommend no more than 25 percent of energy should be consumed from added sugar. For a 2000-kcal diet, <500 kcal should be from added sugar, which is about ¼ of total daily energy intake. This recommendation is based on ensuring sufficient intakes of certain essential micronutrients. There is still insufficient evidence to set an upper limit (UL) for total added sugar intake (Trumbo, et al., 2002). For a child, the recommended kcal intake is normally lower, so the recommended level of added sugar intake would also be lower.

A report from the American Heart Association Nutrition Committee released in August 2009 recommended reductions in added sugar with an upper limit of half of the

discretionary calorie allowance. The recommendation for most American women is no more than 100 kcal per day and for most American men is no more than 150 kcal per day, or about 6 teaspoons of added sugar a day for women and 9 teaspoons a day for men (Van Horn, Johnson, Flickinger, Vafiadis, & Yin-Piazza, 2010).

The 2010 Dietary Guidelines dropped the concept of discretionary calories (the amount of extra calories an individual is allowed to consume after meeting all essential nutrients from foods, or total estimated daily energy requirement [kcal] minus essential kcal) (Nicklas, Weaver, Britten, & Stitzel, 2005). The recommended 5 to 15 percent of total energy from discretionary calories was intended to reduce intake of foods containing added sugar and solid fats, because foods high in added sugar normally contribute excess calories and few, if any, nutrients. For a 2000-kcal diet, a recommended 100 to 300 kcal would be from added sugar, or about 6-19 teaspoons of added sugar a day (McGuire, 2011).

There is no universally accepted recommendation for added sugar intake. To date there is no recommended intake of added sugar for children and/or adolescents. Since children are less likely than adults to read and understand nutrition labels, they are predisposed to over consuming unnecessary added sugar and extra energy.

Table 1.3.3.2.1. Recommendations for added sugar intake

Source	**Recommendation**
DRIs[a]	<25% of total energy
American Heart Association	100 kcal for women, 150 kcal for men
2010 Dietary Guidelines	5 – 15% of total energy

[a]Dietary Reference Intakes, Food and Nutrition Board (FNB), Institute of Medicine (IOM) (Trumbo, et al., 2002)

1.3.3.3 Nonnutritive Sweeteners and Energy Intake Compensation

The popularity of NNS has contributed to the proportionate reduction in energy from added sugar or other sources, and the benefit of facilitating reductions in both energy and carbohydrate intakes. NNS-sweetened foods and drinks are consumed as a strategy for most individuals to reduce energy intake, replace energy-yielding added sugar, and as an artificial sugar substitute to facilitate weight-loss. NNS-sweetened foods and beverages have been recommended, especially for diabetic patients, as a healthier alternative in comparison to energy-dense, nutrient-poor foods and beverages containing high energy from added sugar.

However, what appears to be an immediate benefit of NNS-sweetened foods and beverages in substitution for energy might not be the case over the long term. A body of experimental trials in rats and epidemiological studies has shown that the consumption of NNS-sweetened foods and beverages, mainly in diet beverages, are not necessarily linked to better energy compensation and/or better health outcomes, and may alter or disrupt the normal physiological response to sweet taste (Pepino & Bourne, 2011). The first hypothesis is that the immediate reduction in energy, when added sugar-sweetened foods and beverages are substituted by NNS-sweetened foods or beverages, may potentially be followed by a subsequent increase in consumption of energy and carbohydrate following the ingestion of NNS-sweetened foods and beverages (Pepino & Bourne, 2011)—in other words, the energy compensation is disrupted by NNS.

The second hypothesis is that the human gastrointestinal tract has an automatic physiological response (cephalic response) to calorie-sweetened foods and beverages when ingested, but the NNS disrupt and/or degrade that response (Swithers, Martin, &

Davidson, 2010). At this time, this hypothesis is only supported by studies using rat models. Another hypothesis is that NNS alters gut microbiota—changes the normal make-up of the intestinal bacteria, and may trigger the inflammatory process that promotes insulin resistance, fat storage and weight gain in the host (Vijay-Kumar et al., 2010).

What is the benefit of drinking a diet soda rather than a regular soda if energy balance is even more complicated by a compensatory increase in energy from other sources? In another sense, what is the cost of saving a few calories from drinking an NNS-Sweetened diet drink of your choice when in return it causes one to crave for a more energy-dense double-chocolate mousse cake?

The notion that NNS displaces caloric sweeteners, in regards to carbohydrate intake, which may benefits appetite, energy balance, and body weight may not hold true (Gardner, et al., 2012). However, this issue is difficult to study as current food composition databases do not accurately and sufficiently calculate NNS and many of the results supporting these assumptions are still limited to animal models.

ARTICLE SOURCES AND SELECTION CRITERIA FOR LITERATURE REVIEW

The review of literature started with consumption of sugar-sweetened beverages among children and adolescents, fall 2010. The search terms used were “soda”, “obesity”, “children & adolescent obesity”, and “Dietary Patterns”. The search terms were further refined to “added sugar”, and “sources” to determine the leading food sources of added sugar; “added sugar” and “health” or “diet quality” to determine the effects of dietary added sugar intake to overall health; “added sugar” and “body weight” to determine the relationship between added sugar intake and obesity measures or body weight measures.

The PubMed database was thoroughly searched for relevant articles using the search terms outlined above. Using the terms “added sugar” and “sources,” 251 articles were retrieved. Only four articles were selected that represented recent national data and samples from multiethnic groups of the population, similar to the one under study. For the terms “added sugar” and “diet quality,” 103 articles were retrieved. Only four articles were selected for this review based on the most recent studies on added sugar intake and its association to nutrient adequacy. For the terms “added sugar” and “obesity” or “weight gain” or “BMI,” 303 articles were retrieved. The selection was based on the most recent studies on added sugar and its association with obesity measures.

1.3.4 Dietary Sources of Added Sugar

Added sugar provides favorable qualities to foods and beverages. The most frequently consumed source of added sugar in the U.S. diet is sugar-sweetened beverages (SSB). According to Chun et al. (2010), in an analysis of National Health and Nutrition Examination Survey (NHANES) I and III data on civilian, non-institutionalized population of the U.S. from 1971 to 1994, carbonated soft drinks were the most significant added sugar source during the past three decades for both 1-18 year-old and 19+ year age subgroups. “National” or “US representative” sample dietary data are derived from the 48 contiguous states. The following studies have looked at the leading sources of added sugar in the diets of children, adolescents, and adults.

Lee et al. (2007) looked at the dietary patterns of adolescent girls in the Female Adolescent Maturation Cohort Study in Hawaii, and determined that there was a significant increase in SSB in the female adolescent’s diet aged 9 to 14 years at exam 1 and aged 11 to 16 years at exam 2, from 13.0 to 18.4 grams per day from the of 2001 to 2003. At the time, The Dietary Guidelines for Americans, 2005 suggested that Americans should limit their added sugar intake to 5 teaspoons (tsp) per day for a 1,800 calorie diet total kcal. The adolescent girls consumed much higher levels of added sugar than this recommendation, at approximately13-18 teaspoons per day, or three times greater than the recommended intake.

A cross-sectional study using the National Health and Nutrition Examination Survey (NHANES) data was done by Reedy and Krebs-Smith (2010). Among 2- to 18-year-olds in 48 contiguous United States, they identified top dietary sources of energy, solid fats, and added sugar. The study similarly concluded that the average daily intake of

added sugar among the sample group was 91 grams (365 kcal or about 23 tsp of added sugars), and SSB was the number one source on the list.

Another cross-sectional study done by Welsh et al., (2011) using a U.S. representative sample from NHANES, 1999-2008 data, concluded that added sugar intake of ≥2 year-olds Americans decreased from 100g (400 kcal, 25 tsp of added sugar) in 1999-2000 to 77g (307 kcal, 19 tsp of added sugar) in 2007-2008. Added sugar intakes of children 6-11 year-olds Americans in 1999 and 2008 were 106g (424 kcal , about 27tsp of added sugar) and 84g (334 kcal, about 21 tsp from added sugar), respectively. Added sugar intakes of adolescent 12-17 year-old Americans in 1999 to 2008 were 124 g (496 kcal, 31 tsp of added sugar) and 90g (about 400 kcal, about 23 tsp of added sugar), respectively. Thus while still high, the added sugar intake level appears to have decreased. The Dietary Guidelines for Americans, 2010 suggests an added sugar intake of 5 to 15% of total energy. If children follow an 1800-calorie diet, it allows only 22.5g to 67.5g (90 to 270 kcal or 5.6 tsp to 16.9 tsp of added sugar), and if adolescents are following a 2200-calorie diet, only 110 to 330 kcal per day should come from added sugar. But children and adolescents in that study were still consuming much more than the recommended intake for added sugar, up to 424kcal per day and 496 kcal/day, respectively, in NHANES data during 1999-2008. The study also concluded that the decrease in added sugar intake across all ages was due to the decrease in SSB consumption in the same period. Table 1.3.4.1 provides a summary of the leading food sources of added sugar from various studies.

Table 1.3.4.1 Recent studies showing the leading food sources and kcal intake from added sugar

Reference	Study design & sample	Sugar intake kcal per day	Leading source(s)
(Chun, Chung, Wang, Padgitt, & Song, 2010)	Cross-sectional study of NHANES III data of >2 year-olds	386kcal per day	Soda Fluid milk Cakes Pastries Pies
(Lee, Novotny, Daida, Vijayadeva, & Gittelsohn, 2007)	Cohort study, with exams 2years apart of 9-14 year-old multiethnic girls in Hawaii	279-325 kcal per day*	Sweetened carbonated beverages Fruit drinks
(Reedy & Krebs-Smith, 2010)	Cross-sectional study of National data, 2003-2004 & 2005-2006, 2-18 year-old	365kcal per day	Soda Fruit drinks Dairy desserts Pizza Whole milk
(Welsh, Sharma, Grellinger, & Vos, 2011)	Cross-sectional study of NHANES data from 2007 to 2008 of >2 year-olds	307kcal per day	Soda Cakes Cookies Fruitades & sports drinks Sugar & syrups

* 279kcal in exam 1, and 325kcal in exam 2

1.3.5 Dietary Added Sugar and Diet Quality

Foods and beverages with high added sugar content contain little to no essential nutrients and they are “empty calories”. Added sugar contributed most of the empty calories to children’s and adolescents diets; the number one source of added sugar is sugar-sweetened beverages. Table 1.3.5.1 provides studies that have looked at the levels of added sugar intake across age groups and by diet quality. The studies have reviewed the association between levels of added sugar intake and/or SSBs and diet quality. They demonstrated that levels of added sugar intake and/or SSBs were inversely correlated with micronutrient consumption, such as the essential micronutrient, calcium. A high

level of added sugar intake and/or SSBs was also associated with a lower likelihood of meeting the DRIs for other essential micronutrients, such as folate, fiber, and iron.

Consumption of food and beverages high in added sugar (e.g., cakes, pies, and SSBs) is hypothesized to suppress satiety. A high level of circulating glucose in the blood is hypothesized to modulate neural stimulatory and inhibitory control of food intake (Page et al., 2011). The hypothesis suggests that individuals who consume high-calorie foods and beverages, mainly foods that are high in calories from added sugar and fat, do not feel full after ingestion, leading to overconsumption of these types of foods and beverages.

Table 1.3.5.1. Studies on added sugar intake and overall diet quality

Reference	**Study design & sample**	**Sugar intake**	**Diet quality measure**
(Gibson & Boyd, 2009)	Cross-sectional study of National Diet & Nutrition Survey data Sample: 4-18 years	Added sugar >23% of total energy	Most micronutrient intakes were 24% lower than the Dietary Reference Intake
(Frary, Johnson, & Wang, 2004)	Cross-sectional study of CSFII data, 94-96, Sample: 98 of 6-17 year olds	↑Added sugar intake and sugar-sweetened beverages	↓calcium intake
(Libuda et al., 2009)	Cross-sectional study of Dortmund Nutritional & Anthropometric Longitudinal (DONALD) Sample: 1069, 2-19 year olds	↑sugar-sweetened beverage intake	↓folate & calcium intake
(Marriott, Olsho, Hadden, & Connor, 2010)	Cross-sectional study of NHANES, 2003-2006 Sample: 4 years or older	Added sugar intake >25% of total energy	Below Dietary Reference Intakes (DRIs)—for vitamins E, A, C, and magnesium

1.3.6 Dietary Added Sugar and/or Food Sources of Added Sugar and Obesity Measures

A basis of obesity is an imbalance of energy intake and energy expenditure (Prentice-Dunn & Prentice-Dunn, 2012). The amount of excess energy from empty calories and lack of essential nutrients in the diets of most Americans, coupled with decreased energy expenditure from an increasingly sedentary lifestyle are hypothesized to be risk factors for the development of obesity (Brown & Summerbell, 2009). Table 1.3.6.1 presents selected studies that have examined dietary added sugar and/or food sources of added sugar and obesity measures.

Bermudez and Gao (2010) demonstrated, from a sample of 947 adult Americans, that a greater intake of added sugar was significantly associated with a higher risk of having total and abdominal obesity. Ten additional teaspoons of added sugar (40 g or 160 kcal) per day was associated with a 52% increased likelihood of obesity.

Malik, Schuulze and Hu (2006) did a systematic review of publications from 1966 through 2005 with the overall aim of examining the consumption of SSBs in relation to overweight and obesity. The systematic review consisted of 30 publications (15 cross-sectional, 10 prospective, and 5 experimental studies). Overall, the review supported a link between the consumption of SSB and the risk of overweight and obesity.

The baseline data of the longitudinal Female Adolescent Maturation (FAM) study done by Novotny, Daida, Acharya, Grove, and Vogt (2004) demonstrated that increased intake of soda of adolescents was positively associated with weight. A 1-g increase in soda consumption was associated with a 1.7-kg higher weight (or a 341.6 g/day can of soda with a 1.7-kg greater weight). Another cross-sectional study on children aged 1, 2,

and 7 years, based on a dietary and anthropometric longitudinal data, was done by Herbst, Diethelm, Cheng, Alexy, Icks and Buyken (2011). The study evaluated the associations between added sugar intake during early childhood and BMI and body fat at age 7 years. The study concluded that increase in added sugar intake during the ages of 1 and 2 years was positively associated with higher BMI SD score at ages 7 years.

Table 1.3.6.1. Studies on added sugar and obesity measures

Reference	Study design and sample	Sugar intake	Obesity measure
(Bermudez & Gao, 2010)	Cross-sectional study Sample: 947 adults, 20-39y	10 additional teaspoons (40g) of added sugar per day	↑ risk of total and abdominal obesity by 52% ($p<0.02$)
(Herbst et al., 2011)	Cross-section of Dortmund Nutritional and Anthropometric Longitudinal Designed (DONALD) study Sample: 216, aged 0.5 to y years	Higher added sugar intake	Positive association with higher BMI SD score from age 1y to age 7y (P = 0.04) (adjusted β±SE: 0.074±0.043 BMI-SDS, added sugars; P = 0.09).
(Malik, Schulze, & Hu, 2006)	Systematic review of 30 studies to examine evidence for an association between SSB intake and weight gain and obesity	↑ sugar-sweetened beverages	Significant positively associated with weight gain and obesity in both children and adolescents (6 studies found, individual statistics not shown)
(R. Novotny, Daida, Acharya, Grove, & Vogt, 2004)	Cross-sectional baseline analysis of Female Adolescent Maturation (FAM) study Sample: 323 aged 9 to 14 years	Soda, gram per day (β±SE: 0.0050±0.002 weight in kilogram, added sugar; P = 0.01)	Positively associated with weight (P = 0.01)

1.4. RESEARCH QUESTIONS

1. Are there differences in energy-yielding macronutrients by demographic factors such as age, sex, ethnicity, BMI status, and socioeconomic status?
2. Are there differences in added sugar intake by demographic factors such as age, sex, ethnicity, BMI status, and socioeconomic status?
3. Are obesity measures (BMI status and BMI z-scores) Hawaii associated with dietary added sugar intake when demographic factors such as age, sex, ethnicity, and socioeconomic status, and behavioral factors such as physical activity and food energy are accounted for?
4. What factors are associated with dietary added sugar intake?

CHAPTER 2. METHODOLOGY

2.1 STUDY DESIGN

This thesis presents a cross-sectional analysis of the baseline data of an intervention study, the Pacific Kids DASH for Health (PacDASH, Principal Investigator, Rachel Novotny). PacDASH was a 15-month randomized, controlled intervention study (9-month intervention phase, 6-month maintenance phase). The goal of the PacDASH intervention study was to encourage healthy behaviors in overweight/obese children, helping children to “grow into their weight”. The PacDASH intervention study was funded by the United States Department of Agriculture (USDA), National Institute for Food and Agriculture (NIFA), Agriculture and Food Research Initiative, formerly known as Cooperative State Research, Education, and Extension Services (CSREES), National Research Initiative (NRI) Competitive Grants Program Award. Other collaborating organizations include: University of Hawaii Cancer Center (UH-CC), Kaiser Permanente Center for Health Research (KP-CHRH), the University of Hawaii-John A. Burns School of Medicine (UH-JABSOM), and the University of Hawaii-Clinical Research Center (UH-CRC).

2.2 PARTICIPANTS

Electronic medical record (EMR) data at KP-CHRH were used to identify eligible participants who had their primary care physician at one of four Kaiser Permanente (KP) clinics (Honolulu, Mapunapuna, Waipio and Koolau). The study research assistants (RAS) and registered dietitians (RD) were responsible for the recruitment process including preparing and sending out recruitment mailers, answering initial study related questions on the study phone line from potential participants, and contacting those who

had not responded to the mailer. Those who responded that they would like to participate were then called and asked a series of screening questions to confirm eligibility. Eligibility criteria were selected for the purpose of an obesity prevention and management intervention trial.

Eligibility criteria were:

1. Ages: 5-8 year old
2. $\geq 50^{th}$ to $\leq 99^{th}$ BMI-for-age percentile based on NHANES 2000 data
3. Children with a primary care provider at one of 4 Kaiser Permanente clinics
4. Current residence of the city or county of Honolulu

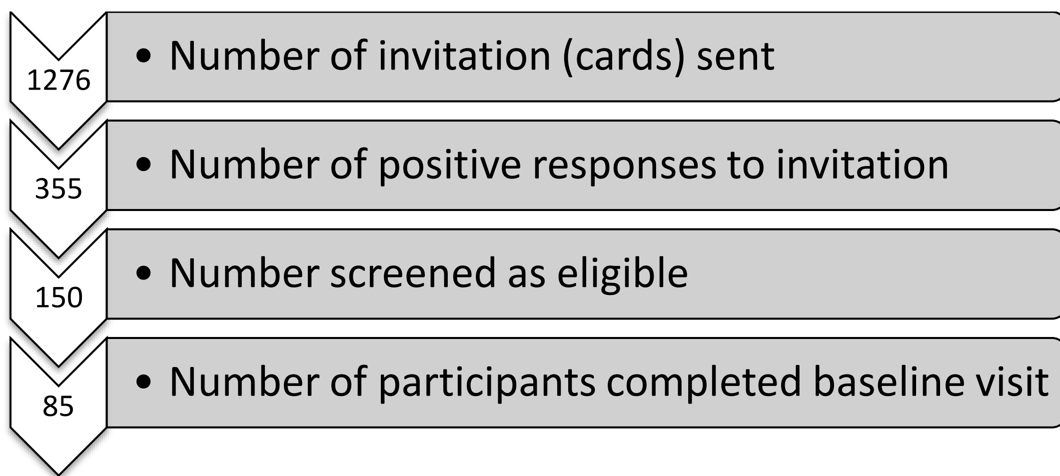
Exclusion criteria were:

1. Diabetes mellitus
2. Polycystic ovarian syndrome
3. Gastroesophageal reflux
4. Gallbladder disease
5. Non alcoholic fatty liver disease
6. Pseudo tumor cerebri
7. Slipped capital femoral epiphysis
8. Blount's disease
9. Obstructive sleep apnea/Sleep disturbance

Invitation cards (Appendix A) with tear-off reply were sent to parents of children that met the eligibility criteria based on electronic medical record (EMR) data. A study staff member at UH-CRC conducted the recruitment calls to interested participants (those that so indicated in reply to invitation), screened for eligibility, and assisted in scheduling the

child (and his/her parent) for the baseline visit at the UH-CRC. Figure 2.2.1 provides the PacDASH recruitment summary. For the first recruitment wave, 1,276 invitation cards were sent and 110 recipients replied. Of these, 76 were interested and scheduled for a visit at the UH-CRC for further screening. In the second recruitment wave, 1,078 of the original non-respondents were contacted by the KPH research assistants. From those contacts, information to contact an additional 279 respondents was sent to UH-CRC for screening. There were total of 355 respondents that were screened for eligibility at UH-CRC. A total of 150 were found eligible and were scheduled for baseline visit at UH-CRC. A total of 85 participants completed the baseline visit.

Figure 2.2.1. PacDASH Participants at Baseline



2.3 MEASURES

2.3.1 Instructions Provided Prior to the Baseline Visit

Parents of participating children were informed that the baseline visit would take approximately 2 ½ hours at UH-CRC. They were requested to not plan anything immediately after the initial visit just in case the visit took longer than anticipated.

The parent/legal guardian was asked to complete/fill out all of the forms included in the "Starter Kit" that was mailed prior to the scheduled visit at UH-CRC.

The mailed "Starter Kit" contained the following materials:

1. Preparing for the visit guideline (Appendix B)
2. Study map and directions (Appendix B)
3. Informed consent and assent forms (Appendix C)
4. Measuring cups & spoons (Appendix D)
5. Physical activity intensity legend (Appendix E)
6. Two-day diet and physical activity records and instructions (Appendix F)
7. UH-CRC reminder card (Appendix B)

They were also informed that the more complete the diet and activity records were prior to arriving at the visit, the faster the visit could be completed. Further, they were asked to bring everything with them to the visit.

Instructions for diet and physical activity record

Measuring tools were provided to serve as reference sizes to aid in the recording of the estimated portions of consumed foods. A phone call was made by the RAS/RD to the child's parent/legal guardian explaining how to complete the 2-day child diet and physical activity record for the appropriate days of the week in which the records were to be filled out. If the initial call was not answered, a voicemail message was left by the RAS/RD providing the instructions and the call back number for any questions. Staff explained the importance of the parent recording what was eaten and drunk on the assigned days, and how much physical activity was done, along with the intensity of the

activity. The parent was instructed to record everything his/her child ate and drank on the assigned Friday and Saturday (exact dates were provided), one week prior the UH-CRC scheduled visit date.

Instructions to complete the 2-day diet/PA records were "Start with recording the time of the day in which a food or beverages was consumed, including water. Have the diet record form in a conspicuous place, near where the child usually eats, as a cue to start recording…and provide the time and place where the food and beverages were consumed". Instructions to complete the 2-day physical activity were "Start with recording the time of day in which the child wakes up." Also, included were instructions for recording the type of the child's activity (e.g., walking, playing video games) and the intensity (light to vigorous). The instructions noted to use the intensity legend provided in the starter kit as a guide for recording the intensity next to the activity, as well as for recording the length in time the child was engaged in the activity.

2.3.2 Baseline PacDASH Assessment

The child participant (in the company of parents/legal guardians) went through the baseline study assessment visit at the UH-CRC, located in the Bingham Building at the Kapi' olani Medical Center for Women and Children. The initial study assessment took about 2 ½ hours per child. At baseline assessment visit, participants received:

1. Welcome letter with study overview and contact information
2. My visit to the Clinical Research Center
3. "A study specific book, "The DASH of Aloha Healthy Cuisine and Lifestyle"
4. A $30 Wal-Mart gift card.

5. PacDASH grocery bag

UH-CRC staff prepared, the child participant study folder, which included patient information sheet with participants name, progress notes, participants checklist, gift card receipt with gift card number, and CRC study assessment form to keep track of the progress of each child participant during the baseline assessment. The prepared folder was stored in locked cabinets in a locked room.

The following study procedures were conducted during the baseline assessment:

Informed consent and assent

This study was approved by the Kaiser Permanente Institutional Review Board and the University of Hawaii Institutional Review Board. Parental or legal guardian consent was required for any child to participate. If the child was 7 or 8 years old, the UH-CRC staff working on the PacDASH study obtained child assent to participate in the study.

Questionnaires

Child socio-demographic questionnaire (answered by the parent) (Appendix G)

Demographic information was collected about the child. Also, the study staff asked about specific medications, supplement intake, and eating away from home.

Diet and physical activity (PA) record assessment

The collected diet and PA records (with assigned Friday and Saturday date) were filled out by the parent/legal guardian of the child prior to the child visit at UH-CRC. An RAS/RD reviewed the diet and physical activity records as part of the UH-CRC. For this review, the RAS/RD used a modification of the probes and passes from the multiple-pass approach used as part of the Automated Multiple Pass Method of the USDA in the What

We Eat in America, the dietary interview component of the National Health and Nutrition Examination Survey, and other research studies (Conway, Ingwersen, Vinyard, & Moshfegh, 2003).This helped to gather detailed information about foods and beverages consumed and to ensure what was written matched what was actually consumed. . For reviewing the physical activity, the RAS/RD used a similar, systematic process, confirming and entering the type, duration and intensity of each activity. The diet and physical activity record was entered into the PacTrac2 database (described below).

A password-protected computerized system was used to enter the diet and physical activity records. The Pacific Tracker 2.0 (PacTrac2) (R. Novotny, Nigg, C., McGlone, K., Renda, G., Jung, N., Matsunaga, M., Karanja, N., 2012) was developed from the MyPyramid Tracker and was used to enter and analyze the 2-day diet/PA records from UH-CRC. PacTrac2 is an interactive, consumer-friendly, online dietary assessment tool. The tool was developed for use in the Pacific Region. PacTrac2 included the MyPyramid Equivalents Database 2.0 (MPED 2.0) (Bowman, Friday, & Moshfegh, 2008) developed by the US Department of Agriculture. PacTrac2 is a unique program, relative to the one found in the USDA website, in that the University of Hawaii Cancer Center incorporated the UH Cancer Center food composition table, which includes foods and recipes gathered from the Pacific Region (S. Murphy, Blitz, & Novotny, 2006). The MyPyramid physical activity analysis tool, which uses energy estimates from Compendium of Physical Activities (Ainsworth et al., 2000), was modified with additional physical activities for children from research studies. The reported food items that were not available in the MyPyramid database and food composition table were substituted with the closest food items found in the PacTrac2 database. For example,

when a child reported “Capri sun drink or 100% juice,” this beverage item is not found in the PacTrac2 database, therefore, RAS/RD would choose a closest beverage, “An apple drink or apple juice.” Appendix H provides the diet reference used by RAS/RD for food and beverage items substitution.

Diet record data was entered using PacTrac2 interactive assessment at UH-CRC as follows:

1. Registration and login
2. Personal information entry: age, sex, weight, and height
3. Food intake entry
    a. Type in, search and select foods from existing food database
    b. Select serving unit and input quantity of food item
4. Analyze food intake for day
5. Food intake assessment results include:
    i. Nutrient intake compared to U.S. Dietary Reference Intakes
    ii. Food intake compared to U.S. MyPyramid recommendations
        1. 5 major food groups: grain, vegetables, fruits, milk, meat & beans

Physical activity data was entered using PacTrac2 interactive assessment at UH-CRC as follows:

1. Physical activity entry:
    a. Type in and search from an existing physical activity database
    b. Select the physical activity and duration for each
2. Analyze physical activity status for the day

3. Physical Activity Assessment results include:
    a. Activity intensity and energy expenditure for each activity
    b. Sum of energy expenditure for all activities
    c. Overall physical activity status compared to U.S. recommendations

To expedite the visit time, only Fridays' records of food and physical activity were used to generate the behavioral material needed for the intervention instructions. Therefore, only the Friday record was entered while the child and parent were present and Saturdays' records were entered at a later time.

Anthropometry (see Appendix H)

Anthropometric measurements were taken during the visit at UH-CRC and included height, weight, and other measures for the intervention study. Participants were asked to wear/bring appropriate clothing for anthropometry measures. Weight in kilograms was measured using a digital scale (SECA Scale) and height in centimeters was measured using a stadiometer (Heightronic Stadiometer). Each measurement was taken at least three times; the average of the two closest values was used for each of the anthropometric measurement. Research study staff members at the UH-CRC were trained and standardized by Dr. Novotny for accuracy and reproducibility, to produce research quality results. Measures were taken following the Anthropometric Standardization Reference Manual (Lohman, Roche, & Martorell, 1988).These measures were recorded on the computerized child data sheet (Appendix H) .

2.3.3 Quality Control Check of the Diet and Physical Activity Record

PacTrac2 2nd data review

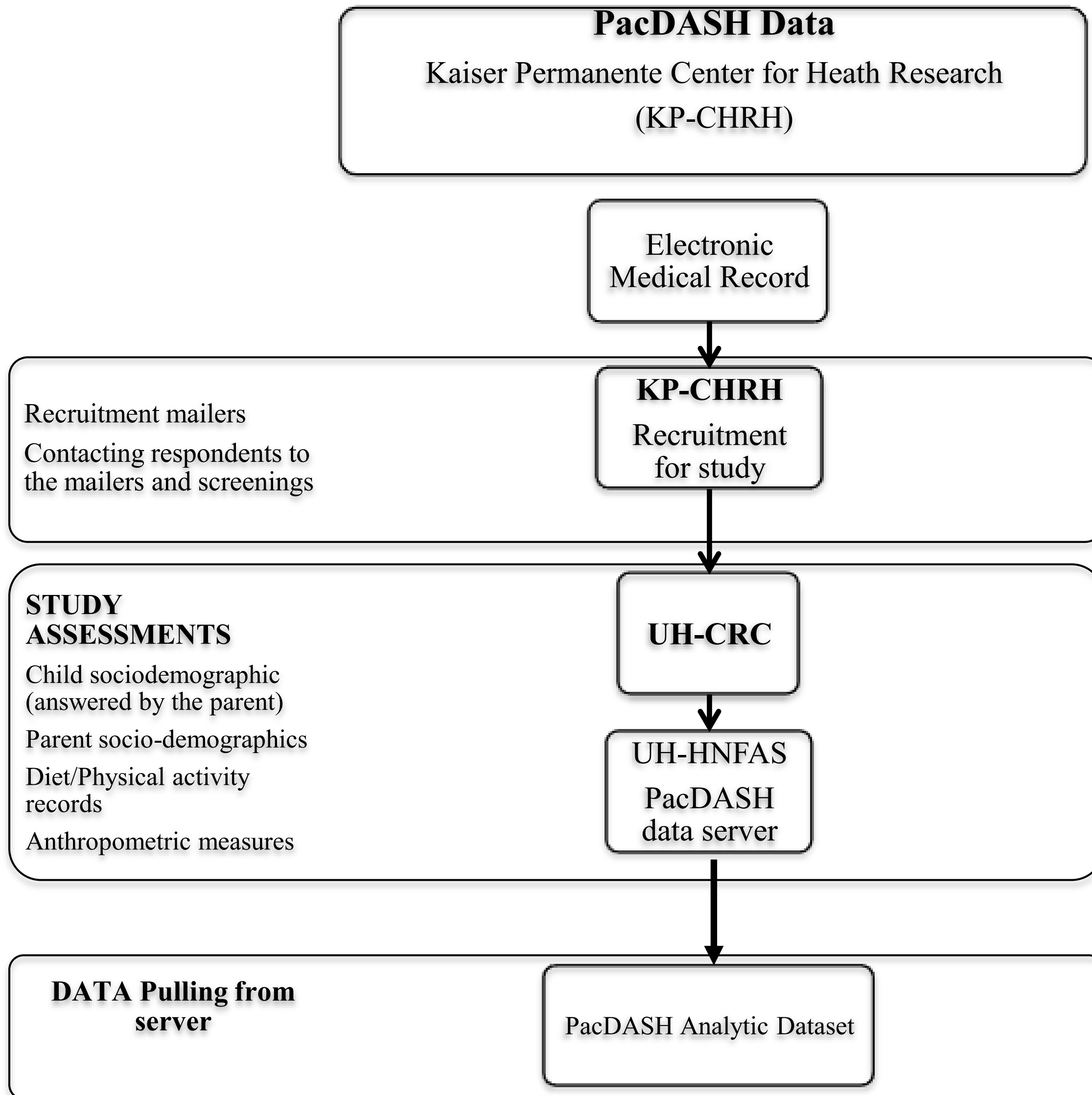
After the visit at UH-CRC, the RAS/RD printed out a hard copy of the Friday and Saturday diet and physical activity records entered into PacTrac2 database for a second data review. The second data review was done by a RAS/RD other than the one who originally entered and saved the diet/PA records. This second data review process involved checking each food and beverage and physical activity entered and saved into the PacTrac2 database. These were simultaneously compared with the lists of foods and beverages from the diet records and verified if there was anything that might have been forgotten and to assure that the entered foods and beverages in the PacTrac2 database matched what was listed on the diet records. Any corrections made by the RAS/RD were done on the hard copy with a designated color pen, not online.

A similar second data review process was done with the physical activity records. The RAS/RD went through the PA records and made sure that the entered type, duration and intensity of each activity matched what was written on the PA records. The RAS ensured that the total minutes for each day on the PA records equaled to 1440, and other calculations were accurately noted on the PacTrac2 database. The printed hard copy was securely delivered to University of Hawaii at Manoa, Department Human Nutrition, Food and Animal Sciences, Nutritional Assessment of Populations (UHM-HNFAS-NAP) (A research group led by Dr. Rachel Novotny) data manager to be filed.

PacTrac2 3rd data review

The purpose of the third data review was to assure study consistency across RAS/RDs and to make online corrections. All corrections made online were securely monitored and conducted by one RAS/RD to the online data system. Figure 2.3.3.1 provides a summary of how the baseline data were collected.

Figure 2.3.3.1. PacDASH Baseline Data Tracking Flow



Confidentiality

The medical contexts of the baseline study visit at UH-CRC required privacy, confidentiality, and sensitivity towards study procedures. To protect member privacy and confidentiality, all consents, assents, study forms/questionnaires were stored in individual participant folders that were filed in a locked cabinet within a locked room at UH. Data entry forms/database were saved securely in password protected computer files on the PacDASH data server, user password and firewall protected server, and transferred files were stored in locked cabinets in a locked room.

Health Insurance Portability & Accountability Act (HIPAA) trained PacDASH staff members include: UH-HNFAS, UH-Public Health, KP-CHRH, UH-CRC employed under Dr. Rachel Novotny on the PacDASH intervention project. The data were collected by UH-CRC and KP-CHRH study staff members using IRB approved study forms and computerized questionnaires on a password and firewall protected server, which was also housed the PacTrac2 program at Dr. Novotny's UH-HNFAS NAP program. The server was located at the Department of Human Nutrition, Food, and Animal Sciences (HNFAS), University of Hawaii and was accessed from the UH-CRC. Data was backed up daily on the server.

2.4 DATA CLEANING AND ANALYSIS

The data collected at UH-CRC were saved on the UH-HNFAS-NAP server. A NAP data manager (Dr. Vinutha Vijayadeva, Dr. Yuhua Su, and then Dr. Fenfang Li) was responsible for preliminary data cleaning and analysis for the PacDASH intervention study objectives. All data collected at UH-CRC was transferred to password-protected

spreadsheets and was securely entered and saved onto the NAP server at UH-HNFAS. Before analysis, the data were cleaned using SAS software (SAS 9.3, Cary, NC, USA).

2.5 STUDY CONCEPTUAL FRAMEWORK

The focus of this cross-sectional study was to examine the behaviors (diet and physical activity) that may influence the outcome (BMI status and BMI z-score) while accounting for demographic factors (age, sex, ethnicity, and socioeconomic status [SES]) in 5- to 8-year-old multiethnic children. Table 2.5.1 provides a summary of factors influencing childhood obesity.

Table 2.5.1. Study conceptual framework—factors influencing child obesity

Environmental Influences	Demographic Factors	Behaviors	Child Outcome	Immediate Health risks	Long-term Health risks
- Home - Child care - School - Community - Health system	**- Ethnicity** **- Age** **- Sex** **- SES*** **Education** **Income**	**-Diet** **Energy** **- Physical Activity**	**- BMI status** **- BMI z score**	- CVD** - Pre-diabetes - Social & psychological problems - Metabolic Syndrome - Non-alcoholic fatty liver disease	- Cancer - High cholesterol - High blood pressure - Type 2 diabetes

*SES—socio-economic status
**CVD—cardiovascular disease

2.6 STUDY ANALYTIC FRAMEWORK

The statistical analysis for this cross-sectional study aims to describe the characteristics of the participants, and to investigate the relationship between added sugar intake, demographic factors, behavioral factors and obesity measures in 5 to 8 year old multiethnic children using SPSS version 20 DESCRIPTIVES, presented in mean and

standard deviation; ANOVA models, presented in mean and standard deviation and p-values; LINEAR REGRESSION and MULTIPLE REGRESSION models, presented in covariate adjusted means by demographic factors and p-values; and POLYTOMOUS REGRESSION models, presented in odds ratio and p-values. Figure 6 presents the summary of this cross-sectional study analytic framework.

Table 2.6.1. Study analytical framework for the study research questions

Demographic Factors	**Behavior**			**Outcome**
Age (5 – 8 years) **Sex** (males, females) **Ethnicity** (NHOPI[a], Asian, White, Other) **Socioeconomic Status** (Education levels: Post-secondary, High school or lower; Income: Less than 35K, 35K to 60K, Greater or equal to 60K)	**Physical Activity** Minutes MET-minutes Energy expenditure (total MET-minutes)	**Total Energy** (kcal, log-transformed*)	**Added sugars** Gram kcal Percent of energy kcal (log-transformed*)	**BMI status** Healthy weight Overweight Obese **BMI z-scores**

[a]Native Hawaiian and other Pacific Islander
*Log transformed to meet the homoscedasticity or linearity assumptions of the models

2.7 STUDY VARIABLES

Added sugar

The dietary added sugar variable along with other nutrients and major food groups were calculated based on MyPyramid Equivalents Database 2.0 for USDA Survey Foods, 2003-2004. Added sugar was expressed in terms of teaspoon equivalents of table sugar

(i.e., granulated, white sugar, USDA food code 91101010). One teaspoon of table sugar weighs 4.2 grams and contains 4.2 grams of total sugars.

Number of teaspoon equivalents of added sugar in 100 grams of table sugar

=100/4.2 tsp equivalents

=23.8 tsp equivalents

As an outcome variable in regression, added sugar was log-transformed in order to meet the homoscedasticity assumption of the models.

Diet record analysis for original food sources of added sugar

To better understand added sugar intake in this population, ten 5- to 8-year-old multiethnic children who consumed the most added sugar, expressed in teaspoons, were identified. The two-day reported foods by these ten 5- to 8-year-olds were examined for added sugar food sources, which were sorted into 5 categories of the most commonly reported food items. The categories for specific foods was adapted from the recent study on dietary sources of energy, solid fats, and added sugars among children and adolescents in the U.S (Reedy & Krebs-Smith, 2010).

Weighted Nutrients

The two-day diet and physical activity records were collected in one weekday and one weekend. A simple average of the two days would assume that half of all days are similar to weekend days and half are similar to weekdays. As diet has been found to vary by weekdays and weekend days, weighting of the two days was used to estimate the usual intake distribution (Tooze et al., 2006). Weekdays were counted as 5/7 of all days and weekend days as 2/7. The weighted nutrients were computed as follows in SPSS version 20:

$$\text{Weighted nutrient} = \frac{5 \times \text{nutrient (day 1 weekday)} + 2 \times \text{nutrient (day 2 weekend)}}{\text{7 days of the week}}$$

Energy Expenditure

An average of two-day physical activity record was used to calculate the total energy using MyPyramid physical activity analysis tool to calculate Metabolic Equivalents (METs) from the Compendium of Physical Activities (Ainsworth, et al., 2000):

1. MET-minutes = MET * minutes spent on the activity
    a. For example, MET = 5 when playing soccer, time spent playing soccer today was 100 minutes, MET-minutes per day for playing soccer = 5 * 100 = 500.
2. MET equivalents:
    a. Sleeping: <=0.9; Sedentary: 1.1-1.5
    b. Light: 1.6-2.9
    c. Moderate: 3.0-5.9
    d. Vigorous: 6.0+

The total energy expenditure is the total MET-minutes for all the activities for the day.

Ethnicity

The child demographic questionnaire was used to capture the proportion of all of fathers and mothers ethnicities, including ethnic mixing, which was used to determine the

child's ethnicity BLEND method (R. Novotny & Daida, 2009). The following question was asked:

What is the ethnicity of each of the biological parents of this child? (Estimate percent ethnicity of each parent).

	Father	**Mother**
	%	%
Ethnicity		
Japanese	_____	_____
White	_____	_____
Hawaiian	_____	_____
Filipino	_____	_____
Chinese	_____	_____
Others	_____	_____
Total	**(must add to 100%)**	

The following ethnic classification scheme was created. The demographic question for ethnicity was designed to capture the proportion of fathers' and mothers' ethnicities, and was expressed in percentage. The child was assigned the ethnicity with the predominant percentage. The summary ethnic groups were Native Hawaiian and Pacific Islander (NHOPI), which includes Native Hawaiians, Samoan, Tongan, and Micronesian; Asian, which includes Chinese, Filipino, Japanese, and Korean; White, which includes White, German, Portuguese, French, and Irish; Other, which includes Puerto Rican, African-American, Mexican, Spanish, Indian, Black, Cherokee, Alaskan, Algerian, and highly mixed ethnicity. For example if a child is 36.5% NHOPI, 50% Portuguese, and 13.5% Asian, the child was classified as White (since Portuguese is a White ethnic group).

If there was a tie in proportional ethnicity, the following prioritization category was used:

1. If any Native Hawaiian or Other Pacific Islander classify as NHOPI
2. If any Asian group and not NHOPI, classify as Asian
3. If White and not NHOPI or Asian, classify as White
4. All other classify as Other

BMI Status and BMI z-scores

BMI status and BMI z-scores were calculated based on 2000 CDC BMI-for-age growth data (for either girls or boys) to obtain the percentile ranking (Kuczmarski et al., 2002). The weight status categories were healthy weight (percentile range: $<5^{th}$ percentile to $<85^{th}$ percentile), overweight (85th percentile to $< 95^{th}$ percentile), and obese ($\geq 95^{th}$ percentile).

Data were examined for outliers and normality. After data cleaning, key outcome variables were transformed if non-normal. The percent of energy from added sugar was log transformed when used as a dependent variable.

CHAPTER 3. RESULTS

3.1 STUDY CHARACTERISTICS

This section includes descriptive statistics of the children at baseline—means intakes of energy-yielding nutrients; food groups; and physical activities—both overall, and by baseline demographic characteristics such as age, sex, ethnicity, BMI status, and socioeconomic status. Statistics test differences between subgroups.

3.1.1 Demographic Characteristics of 5- to 8– year-old Multiethnic Children

There were a total of 85 children, aged between 5 and 8 years old at baseline (Table 3.1.1.1). There were 32 (38%) boys, and 53 (62%) girls. Of the 85 children, 24 were classified as Native Hawaiian and Other Pacific Islander (28%), 37 were classified as Asian (44%), 18 were classified as White (21%), and six were classified as Other (7%) . Thirty-seven percent were classified as healthy weight (5th percentile to < the 85th percentile), 26 percent were classified as overweight (85th percentile to < 95th percentile), and 38 percent were classified as obese ($\geq 95^{th}$ percentile). Seventy-one percent of the parents/guardians completed post-secondary education, and 29 percent of the parents completed high school or had less education. A little over half of the participants had an annual household income of $60,000 or more, 27 percent were from the household income of $35,000 to ≤$60,000, and 17 percent of the participants had an annual household income of less than $35,000.

Table 3.1.1.1. Demographic characteristics of children

	Frequency	Percent
Age		
5	12	14%
6	30	35%
7	23	27%
8	20	24%
Sex		
Female	53	62%
Male	32	38%
Ethnicity		
Native Hawaiian and Other Pacific Islander (NHOPI)	24	28%
Asian	37	44%
White	18	21%
Other	6	7%
BMI Status		
Normal weight	31	37%
Overweight	22	26%
Obese	32	38%
Socioeconomic Status		
Education level		
Post-secondary	60	71%
High School or Lower	25	29%
Income level[a]		
Less than 35K	14	17%
35K to less than 60K	23	27%
Greater or equal to 60K	47	55%

[a] n = 84, as one participant refused to provide income information

3.1.2 Mean Energy-yielding Macronutrients

The mean consumption of energy-yielding macronutrients is presented in Table 3.1.2.1. The means (±SD) for the consumption of energy, carbohydrate, protein, total fat, and added sugar were 1702kcal (±445), 231g (±67), 64g (±21), 60g (±22), 60g (±35), respectively.

Table 3.1.2.1. Total food energy and energy-yielding macronutrient and added sugar intakes (mean ± SD of weighted two-day diet records) (n = 85)

Total food energy & Macronutrients	PacDASH Mean±SD	Interquartile Range (25- to 75-centile)	Percent of Energy Mean±SD
Total food energy, kcal	1702±445	1414-1993	--
Carbohydrate, g	231±67	182-265	55±8
Protein, g	64±21	50-73	15±3
Total fat, g	60±22	43-74	31±7
Saturated fat, g	21±9	15-27	11±3
Added sugar			
Teaspoon (tsp)	14±8	8-18	
gram	60±35	33-76	
Kcal	253±148	136-321	15±7

3.1.3 Mean Energy-yielding Macronutrients by Age, Sex, Ethnicity, BMI Status, and Socioeconomic Status

Table 3.1.3.1 presents the mean energy-yielding macronutrients of children. No significant mean differences in macronutrient intake were found between the age groups.

Table 3.1.3.1. Mean total food energy and energy-yielding macronutrient intakes by age, ANOVA (n = 85)

Total food energy & Macronutrients	5 y (n = 12) Mean±SD (Min-Max)	6 y (n = 30) Mean±SD (Min-Max)	7 y (n = 23) Mean±SD (Min-Max)	8 y (n = 20) Mean±SD (Min-Max)	ANOVA[a] P-Value
Total Food energy, kcal	1684±404 (990-2541)	1780±437 (974-2733)	1708±481 (871-2983)	1588±445 (816-2489)	.53
Carbohydrate, g	244±78 (143-392)	238±63 (101-339)	228±72 (103-415)	219±62 (104-353)	.68
Protein, g	59±17 (35-99)	66±26 (34-150)	66±20 (36-114)	61±18 (29-109)	.65
Total fat, g	54±17 (29-75)	64±22 (29-138)	61±20 (31-99)	53±24 (19-125)	.27
Saturated fat, g	21±9 (10-36)	23±11 (7-64)	21±6 (8-32)	17±7 (7-32)	.11

[a]ANOVA P-value test for any difference across age group

Table 3.1.3.2 presents the mean intake of the energy-yielding macronutrient intake of females and males. Males consumed significantly more energy from food, including carbohydrate, protein, total fat, and saturated fat compared to their female counterparts.

Table 3.1.3.2. Mean total food energy and energy-yielding macronutrient intakes by sex, ANOVA (n = 85)

Total food energy & Macronutrients	Female (n = 53) Mean±SD (Min-Max)	Male (n = 32) Mean±SD (Min-Max)	ANOVA P-Value
Total food energy, kcal	1594±442 (816-2983)	1880±395* (1207-2732)	.002
Carbohydrate, g	219±70 (101-414)	251±58* (174-370)	.04
Protein, g	58±17 (29-114)	72±25* (36-150)	.00
Total fat, g	55±21 (19-125)	66±21* (33-138)	.02
Saturated fat, g	19±8 (7-39)	24±9* (10-64)	.02

*Significantly higher intake than females

Table 3.1.3.3 presents the mean intake of energy-yielding macronutrients between ethnic groups. There was a significant difference in mean food energy and carbohydrate intakes among White, NHOPI, Asian, and Other at baseline. Post Hoc Tests were used to determine which groups were significantly different from each other. TUKEY HSD showed that NHOPI significantly consumed more energy (kcal) (p=0.05) and carbohydrates (gram) (p=0.01) as compared to Asian. NHOPI consumed the most food, while Asians consumed the least.

Table 3.1.3.3. Mean total food energy and energy-yielding macronutrient intakes by ethnicity, ANOVA (n = 85)

Total food energy & Macronutrients	White (n = 18) Mean±SD (Min-Max)	NHOPI (n = 24) Mean±SD (Min-Max)	Asian (n = 37) Mean±SD (Min-Max)	Other (n = 6) Mean±SD (Min-Max)	ANOVA[a] P-Value
Total food energy, kcal	1741±351 (1383-2541)	1888±489* (987-2983)	1564±423 (816-2733)	1691±451 (1123-2080)	.05
Carbohydrate, g	239±60 (163-370)	261±79* (101-415)	206±52 (103-337)	247±77 (156-333)	.01
Protein, g	65±19 (36-106)	70±17 (40-114)	59±25 (29-150)	58±14 (31-71)	.22
Total fat, g	60±17 (19-84)	63±20 (33-99)	57±25 (29-138)	54±18 (27-76)	.69
Saturated fat, g	22±7 (7-30)	22±7 (10-39)	20±11 (7-64)	17±7 (9-24)	.59

*Significantly higher than Asian group
[a]ANOVA P-value test for any difference across age group

Table 3.1.3.4 presents the mean intake of energy-yielding macronutrients by BMI status. No significant difference between healthy weight, overweight, and obese children was observed.

Table 3.1.3.4. Mean total food energy and energy-yielding macronutrient intakes by BMI Status, ANOVA (n = 85)

Total food energy & Macronutrients	Healthy Weight (n = 31) Mean±SD (Min-Max)	Overweight (n = 22) Mean±SD (Min-Max)	Obese (n = 32) Mean±SD (Min-Max)	ANOVA[a] P-Value
Total food energy, kcal	1683±357 (974-2312)	1677±465 (816-2562)	1738±514 (990-2983)	.85
Carbohydrate, g	230±63 (101-392)	224±70 (102-344)	237±70 (143-415)	.79
Protein, g	60±19 (35-114)	64±17 (29-106)	67±26 (31-150)	.49
Total fat, g	59±18 (32-125)	60±22 (19-103)	60±24 (27-138)	.98
Saturated fat, g	21±7 (8-39)	20±7 (7-34)	21±11 (7-64)	.88

[a]ANOVA P-value test for any difference across age group

Table 3.1.3.5 presents the mean intake of energy-yielding macronutrients by education level of responding parent. There were no significant differences in mean energy-yielding macronutrient intake between children whose parents completed post-secondary education and children whose parents completed high school or had less education.

Table 3.1.3.5. Mean total food energy and energy-yielding macronutrient intakes by education level of responding parent, ANOVA (n = 85)

Total food energy & Macronutrients	Post-Secondary (n = 60) Mean±SD (Min-Max)	High School or Lower (n = 25) Mean±SD (Min-Max)	ANOVA P-Value
Food energy, kcal	1696±434 (871-2983)	1717±479 (816-2489)	.84
Carbohydrate, g	232±67 (101-415)	229±69 (104-353)	.83
Protein, g	63±21 (34-150)	64±23 (29-114)	.83
Total fat, g	58±21 (19-138)	61±24 (29-125)	.60
Saturated fat, g	21±9 (7-64)	20±8 (7-34)	.54

Table 3.1.3.6 presents the mean intake of the energy-yielding macronutrients between annual household incomes of less than \$35, 000, equal to \$35, 000 or less than \$60, 000, and greater than or equal to \$60, 000. No significant differences were found between income levels.

Table 3.1.3.6. Mean total food energy and energy-yielding macronutrient intakes by annual household income level, ANOVA (n = 84)

Total food energy & Macronutrients	Less than 35K (n = 14) (Min-Max)	35K -60K (n = 23) (Min-Max)	≥ 60K (n = 47) (Min-Max)	ANOVA[a] P-Value
Total food energy, kcal	1683±437 (816-2372)	1704±388 (990-2489)	1708±485 (871-2983)	.98
Carbohydrate, g	219±60 (104-307)	234±55 (143-353)	233±75 (101-415)	.78
Protein, g	70±29 (29-114)	60±15 (31-88)	64±21 (36-150)	.37
Total fat, g	59±16 (32-85)	60±22 (29-125)	59±23 (19-138)	.99
Saturated fat, g	22±7 (10-33)	21±8 (7-39)	21±9 (7-64)	.80

[a]ANOVA P-value test for any difference across age group

3.1.4 Mean Food Group Intake

The mean food group intake is presented in Table 3.1.4.1. The average child consumed about 1 cup of fruits, approximately one cup equivalent of vegetables (one cup equivalent of vegetable is equal to 1 cup of cooked green beans and/or 1 cup of chopped green cabbage), approximately 6 ounce equivalent of grains (an ounce equivalent is equal to 1 "mini" bagel), one small (2" diameter) biscuit and/or 1 small (2 ½" diameter) muffin of any kind, approximately 2 cups of milk, and approximately 8 ounce equivalents of protein foods and products (an ounce equivalent of protein foods and products is equal to 1 ounce cooked lean beef, 1 ounce cooked fish or shell fish and/or 1 egg). Notably, most grain consumed was non-whole grain.

Table 3.1.4.1. Food group intakes (mean ± SD of weighted two-day diet records) (n = 85)

Food group	PacDASH Mean±SD	Interquartile Range (25- to 75-centile)
Fruits, c	1±1	0.6-1.5
Vegetables, c	1±1	0.4-1.1
Total grain, oz-eq	6±2	4.6-6.9
Whole grain	1±1	0.0-1.1
Non-whole grain	5±2	3.8-6.2
Total dairy, c	2±1	1.0-2.4
Protein foods, oz-eq	8±4	6.0-11.2

3.1.5 Average of Two-days of Physical Activity

The average of two-day physical activity is presented in Table 3.1.5.1. The activities were summarized by their intensities. On average, the children spent 589 minutes (±63) in sleeping, 156 minutes (±84) in light activity, 513 minutes (±128) in sedentary activity, 107 minutes (±91) in moderate activity, and 76 minutes (±69) in vigorous activity.

Table 3.1.5.1. Average of two-day physical activity in minutes (n=85)

Activity Intensity	PacDASH Mean±SD Minutes per day	Interquartile Range (25- to 75-centile) Minutes per day
Light	156±84	87-209
Sleeping	589±63	553-630
Sedentary	513±128	409-599
Moderate	107±91	36-155
Vigorous	76±69	23-113

3.1.6 Major Sources of Added Sugar

Table 3.1.6.1 presents major sources of added sugar in 5- to 8-year-old multiethnic children diets are all children's brand cereals, beverages including skim milk, carbonated soda, and fruit juices/drinks, snacks including candy and chocolate cookies, bakery/breads including cakes and doughnuts, and dressings, spreads, and other additions including regular syrup in pancakes and chocolate syrup. As an example of the added sugar content per serving of each food category, the kcal from added sugar column is included. Note that the kcal here is only for the example of added sugar content per serving, not the total amount of energy in the food. Also, each food type in every category may vary in added sugar content.

Table 3.1.6.1. Major sources of added sugar

Food category	**Example food per serving**	**Kcal from added sugar per serving of example**
Cereals[a]	¾ cup ready-to-eat, frosted oat cereal	44
Beverages[b]	12 oz can soda	132
Snacks[c]	1 chocolate cookie	14
Bakery/breads[d]	Doughnut	74
Dressings, spreads, other additions[e]	1 tbsp pancake syrup	27

[a]Including Cap'N Crunch
[b]Including skim milk, whole milk, Sunny delight drink, pineapple juice, soda, Capri sun juice drink, apple juice, fruit drink, soymilk, fruit punch drink, Fanta orange juice, HI-C juice/drink, and chocolate milk
[c]Including ice cream, sweetened apple sauce, candy, fruit leather, chocolate pudding, cookies, and fruit snacks
[d]Including cupcakes, cakes, and doughnuts
[e]Including maple syrup and chocolate syrup

3.1.7 Added Sugar Intake by Age, Sex, Ethnicity, BMI Status, and Socioeconomic Status

Table 3.1.7.1 to Table 3.1.7.6 presents the mean added sugar intake (summarized in teaspoon, gram, kcal, and percent of energy) by age, sex, ethnic group, BMI status, parent's education level and household income level.

Table 3.1.7.1 shows that younger children in the sample consumed significantly more added sugar than their older counterparts. Post Hoc TUKEY HSD test showed that 5 year old children consumed more added sugar as compared to 8 year old children.

Table 3.1.7.1. Mean added sugar intakes (mean ± SD of weighted two-day diet records) by age, ANOVA (n = 85)

Added sugar	5 y (n = 12) Mean±SD (Min-Max)	6 y (n = 30) Mean±SD (Min-Max)	7 y (n = 23) Mean±SD (Min-Max)	8 y (n = 20) Mean±SD (Min-Max)	ANOVA[a] P-Value
Teaspoon	19±13* (6-44)	15±8 (2-36)	13±7 (3-30)	11±6 (3-23)	.05
Gram	82±55* (27-186)	63±34 (7-151)	57±28 (11-126)	46±25 (12-97)	.05
Kcal	343±230* (113-780)	265±141 (30-635)	240±117 (47-530)	195±105 (51-408)	.05
Percent of energy	19±9* (7-36)	15±7 (17-32)	14±6 (4-29)	12±5 (3-22)	.04

$^*P \leq 0.05$, significantly higher than other age groups
[a]ANOVA P-value test for any difference across age groups based on Tukey Post hoc tests

Table 3.1.7.2 presents the mean added sugar intake between females and males. No significant differences in mean added sugar intake between females and males were observed.

Table 3.1.7.2. Mean added sugar intakes (mean $\pm$ SD of weighted two-day diet records) by sex, ANOVA (n = 85)

Added sugar	Female (n = 53) Mean±SD (Min-Max)	Male (n = 32) Mean±SD (Min-Max)	ANOVA P-Value
Teaspoon	14±8 (3-44)	16±9 (2-44)	.22
Gram	57±34 (11-186)	65±37 (7-185)	.22
Kcal	241±143 (47-780)	272±156 (30-777)	.22
Percent of energy	15±143 (4-36)	15±7 (1-36)	.50

Table 3.1.7.3 presents the mean added sugar intake by ethnic group. There was no significant difference in dietary added sugar intake between White, NHOPI, Asian, and Other participants was observed.

Table 3.1.7.3. Mean added sugar intakes (mean $\pm$ SD of weighted two-day diet records) by ethnicity, ANOVA (n = 85)

Added sugar	White (n = 18) Mean±SD (Min-Max)	NHOPI (n = 24) Mean±SD (Min-Max)	Asian (n = 37) Mean±SD (Min-Max)	Other (n = 6) Mean±SD (Min-Max)	ANOVA[a] P-Value
Teaspoon	16±9 (7-44)	16±10 (4-44)	12±7 (2-36)	17±7 (9-25)	.22
Gram	69±37 (28-185)	65±42 (18-186)	51±30 (7-151)	69±28 (36-106)	.22
Kcal	288±156 (117-777)	275±174 (74-780)	215±124 (30-635)	292±118 (152-445)	.22
Percent of energy	16±7 (7-31)	14±7 (6-36)	14±7 (1-32)	17±3 (12-21)	.50

[a]ANOVA P-value test for any difference across age group

Table 3.1.7.4 presents the mean added sugar intake of children by BMI status, defined as healthy weight, overweight, and obese categories. There was a marginally significant difference in percent of energy from dietary added sugar by BMI status (p=0.08). Post Hoc tests were used to determine which groups were significantly different from each other. TUKEY HSD showed that healthy weight children consumed a higher percent of energy from added sugar as compared to obese children (p=0.08).

Table 3.1.7.4. Mean added sugar intakes (mean ± SD of weighted two-day diet records) by BMI Status, ANOVA (n = 85)

Added sugar	Healthy Weight (n = 31) Mean±SD (Min-Max)	Overweight (n = 22) Mean±SD (Min-Max)	Obese (n = 32) Mean±SD (Min-Max)	ANOVA[a] P-Value
Teaspoon	16±10 (3-44)	15±6 (5-29)	12±8 (2-44)	.28
Gram	68±40 (12-186)	62±26 (21-121)	52±35 (7-185)	.28
Kcal	284±169 (51-780)	259±108 (86-507)	218±147 (30-780)	.28
Percent of energy	16±8** (3-36)	15±5 (7-24)	12±9 (1-31)	.08

** Marginally significant (p=0.08) higher than other weight groups
[a]ANOVA P-value test for any difference across age group

Table 3.1.7.5 presents the mean added sugar intake by parent's education level. No significant difference in mean added sugar intake by parent's education level was observed.

Table 3.1.7.5. Mean added sugar intakes (mean ± SD of weighted two-day diet records) by education level of responding parent, ANOVA (n = 85)

Added sugar	Post-Secondary education (n = 60) Mean±SD (Min-Max)	High School or lower education (n = 25) Mean±SD (Min-Max)	ANOVA P-Value
Teaspoon	15±9 (2-44)	13±7 (3-30)	.47
Gram	62±38 (7-186)	56±28 (12-126)	.47
Kcal	260±159 (30-780)	235±118 (51-530)	.47
Percent of energy	15±7 (1-36)	14±5 (3-23)	.36

Table 3.1.7.6 presents the mean added sugar intake by annual household income level. No significant difference in mean added sugar intake by annual household income level.

Table 3.1.7.6. Mean added sugar intakes (mean ± SD of weighted two-day diet records) by annual household income level, ANOVA (n = 84)

Added sugar	Less than 35K (n = 14) (Min-Max)	35K -60K (n = 23) (Min-Max)	≥ 60K (n = 47) (Min-Max)	ANOVA[a] P-Value
Teaspoon	13±5 (5-23)	14±6 (5-29)	15±10 (2-44)	.69
Gram	53±21 (21-98)	59±26 (22-121)	62±42 (7-186)	.69
Kcal	223±86 (86-413)	246±110 (93-507)	261±176 (30-780)	.69
Percent of energy	13±5 (7-23)	14±5 (6-29)	15±7 (1-36)	.80

[a]ANOVA P-value test for any difference across age group

3.1.8 BMI Status by Age, Sex, Ethnicity, and Socioeconomic Status

Tables 3.1.8.1 to 3.1.8.4 present BMI status by demographic characteristics. There was no significant difference observed in BMI status among age group.

Table 3.1.8.1. BMI status by age, ANOVA (n = 85)

	Normal Weight (n = 31) Frequency (%))	Overweight (n = 22) Frequency (%)	Obese (n = 32) Frequency (%)	ANOVA P-Value
Age				.17
5	3(25%)	2(17%)	7(58%)	
6	14(45%)	8(26%)	9(29%)	
7	10(45%)	5(23%)	7(32%)	
8	4(20%)	7(35%)	9(45%)	

Table 3.1.8.2 presents the BMI status by sex. There was no significant difference observed in BMI status between females and males.

Table 3.1.8.2. BMI status by sex, ANOVA (n = 85)

	Normal Weight (n = 31) Frequency (%)	Overweight (n = 22) Frequency (%)	Obese (n = 32) Frequency (%)	ANOVA P-Value
Sex				.87
Female	20(38%)	13(24%)	20(38%)	
Male	11(34%)	9(28%)	12(38%)	

Table 3.1.8.3 presents the BMI status by ethnicity. There was no significant difference observed in BMI status between ethnic groups.

Table 3.1.8.3. BMI status by ethnicity, ANOVA (n = 85)

	Normal Weight (n = 31) Frequency (%)	Overweight (n = 22) Frequency (%)	Obese (n = 32) Frequency (%)	ANOVA P-Value
Ethnicity				.18
NHOPI	6(25%)	6(25%)	12(50%)	
Asian	14(38%)	9(24%)	14(38%)	
White	9(50%)	6(33%)	3(17%)	
Other	2(33%)	1(17%)	3(50%)	

Table 3.1.8.4 presents BMI status by socioeconomic status. There were no significant differences in BMI status between parents/guardians of children with post-secondary education and parents/guardian with high school or had less education. There were no significant differences in BMI status between children whose household's income was less than $35,000, greater than $35,000 to less than $60,000, or greater or equal to $60,000.

Table 3.1.8.4. BMI status by socioeconomic status, ANOVA (n=85)

	Normal Weight (n = 31) Frequency (%)	**Overweight (n = 22) Frequency (%)**	**Obese (n = 32) Frequency (%)**	**ANOVA P-Value**
Socioeconomic Status				
Education level				.85
Post-secondary	22(37%)	16(26%)	22(37%)	
High School or Lower	9(36%)	6(24%)	10(40%)	
Income level[a]				.43
Less than 35K	4(29%)	4(29%)	6(42%)	
35K -60K	7(30%)	5(22%)	11(48%)	
Greater or equal to 60K	19(40%)	13(28%)	15(32%)	

[a]n=84

3.2 ANALYSIS OF ASSOCIATIONS WITHIN THE CONCEPTUAL FRAMEWORK

3.2.1 Models for Added Sugar

Table 3.2.1.1 presents parameter estimates (slopes) for demographic factors in a regression of percentage of energy from added sugar as log-transformed. Linear regression was used to assess how much variance is accounted for in added sugar intake after controlling for the effects of independent variables. Age and obesity were inversely associated with percentage of energy from added sugar intake. Other demographic factors were not associated with added sugar intake.

Table 3.2.1.1. Dietary added sugar in percent of energy and demographic factors, and BMI status, Linear regression (n=85)

Dependent Variable	Independent Variable	β	P-Value
Added sugar, percent of energy, log-transformed	**Age, year** (categorical by year)	-0.147	.02*
	Sex (males =1, categorical)	-0.118	.32
	Ethnicity		
	White	0	0
	NHOPI	-0.129	.44
	Asian	-0.152	.33
	Other	0.372	.15
	BMI Status		
	Healthy weight	0	0
	Overweight	0.071	.62
	Obese	-0.272	.05*
	Education level[a] (categorical)	-0.043	.75
	Income level[b] (categorical)	-0.069	.39

*P ≤ 0.05
[a]Post-secondary = 0, High school lower=1
[b]n=84, Less than 35K = 1, equal to 35K -60K = 2, less than or equal to 60K = 3

Table 3.2.1.2 presents the parameter estimates (slopes) for behvaioral factors in a regression of added sugar as log-transformed kcal. Physical activity is given in MET-minutes. Food energy was positively associated with added sugar intake ($P \leq 0.05$). Vigorous physical activity in MET-minutes was also positively associated with added sugar intake in children.

Table 3.2.1.2. Dietary added sugar in kilocalorie and behavioral factors such as total food energy and physical activity (MET-minutes of moderate-vigorous), Linear regression (n=85)

Dependent Variable	Independent Variable	β	P-Value
Added sugar, kcal, log-transformed	**Total food energy, kcal, log-transformed**	1.136	.001***
	Physical Activity, MET-minutes, moderate	8.647E-005	.54
	Physical Activity, MET-minutes, vigorous	-2.829E-005	.01*

*$P \leq 0.05$
***$P \leq 0.001$

Table 3.2.1.3 presents the parameter estimates (slopes) for demographic factors in a regression of added sugar as log-transformed kcal. Physical activity is given in minutes. Vigorous physical activity in minutes was associated with added sugar intake in children ($P \leq 0.05$), and total food energy was positively associated with added sugar intake.

Table 3.2.1.3. Dietary added sugar in kilocalorie and behavioral factors such as total food energy and physical activity (minutes of moderate-vigorous), Linear regression (n=85)

Dependent Variable	**Independent Variable**	β	P-Value
Added sugar, kcal, log-transformed	**Total food energy, kcal, log-transformed**	0.172	.000***
	Physical Activity, minutes, moderate	-0.037	.81
	Physical Activity, minutes, vigorous	-0.428	.03*

*$P \leq 0.05$
***$P \leq 0.001$

Table 3.2.1.4 presents the relationship between dietary added sugar and behavioral factors. Total food energy was positively associated with added sugar intake ($P \leq 0.01$), and energy expenditure was not associated with added sugar intake in children.

Table 3.2.1.4. Dietary added sugar and behavioral factors, Linear regression (n =85)

Dependent Variable	**Independent Variable**	**β**	**P-Value**
Added sugar, kcal, log-transformed	**Total food energy, kcal**	1.177	.000***
	Energy expenditure, kcal/day (total MET-minutes)	-1.509E-005	0.23

*P ≤ 0.01
** Marginally significant, (p=0.06)
***P ≤ 0.001

3.2.2 Models of BMI Status

Table 3.2.2.1 presents results from a polytomous regression model comparing overweight and obesity category with healthy weight children as the reference. Added sugar as the independent variable is parameterized in three ways. Obese children were less likely to consume added sugar (g or kcal) as compared to their healthy weight counterparts (OR = 0.45, p=0.07). When total food energy was accounted for, obese children were still less likely to consume energy from added sugar as compared to their healthy weight and obese counterparts (OR=0.31, $P \leq 0.05$).

Table 3.2.2.1. BMI status and dietary added sugar (gram, kilocalorie, and percent of energy, Polytomous regression (n = 85)

Model Number	Independent Variable	Dependent Variable	β	Odds ratio	P-Value
1	**Added sugar, g, log-transformed**	**Healthy weight**	0	0	0
		Overweight	-0.053	0.949	.91
		Obese	-0.789	0.454	.07**
2	**Added sugar, kcal, log-transformed**	**Healthy weight**	0	0	0
		Overweight	-0.053	0.949	.91
		Obese	-0.789	0.454	.07**
3	**Added sugar, percent of energy, log-transformed**	**Healthy weight**	0	0	0
		Overweight	0.019	1.019	.98
		Obese	-1.157	0.314	.04*

*$P \leq 0.05$
** Marginally significant, (p=0.07)

Table 3.2.2.2 presents the associations of total food energy and BMI status, from a polytomous regression model comparing overweight and obesity, with healthy weight as the reference. Total food energy was the independent variable. No significant findings were observed.

Table 3.2.2.2. BMI status and total food energy, Polytomous regression (n = 85)

Independent Variable	**Dependent Variable**	**β**	**Odds ratio**	**P-Value**
Total food energy, kcal, log-transformed	**Healthy weight**	0	0	0
	Overweight	-0.290	0.748	.78
	Obese	0.192	1.212	.84

Table 3.2.2.3 presents the associations of physical activity and BMI status, from a polytomous regression model comparing overweight and obesity, using healthy weight as the reference. Overweight children were tended to expend more energy than healthy weight children (p=0.09).

Table 3.2.2.3. BMI status and physical activity in MET-minutes, minutes of vigorous activity, and energy expenditure (total MET-minutes), Polytomous regression (n = 85)

Model	Independent Variable	Dependent Variable	β	Odds ratio	P-Value
1	**Physical activity, MET-minutes, vigorous**	**Healthy weight**	0	0	0
		Overweight	0.000	1.000	.39
		Obese	0.000	1.000	.38
2	**Physical activity, Minutes, vigorous**	**Healthy weight**	0	0	0
		Overweight	0.002	1.002	.59
		Obese	0.002	1.002	.64
3	**Energy expenditure , kcal/day (total MET-minutes)**	**Healthy weight**	0	0	0
		Overweight	0.001	1.001	.09**
		Obese	0.001	1.001	.21

** Marginally significant, (p=0.09)

Table 3.2.2.4 presents the associations of socioeconomic status and BMI status, from a polytomous regression model comparing overweight and obesity, with healthy weight as reference. No significant findings were observed.

Table 3.2.2.4. BMI status and socioeconomic status, Polytomous regression

Model Number	Independent Variable	Dependent Variable	β	Odds ratio	P-Value
1	**Education level 2[a]**	**Healthy weight**	0	0	0
		Overweight	-0.087	0.917	.89
		Obese	0.105	1.111	.85
2	**Income level[b]**	**Healthy weight**	0	0	0
		Overweight	-0.172	0.842	.66
		Obese	-0.387	0.679	.26

[a]Post-secondary=0, High school lower=1
[b]n=84, Less than 35K=1, equal to 35K -60K =2, less than or equal to 60K=3

3.2.3 Models of BMI z-scores excluding Obese Children

In this analytic section, obese children were excluded from the analysis to examine the association between dietary added sugar and BMI z-scores among normal and overweight children (BMI percentiles in the 50th-95th percentiles). This exclusion was made as it was clear from the earlier results that obese children consumed less added sugar than normal weight and overweight children, and their inclusion would necessarily lead to an inverse relationship. If the hypothesis is that obese children change behavior is correct, it is of interest to know the relationship between added sugar and BMI prior to the occurrence of obesity. Table 3.2.3.1 presents BMI z-scores and added sugar intake (gram, kcal, and percent of energy). There were no significant findings observed.

Table 3.2.3.1. BMI z-scores (among healthy and overweight) and added sugar intake, Linear regression (n = 53)

Dependent Variable	Model Number	Independent Variable	β	P-Value
BMI z-scores	**1**	**Added sugar, g, log-transformed**	-0.134	.29
	2	**Added sugar, kcal, log-transformed**	-0.134	.29
	3	**Added sugar, percent of energy, log transformed**	0.371	.20

Table 3.2.3.2 presents the results of the regression of BMI z-scores and total food energy intake. No significant relationship was observed.

Table 3.2.3.2. BMI z-scores (among healthy and overweight) and total food energy intake, Linear regression (n = 53)

Dependent Variable	Independent Variable	β	P-Value
BMI z-scores	**Total food energy, kcal, log-transformed**	0.371	.20

Table 3.2.3.3 presents the results of the regression of BMI z-scores and physical activity. No significant findings were observed.

Table 3.2.3.3. BMI z-scores (among healthy and overweight) and physical activity, Linear regression (n = 53)

Dependent Variable	Model Number	Independent Variable	β	P-Value
BMI z-scores	**1**	**Physical activity, minutes, vigorous**	0.000	.67
	2	**Physical activity, MET-minutes, vigorous**	0.000	.98
	3	**Energy expenditure , kcal/day (total MET-minutes)**	0.000	.50

Table 3.2.3.4 presents the results of the regression of BMI z-scores and all behavioral factors. After excluding obese children, BMI z-scores of healthy weight and overweight children was inversely associated with added sugar intake ($P \leq 0.05$), and positively associated with total energy intake ($P \leq 0.05$), adjusting for physical activity level.

Table 3.2.3.4. BMI z-scores (among healthy weight and overweight) and behavioral factors, Multiple regression (n = 53)

Dependent Variable	**Independent Variable**	**β**	**P-Value**
BMI z-scores	**Added sugar, g, log-transformed**	-0.324	.03*
	Total food energy intake, kcal	0.723	.03*
	Physical activity, minutes, vigorous	-0.001	.34

*$P \leq 0.05$

Table 3.2.3.5 presents the results of the regression of BMI z-scores and demographic and behavioral factors. After controlling for other demographic and behavioral factors, BMI z-scores was inversely associated with annual household income ($P \leq 0.05$). It was expected that sex and age would not be related to BMI z-scores because the z-scores are based on sex and age specific growth curves. Native Hawaiian and Other Pacific Islander and Other (marginally) ethnic group were positively associated with BMI z-scores ($P \leq 0.05$). Other ethnic group and total food energy was marginally positively associated with BMI z-scores (p=0.09). Income was negatively associated with BMI z-scores. Other factors in this model were not found to be associated with BMI z-scores.

Table 3.2.3.5. BMI z-scores (among healthy weight and overweight children) and demographic and behavioral factors, Multiple regression (n = 53)

Dependent Variable	**Independent Variable**	**β**	**P-Value**
BMI z-scores	**Age, year** (categorical)	0.029	.52
	Sex (males =1, categorical)	-0.030	.87
	Ethnicity		
	White	0	0
	NHOPI	0.452	.05*
	Asian	0.341	.11
	Other	0.594	.09**
	Education level[a] (categorical)	-0.203	.28
	Income level[b] (categorical)	-0.223	.05*
	Total food energy, kcal/day, log-transformed	0.522	.09**
	Energy expenditure, kcal/day (total MET-minutes)	0.000	.34

*$P \leq 0.05$
** Marginally significant, (p=0.09)
[a]Post-secondary=0, High school lower =1
[b]n=84, Less than 35K =1, equal to 35K -60K=2, less than or equal to 60K=3

CHAPTER 4. DISCUSSION

4.1 ADDED SUGAR INTAKE AND DEMOGRAPHIC CHARACTERISTICS

Currently, there is no absolute recommendation for added sugar intake for children. The mean added sugar intake of the participants was 60g (15% of total energy) as compared to the US population consuming 52g of added sugar intake for 2-5 year of age (Welsh, et al., 2011). The findings from this study confirmed that children consumed less added sugar than the IOM-recommended maximum intake of 25% or less of energy from added sugar (S. P. Murphy & Barr, 2011). However, according to the *2010 Dietary Guidelines* recommends no more than 5-15%of calories from solid fats and added sugars, but children 5 to 8 years old in this study consumed more at 15% of energy from added sugar alone, not accounting solid fat consumption. Added sugar contributes an average of 16% of the total energy in American diets (Reedy & Krebs-Smith, 2010).

Furthermore, younger children, aged 5-year-old, children consumed significantly more added sugar as compared to older children, aged 8-year-old children, in this study. These 5 year-old children consumed a mean intake of 343kcals from added sugar (19% of total energy). This finding was similar to the recent data from the National Health and Nutrition Examination Survey, 2005-2008, in the analysis of consumption of added sugar among U.S. children and adolescents in which caloric intake from added sugar increased linearly with age. School-aged boys and girls (6-7 years) consumed an average of 345kcals and 293kcals, respectively (Ervin, Kit, Carroll, & Ogden, 2012). Thus, the 5-year-old age group deserves further attention, to decrease added sugar intake.

There were no significant differences in mean kilocalorie intakes from added sugar between BMI status, however, obese children's intakes were lower than healthy weight children and overweight children when the amounts are expressed as percentage of total energy intakes. This is likely due to change in diet changed behavior or underreporting as will be discussed further below.

Major food sources of added sugar for those children who consumed the most dietary added sugar, expressed in teaspoons, in this population were identified to better understand consumption of sugar. The most commonly reported foods in the study participants were all-brands children's cereals; beverages, including milk and fruit juices and drinks; snacks including chocolate cookies and candies; and bakery/breads. This finding was similar to the recent study of food sources of energy, solid fats, and added sugars among children and adolescents in the United States, and the FAM study in Hawaii (Lee, et al., 2007). The major food sources of added sugar among all 2- to 18-year-olds were soda, fruit drinks, grain desserts, dairy desserts, and candy (Lee, et al., 2007; Reedy & Krebs-Smith, 2010).

All brands of 5- to 8-year children's cereals, 2% milk, fruit drinks and juices, were commonly reported in this study population. Capri sun, as one of the juices, was an especially frequently source of added sugar. This food and beverage intake pattern may be important indicator of the nutritional value of food children consume, and a contributor to overall diet quality.

4.3 DIET RECORDS

There were no significant differences in energy-yielding macronutrient intakes between healthy weight, overweight, and obese children. However, parents of overweight and obese children reported a lower added sugar intake than the normal-weight children

in this age group. This could reflect underreporting of food intake, which is more pervasive among overweight and obese children and adolescents (Livingstone, Robson, & Wallace, 2004). Parents of obese children in this sample may have underreported their actual added sugar intake more than those of healthy weight, particularly foods high in added sugar (Krebs-Smith et al., 2000).

Underreporting in this sample could be explained as parents may reliably report their children's food intake in the home setting but often do not know what their children consume in school or outside the home. In this sample, one of the diet records was on school day, and it was often difficult for parents or guardians involved in reporting process to report what their children ate in the school setting. Even when the school menu was provided, which was not common, it was difficult to capture the amount of food that was actually eaten by their children, regardless of the amount given to them. Often the children were away from home during the weekend diet record and, even with the help of food models and measuring tools to facilitate children's recall skills, their ability to estimate and indicate portion sizes, and knowledge of foods was limited (Livingstone, et al., 2004). Another possibility is that obese children may have modified their added sugar consumption in response to their increasing body weight.

4.3. DEMOGRAPHIC AND BEHAVIORAL FACTORS ASSOCIATED WITH ADDED SUGAR INTAKE

There is little published work examining associations between added sugar intakes and demographic and behavioral factors in U.S. children. This study found that when other demographic factors were accounted for, age was inversely associated with added sugar intake when expressed in percentage. The predicted percent of added sugar

of 5- to 8-year-old children in this sample decreases by 0.2 percent of energy each year. Sex, ethnicity, educational level of responding parent, and income level were not found to be associated with added sugar intake when expressed in percentage of energy. A study on socioeconomic status and race/ethnicity with added sugar intake in adults (≥18 years) found that intake of added sugar was inversely related to age, educational status, and family income. However, this study was using the 2005 US National Health Interview Survey (NHIS) Cancer Control Supplement using a validated questionnaire with 4 added sugar questions with a larger sample size (n=28948) (Thompson et al., 2009).

4.4 ADDED SUGAR INTAKE AND BMI STATUS

Obese children in this study were observed to consume less added sugar intake than healthy weight and overweight children. When other demographic and behavioral factors were accounted for, obesity in 5- to 8-year-old children was found to be inversely associated with added sugar intake when expressed in percentage of energy. An inverse correlation between total sugar intake and body mass index has been consistently reported in children and adults (Song et al., 2012). A study on demographic and lifestyle factors associated with body mass index among children and adolescents has also found that carbohydrates minus added sugar have a statistically significant, negative association with BMI (Storey, Forshee, Weaver, & Sansalone, 2003). That study, however, accounted for lifestyle factors such as television viewing in predicting BMI in this larger sample of 6- to 19-year-old children and adolescents.

4.5 DEMOGRAPHIC AND BEHAVIORAL FACTORS ASSOCIATED WITH BMI Z-SCORES AMONG HEALTHY WEIGHT AND OVERWEIGHT CHILDREN

Obese children were more likely to consume less added sugar in this study. They were excluded in an analysis of demographic and behavioral factors and BMI z-scores. The regression analysis between BMI z-scores and intakes of added sugar showed a significant inverse association in children, after accounting for total food energy and vigorous physical activity in minutes. This was consistent with a recent study on the association between added sugar intake and weight/adiposity in children using more recent nationally reported data from the 2003-2006 NHANES (Nicklas, O'Neil, & Liu, 2011) This may suggest that children consume more added sugar, possibly from sports drinks or snacks after performing a physical activity .

After accounting for other demographic factors and behavioral factors, Native Hawaiian and Other Pacific Islander ethnicity was, while Other ethnic group was marginally, positively associated with BMI z-scores. In addition to this, Native Hawaiians and Other Pacific Islander children in this study consumed the most energy and carbohydrates than Asian children. A recent study showed that Native Hawaiians and other Pacific Islanders had a higher levels of overweight and obesity than Whites and Asians (R. Novotny, Oshiro, & Wilkens, 2013). This group of population deserves further study related to food sources of energy and carbohydrate, including added sugar, relative to body size.

4.6LIMITATIONS

This cross-sectional study has examined the association of dietary added sugar intake to overweight and obesity in 5- to 8-year-old multiethnic children in Hawaiʻi. The study has limitations to consider which are discussed in the following sections.

4.6.1 Cross-sectional Design

The design is an observational, cross-sectional study which can only demonstrate prevalence of or risk for disease and/or exposure in a specified population at one point in time. This study took a snapshot of the 5- to 8-year-old multiethnic children in Hawaii regarding dietary added sugar intake and the prevalence of overweight and obesity at study baseline of the PacDASH Intervention study. Therefore, this study can only examine the association of dietary added sugar intake of children and the prevalence and risk for overweight and obesity among them. A longitudinal study is necessary to establish a cause and effect of added sugar intake with overweight and obesity in children, aged 5- to 8-year-old.

4.6.2 Sample Size

The sample size for this study was 85 participants. There were only a few analyses with significant associations (age and percentage of energy from added sugar, and obesity and percentage of energy from added sugar, total food energy and vigorous PA [in MET-minutes and minutes] and energy from added sugar intake, NHOPI and BMI z-scores, and annual income level and BMI z-scores), and marginal associations (Other ethnic group and total and BMI z-scores. With a small sample size and with the complex analysis of various variables, there is a possibility of random findings, and associations may be found due to chance, a lack of statistical power to show associations.

4.6.2Measuring Dietary Added Sugar Intake

For this study, analyses of added sugar intake of children relied on the MyPyramid Equivalents Database 2.0 (MPED version 2.0) for USDA Survey Foods, through the NHANES cycle 2003-2004 that was part of the PacTrac2 software used. Therefore, added sugar intake of the children may have had underestimated actual

consumption, or availability data may overestimate it. Furthermore, the added sugar contents of many foods appearing in the PacTrac2 software are derived from the summation of recipe ingredients rather than from actual measurements. Food codes for other food and beverage items that are new to the market and consumed by the children were entered only with similar foods (see Appendix H).

While some local foods were added to the PacTrac2 software, others were still not available. For example, "Aloha maid natural: Lilikoi passion drink", a local fruit drink, was reported by one or more children in the study but did not have a corresponding MPED equivalent even with added local foods on the food composition table. The added sugar content of this drink was therefore assigned the same value as "Cranberry fruit drink". For complex processed foods that are sold in today's market, but had no similar comparison food in the PacTrac2 software.. PacTrac2 incorporated the UH Cancer Center food composition table, which includes foods and recipes gathered from the Pacific Region. However, the majority of the foods and recipes gathered from the Pacific Region were based on the adult population rather than child population (S. Murphy, et al., 2006). The added sugar content of reported foods of children therefore may be underestimated or overestimated.

4.7FUTURE STUDIES

Further studies are needed to fully understand the association of added sugar intake and overweight and obesity status in children. However, with the inconsistent results between studies using different methodology to measure added sugar intake and weight status, there should be consistent methological approaches in measuring consumption of added sugar in children in regards to health effects of sugars. This study

relied on PacTrac2 software to measure dietary added sugar intake and is both one of the study's strengths in having more local foods than most commercial software, but still a limitation in being able to capture many of the added sugar sources of young children. Thus, there is a need for further development of dietary analysis methods and for a dietary biomarkers approach using values of plasma glucose to measure added sugar consumption of children (Cook, Alvig, Liu, & Schoeller, 2010).

4.8CONCLUSION

This study found that age and obesity were inversely associated with added sugar intake when expressed in percentage. Sex, ethnicity, educational level of responding parent, and annual household income were found to be not associated with intake of added sugar. The younger age group in this study was particularly vulnerable to diets with high added sugar intake.

APPENDIX A. PACDASH INVITATION CARD

NO POSTAGE NECESSARY IF MAILED IN THE UNITED STATES

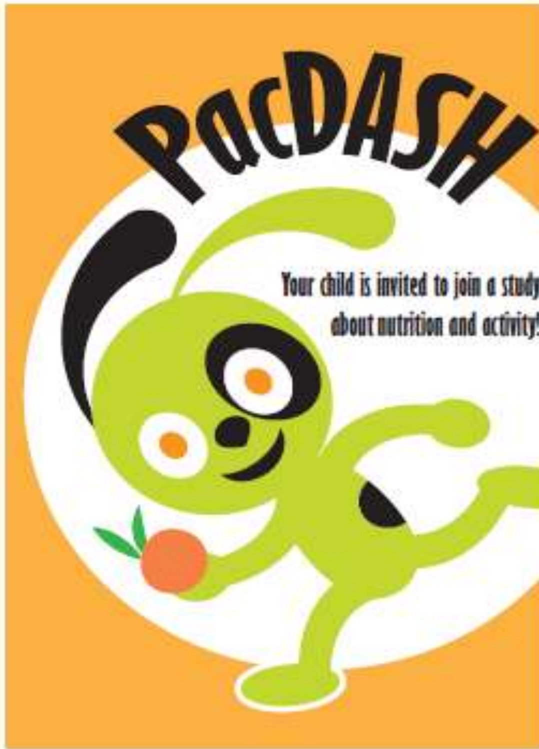
BUSINESS REPLY MAIL

FIRST CLASS MAIL PERMIT NO. 5962 HONOLULU HI

POSTAGE WILL BE PAID BY ADDRESSEE

CENTER FOR HEALTH RESEARCH, HAWAI'I
KAISER PERMANENTE
501 ALAKAWA STREET
HONOLULU HI 96817

PacDASH



Good nutrition, lots of physical activity, and fun are important ingredients to make a healthy child!

The Pacific Kids DASH for Health (PacDASH) study is looking at ways to improve the health of children through nutrition and physical activity.

Your child can join this study if:

- He/she is between the age of 5 and 8 years old
- He/she is due for or has a 'well child' visit scheduled at a Kaiser Permanente Clinic
- You and your child do **not plan to move** off O'ahu in the next 6 to 18 months

What happens in the study:

- Complete surveys and other assessments during 5 visits to the University of Hawaii Clinical Research Center.
- Attend a 'well child' visit at a Kaiser Permanente Clinic.
- Receive **up to 5 $30 gift cards** to thank you for your time.

Interested in joining? Please . . .

1. **Detach and complete the postcard at right**
2. **Mark "YES, I am interested..."**
3. **Then fold and mail it!**

OR Call us at **(808) 432-5777, extension 1459.**
We may call you if we receive no response.

A PacDASH staff member will contact you, answer any questions, check your eligibility to join the study, and schedule a visit.

KAISER PERMANENTE.

This study is being run by the Kaiser Permanente Center for Health Research, Hawaii, and the University of Hawaii with funding from the United States Department of Agriculture.

☐ **YES**, I'm interested in having my child participate in the PacDASH Project. A University of Hawaii Clinical Research Center staff member may contact me.

☐ **NO** thank you, I am **not** interested in having my child participate at this time. Contact me in a ☐ **month**/☐ **year**.

☐ **NO** thank you, I am **not** interested in having my child participate in the PacDASH Project.

FOLD HERE

TEAR HERE + FILL OUT, PEEL, FOLD & SEAL

Name: ________

Address: ________

Home phone: ________

Best time to call: ________

Work phone: ________

Best time to call: ________

Peel off strip ▼ to seal postcard sides together, then mail.

APPENDIX B. PREPARING FOR THE VISIT GUIDELINE

Preparing for the Visit

1. Bring the completed 2 days diet and activity forms and early life questionnaire.

2. Read and bring the assent/consent forms.

3. Have your child wear their bathing suit under their clothes. This will help us take the physical measures such as skin folds, circumferences and bone measures.

4. If for any reason you are unable to make the scheduled visit date please call the Clinical Research Center at 983-6234.

Pacific Kids DASH for Health
VISIT TO THE UH-CRC

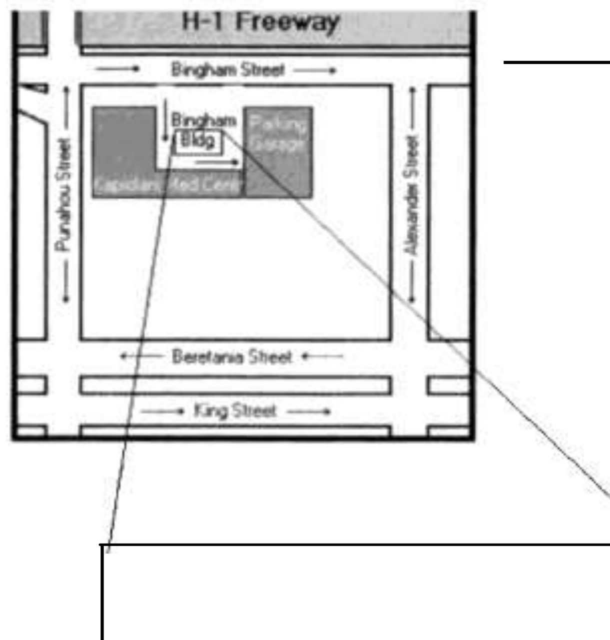
Name of Participants:
Parent/Legal Guardian:
Child:

1. Fill out diet and physical activity record on these dates:
   ____
2. Complete Early Life Questionnaire
3. Review Consent and Assent
4. Bring all forms to your visit at the University of Hawaii Clinical Research Center located at:

Kapiolani Medical Center for Women and Children
1319 Punahou St., Bingham Building, Room 101
Receptionist

Visit Date:

We look forward to seeing you! If you have any questions please call study coordinator Jane at (983-6234). Your parking will be validated. (Visit will be approximately 2 1/2 hours). Thank you!



APPENDIX C. INFORMED CONSENT AND ASSENT FORMS

Title: Pacific Kids DASH for Health (PacDASH)

Principal Investigator:	Rachel Novotny, PhD, RD	Phone:	(808) 432-5555 ext. 1426
Co-investigators:	Claudio Nigg, PhD John Grove, PhD Suzanne Murphy, PhD, RD Njeri Karanja, PhD		
Funded by:	United States Department of Agriculture		

INFORMED CONSENT
To Participate In A Research Study

Researchers at Kaiser Permanente in Hawaii are conducting a research study. To decide if you want your child to be part of this research, you must understand the risks and benefits to make an informed decision. You have the right to know what the purpose of the study is, how participants are selected, what procedures will be used, and what the potential risks and benefits and possible alternative treatments are. We also need to explain what is expected of you if you decide to allow your child to participate. This process is called "informed consent". This consent form gives information about the research study, which the study staff will discuss with you. Because your child does not have the legal capacity (under age 18) to consent to his/her participation, we must have permission from you. Therefore, you will be required to sign this form and your child (7 – 8 years old) will be asked to read and sign a separate form (assent). We encourage you to include your child in the discussion and decision to the extent that he/she is able to understand and take part.

This consent form may contain words or phrases that you do not understand. Please ask the study doctor or the study staff to explain any words or information that you do not clearly understand. You may take home an unsigned copy of this consent form to think about or discuss the study with family or friends before making your decision. Once you are satisfied that you understand the study and you choose to have your child participate in this study, you will be asked to sign and date this consent form. You will be given a copy of the signed and dated consent form.

PURPOSE OF RESEARCH STUDY

This research study, called Pacific Kids DASH for Health Study (PacDASH), is designed to look at ways to improve the health of children through nutrition and physical activity. Researchers would like to learn more about what children eat, what activities they like to do, and their thoughts about nutrition and physical activity. Other research have shown that children who form healthy habits become healthy adults. Families and family can support healthy habits.

Part of doing research is comparing follow more usual procedures. It is a which are important to research. To be in this you your child will need to to be randomly placed either in the group that will try new things (intervention) or the group that will follow usual procedures (usual care). Both groups materials and gift cards for in the study.

NUMBER OF PARTICIPANTS

About 360 children will be enrolled in this research study. Half of the children (180) will be randomly placed in the intervention group and 180 will be placed in the usual care group.

Kaiser Permanente – Hawaii Region
Institutional Review Board
Reapproved 14 January 2010 –5 January 2011

ASSENT FORM
To Participate in a Research Study
(CHILDREN 7 TO 8 YEARS OF AGE)

Study Title: Pacific Kids DASH for Health (PacDASH) Funded by: United States Department of Agriculture (USDA)

Principal Investigator:
Rachel Novotny, PhD, RD
Kaiser Permanente Center for Health Research
501 Alakawa St. Suite 201, Honolulu, HI96817
(808) 432-5555 ext. 1426

IT'S OKAY TO ASK QUESTIONS

Research is all about finding answers to interesting questions. Part of doing research is comparing groups that try new things to those that follow more usual procedures. It is also part of research to agree to be a part of either group, both of which are important to research. To be in this study, you will need to agree to be placed in the group that will try new things or the group that will follow usual procedures. Both groups get materials and gift cards for being in the study. You might read words in this paper that do not make sense. It's okay to ask the study staff member to tell you what the words mean. You might also hear this research project called "experiment," "protocol," "study," or just "research." These words all mean the same thing.

WHAT IS THIS RESEARCH STUDY ABOUT?

You are being asked to be in a research study. Before you can decide to be in this study:

1. Someone who works on the study will tell you all about the study and answer any of your questions.
2. It's OK to say "no" if you don't want to be in the study. You can still keep your doctor without being in this study.
   We will ask your parent/legal guardian if you may join the study and they will sign a form saying this is okay.
   You will to sign and write today's date on this form.
   You and your parent/legal guardian will get a copy of both forms.

The name of this study is Pacific DASH for Health or are studying how help kids be healthier by eating foods and being active. want to learn more about what kids eat, what things they like do, and what they think about health. Other research studies learned that children who form healthy habits become healthy adults. Your family and doctor can teach you about health habits.

APPENDIX D. MEASURING CUPS AND SPOONS

APPENDIX E. PHYSICAL ACTIVITY INTENSITY LEGEND

Use the following descriptions and examples to help you complete the Intensity column in the 2-Day Child Diet and Activity Record.

Low/Light

When you're moving at low intensity,

- You can talk and sing a song
- You're breathing normally
- Your heart is beating normally
- You're not sweating

Low intensity activities include

- Walking slowly
- Playing with toys, video games, cards, board games, and puzzles
- Stretching

Medium/Moderate·

When you're moving at medium intensity,

- You can still talk when moving, but can't sing a song
- Your heart is pumping
- You're breathing a little harder than usual
- You're sweating a little

Medium intensity activities include

- Hiking
- Walking fast
- Shopping

- Rollerblading, biking, riding a scooter, skateboarding
- Playing in the playground
- Doing housework- cleaning the house, vacuuming, raking leaves, gardening, washing windows, washing the car, taking out the trash

High/Strenuous

When you're moving at
high intensity,

- Your heart is beating fast
- You're breathing very hard
- You have a hard time talking while moving
- You're sweating

High intensity activities include

- Games with running and chasing such as tag
- Running
- Playing soccer or basketball
- Jumping rope
- Swimming

APPENDIX F. TWO-DAY DIET AND PHYSICAL ACTIVITY RECORDS AND INSTRUCTIONS

PacDash Study
University of Hawaii-Kaiser Permanente
2-day Child Diet and activity Record

INSTRUCTIONS

ID#:______________________.

We are interested in finding out what you do on a normal basis. Please do not change your eating or physical activity habits during the recording period.

Who is this for?	✓ For the child who is participating in our PacDASH study. The parent or guardian should fill out this Food and Activity Record, with help from the child. Call the PacDASH study line with questions at 432-5777 ext 1459.
When & Where?	✓ Record foods immediately after they are consumed. ✓ Keep the food and activity form with you at all times so that you can keep accurate records. ✓ Write the location of where the food/beverage was consumed.
What did you eat?	✓ Write down everything your child ate and drank throughout the day and night. ✓ Record only the portion which was consumed.
Describe it accurately.	✓ Include the cooking method used to prepare food e.g. baked, broiled, fried, canned, fresh, or frozen. ✓ Include brand names and the name of fast food restaurants whenever possible. ✓ Describe the liquid included in canned foods e.g. tuna in water, sliced peaches in heavy syrup. ✓ Include added condiments e.g. ketchup, mayonnaise, or mustard. ✓ Record the amount of oil added in cooking.
Physical activity?	✓ Record the type of activity your child did in e.g. swimming, running, playing tennis. ✓ Be as specific as possible. ✓ Include the intensity level of the activity e.g. light, moderate, hard. ✓ Estimate the duration of the activity and record it in the "activity" column. ✓ Be sure to include where your child did the activity.

KP -Center for Health Research Hawaii

PacDASH
2-Day Child Diet and Activity Record
ID#:____________________

DATE: Jan 22 2010

Day of the week: Friday

TIME	WHAT YOU ATE	DESCRIPTION	AMOUNT	PLACE	ACTIVITY	INTENSITY *
5am						
6am						
7am						
8am						
9am						
10am						
11am						
12noon						
1pm						
2pm						
3pm						
4pm						
5pm						
6pm						
7pm						
8pm						
9pm						
10pm						
11pm						
midnight						

APPENDIX G. CHILD SOCIO-DEMOGRAPHIC QUESTIONNAIRE

Child's Socio-Demographic Data

Today's Date:
11 / 4 / 2011
MM / DD / YYYY

Entered By:

1. ID:

2. Name of Parent/Guardian:

3. Child's Full Name (First, Middle, Last):

4. Child's Sex:
Male Female

5. Child's Birth Date (MM/DD/YYYY):
/ /

6. Has this child ever taken Prednisone, Azmacort, or any oral medication with steroid content for asthma?
Yes No I Don't Know
Oral
Inhaled

6a. How many courses of treatment has the child had in the last year?
(1 course being ≥ 3 continuous days treatment of oral or inhaled treatment)
courses

7. How often does the child take vitamin or mineral supplements?
Never 1-4 Days a Week 5-7 Days a Week I Don't Know

7a. When did your child start taking vitamins or mineral supplements?
When the child was:
months old. Or: years old.

8. How often does the child go to take-out restaurants (like McDonalds Burger King, L&L, plate lunch wagons)?

- ○ Never or Less Than once a month.
- ○ Once a month.
- ○ 2-3 times per month.
- ○ Once a week.
- ○ 2-3 times per week.
- ○ 4-6 times per week.
- ○ Once per day.
- ◉ 2 or more times per day

9. What is the ethnicity of each biologic parent of this child? (Estimate percent ethnicity of each parent).

Ethnicity	Father %	Mother %
Japanese		
White		
Hawaiian		
Filipino		
Chinese		
Others:		

APPENDIX H. FOOD SUBSTITUTIONS

Reported food items (alphabetical order)	Choose….
100% juice	Juice that is close to reported item (e.g., apple juice, orange juice. Do not choose XXXX DRINK)
Capri sun (100% juice)	Juice that is close to reported flavor (e.g.., apple juice, orange juice, grape juice, etc.)
Capri sun (original)	Fruit drink that is close to reported flavor (e.g.., passion orange drink, passion fruit drink, etc.)
Capri sun (Roarin' Water)	Fruit drink with sugar substitute
Cheetos	CHEESE PUFF (one individual serving = 1 cup)
Cheetos, Baked	CHEESE PUFF, CORN BASE, LOW FAT (one individual serving = 1 cup)
Doughnut, chocolate covered	Doughnut, cake (or yeast) type, sugared or glazed
Fruit punch drink (not 100% juice)	FRUIT PUNCH DRINK, CANNED
Fruit roll-ups	FRUIT LEATHER, ROLLS
Gummy Bear	2.75 pieces of gummy bear candy are equivalent to 1 piece (not small piece) of "CANDY, HARD"
Haagen-Dazs ice cream	ICE CREAM, RICH OR GOURMET (16% FAT) Note. Use ICE CREAM, REGULAR (10% FAT) for regular ice cream
Hot Dog (about 6 inches)	HOT DOG, BEEF OR PORK (serving size = 1 frankfurter) and HOT DOG BUN (serving size = 1 bun)
Hot Dog (beef) from Costco	SAUSAGE, FRUNFURTER BEEF (1 item (Costco)) and HOT DOG BUN (1.5 roll)
Hot Dog (Polish) from Costco	SAUSAGE, POLISH (0.45 sausage) and HOT DOG BUN (1.5 roll)

Hot Pocket	
Japanese cracker	ARARE [MIXED RICE CRACKERS]
Jell-O	GELATIN, FLAVORED, PLAIN (if sugar free, choose REDUCED CALORIES W/ASPARTAME. If with fruits, choose W/FRUIT)
Korean Seaweed (Nori)	SEAWEED, NORI, GREEN, DRY (1 sheet of NORI = about 8 sheets of Korean Nori)
Lean Pocket	
Lemonade homemade	LEMON JUICE, FRESH or CANNED OR BOTTLE, and SUGAR
Lemonade, commercial	LEMONADE, FROZEN, WITH WATER
Lemonade, Crystal light	CRYSTAL LIGHT
Li Hing Mui	UME or UMEBOSHI (if one or two pieces were consumed, you can ignore this item, but make a note to 2nd/3rd pass.)
Li Hing Powder	No equivalent item in PacTrac2. Make a note for 2nd and 3rd pass.
Oatmeal cooked, plain (e.g., Quaker Oats Old Fashion/Quick Oats)	CEREAL, OATS, REGULAR OR QUICK, NOT FORTIFIED, COOKED
POG juice / nectar	PASSION-ORANGE-GUAVA NECTAR
Popsicle	FRUIT ICE PREPARED W/WATER (serving size = 1 bar)
Poweraid	GATORADE
Real Fruit Bar	FROZEN FRUIT BAR (serving size = 1 bar)
Slurpee (7-11)	SHAVED ICE (1:4, 16 oz of Slurpee = 1 SHAVED ICE (1/2 cup), 22 oz = 1.4, 32 oz = 2, 44 oz = 2.75)
Slurpee (7-11) , sugar free	SHAVED ICE (1:6.7, 16 oz of Slurpee = 0.6 SHAVED ICE (1/2 cup), 22 oz = 0.85, 32 oz = 1.2, 44 oz = 1.65)
Spam musubi (unless homemade)	MUSUBI, SPAM

APPENDIX I: ANTHROPOMETRIC MEASUREMENTS

PacDash Study
University of Hawaii-Kaiser Permanente
Child Data Sheet

#:_______ Date:

ANTHROPOMETRY	Measurement 1	Measurement 2	Measurement 3
Weight (kg)			
Height (cm)			
Study Eligible? Yes No Eligible if greater than or equal to 50th - 98th BMI-for-age percentile			
Blood pressure			
Sitting height (cm)			

REFERENCES

Ainsworth, B. E., Haskell, W. L., Whitt, M. C., Irwin, M. L., Swartz, A. M., Strath, S. J., . . . Leon, A. S. (2000). Compendium of physical activities: an update of activity codes and MET intensities. *Medicine and science in sports and exercise, 32*(9 Suppl), S498-504.

Bermudez, O. I., & Gao, X. (2010). Greater consumption of sweetened beverages and added sugars is associated with obesity among US young adults. *Annals of nutrition & metabolism, 57*(3-4), 211-218. doi: 10.1159/000321542

Biro, F. M., & Wien, M. (2010). Childhood obesity and adult morbidities. *The American journal of clinical nutrition, 91*(5), 1499S-1505S. doi: 10.3945/ajcn.2010.28701B

Bowman, S. A., Friday, J. E., & Moshfegh, A. (2008). MyPyramid Equivalents Database, 2. 0 for USDA Survey Foods, 2003-2004 Food Surveys Research Group.

Brown, T., & Summerbell, C. (2009). Systematic review of school-based interventions that focus on changing dietary intake and physical activity levels to prevent childhood obesity: an update to the obesity guidance produced by the National Institute for Health and Clinical Excellence. [Review]. *Obesity reviews : an official journal of the International Association for the Study of Obesity, 10*(1), 110-141. doi: 10.1111/j.1467-789X.2008.00515.x

Chun, O. K., Chung, C. E., Wang, Y., Padgitt, A., & Song, W. O. (2010). Changes in intakes of total and added sugar and their contribution to energy intake in the U.S. *Nutrients, 2*(8), 834-854. doi: 10.3390/nu2080834

Cook, C. M., Alvig, A. L., Liu, Y. Q., & Schoeller, D. A. (2010). The natural 13C abundance of plasma glucose is a useful biomarker of recent dietary caloric sweetener intake. *The Journal of nutrition, 140*(2), 333-337. doi: 10.3945/jn.109.114777

Ervin, R. B., Kit, B. K., Carroll, M. D., & Ogden, C. L. (2012). Consumption of added sugar among U.S. children and adolescents, 2005-2008. *NCHS data brief*(87), 1-8.

Fitch, C., & Keim, K. S. (2012). Position of the Academy of Nutrition and Dietetics: Use of Nutritive and Nonnutritive Sweeteners. *Journal of the Academy of Nutrition and Dietetics, 112*(5), 739-758. doi: 10.1016/j.jand.2012.03.009

Frary, C. D., Johnson, R. K., & Wang, M. Q. (2004). Children and adolescents' choices of foods and beverages high in added sugars are associated with intakes of key nutrients and food groups. *The Journal of adolescent health : official publication of the Society for Adolescent Medicine, 34*(1), 56-63.

Freedman, D. S., Mei, Z., Srinivasan, S. R., Berenson, G. S., & Dietz, W. H. (2007). Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. [Research Support, N.I.H., Extramural]. *The Journal of pediatrics, 150*(1), 12-17 e12. doi: 10.1016/j.jpeds.2006.08.042

Gardner, C., Wylie-Rosett, J., Gidding, S. S., Steffen, L. M., Johnson, R. K., Reader, D., & Lichtenstein, A. H. (2012). Nonnutritive Sweeteners: Current Use and Health Perspectives: A Scientific Statement From the American Heart Association and the American Diabetes Association. *Circulation*. doi: 10.1161/CIR.0b013e31825c42ee

Gibson, S., & Boyd, A. (2009). Associations between added sugars and micronutrient intakes and status: further analysis of data from the National Diet and Nutrition Survey of Young People aged 4 to 18 years. *The British journal of nutrition, 101*(1), 100-107. doi: 10.1017/S0007114508981484

Gray, J. (2003). ILSI Europe concise monograph series: Carbohydrates: Nutritional and Health Aspects. *International Life Sciences Institute*.

Gropper, S. S., Smith, J. L., & Groff, J. L. (2009). Advanced Nutrition and Human Metabolism: *Carbohydrates*. (Fifth Edition), pp. 63-102.

Gurr, M. (1995). ILSI Europe concise monograph series: Nutritional and Helath Aspects of Sugars: Evaluation of new findings. *International Life Sciences Institute*.

Han, J. C., Lawlor, D. A., & Kimm, S. Y. (2010). Childhood obesity. *Lancet, 375*(9727), 1737-1748. doi: 10.1016/S0140-6736(10)60171-7

Harvey, A. E., Lashinger, L. M., & Hursting, S. D. (2011). The growing challenge of obesity and cancer: an inflammatory issue. [Review]. *Annals of the New York Academy of Sciences, 1229*, 45-52. doi: 10.1111/j.1749-6632.2011.06096.x

Herbst, A., Diethelm, K., Cheng, G., Alexy, U., Icks, A., & Buyken, A. E. (2011). Direction of associations between added sugar intake in early childhood and body mass index at age 7 years may depend on intake levels. *The Journal of nutrition, 141*(7), 1348-1354. doi: 10.3945/jn.110.137000

Krebs-Smith, S. M., Graubard, B. I., Kahle, L. L., Subar, A. F., Cleveland, L. E., & Ballard-Barbash, R. (2000). Low energy reporters vs others: a comparison of reported food intakes. [Comparative Study]. *European journal of clinical nutrition, 54*(4), 281-287.

Kuczmarski, R. J., Ogden, C. L., Grummer-Strawn, L. M., Flegal, K. M., Guo, S. S., Wei, R., . . . Johnson, C. L. (2000). CDC growth charts: United States. *Advance data*(314), 1-27.

Kuczmarski, R. J., Ogden, C. L., Guo, S. S., Grummer-Strawn, L. M., Flegal, K. M., Mei, Z., . . . Johnson, C. L. (2002). 2000 CDC Growth Charts for the United States: methods and development. [Comparative Study]. *Vital and health statistics. Series 11, Data from the national health survey*(246), 1-190.

Lee, S. K., Novotny, R., Daida, Y. G., Vijayadeva, V., & Gittelsohn, J. (2007). Dietary patterns of adolescent girls in Hawaii over a 2-year period. *Journal of the American Dietetic Association, 107*(6), 956-961. doi: 10.1016/j.jada.2007.03.009

Libuda, L., Alexy, U., Buyken, A. E., Sichert-Hellert, W., Stehle, P., & Kersting, M. (2009). Consumption of sugar-sweetened beverages and its association with nutrient intakes and diet quality in German children and adolescents. *The British journal of nutrition, 101*(10), 1549-1557. doi: 10.1017/S0007114508094671

Liem, D. G., & Mennella, J. A. (2002). Sweet and sour preferences during childhood: role of early experiences. [Research Support, U.S. Gov't, P.H.S.]. *Developmental psychobiology, 41*(4), 388-395. doi: 10.1002/dev.10067

Livingstone, M. B., Robson, P. J., & Wallace, J. M. (2004). Issues in dietary intake assessment of children and adolescents. *The British journal of nutrition, 92 Suppl 2*, S213-222.

Lohman, T. G., Roche, A. F., & Martorell, R. (1988). *Anthropometric standardization reference manual*. Champaign, IL: Human Kinetics Books.

Malik, V. S., Schulze, M. B., & Hu, F. B. (2006). Intake of sugar-sweetened beverages and weight gain: a systematic review. *The American journal of clinical nutrition, 84*(2), 274-288.
Marriott, B. P., Olsho, L., Hadden, L., & Connor, P. (2010). Intake of added sugars and selected nutrients in the United States, National Health and Nutrition Examination Survey (NHANES) 2003-2006. *Critical reviews in food science and nutrition, 50*(3), 228-258. doi: 10.1080/10408391003626223
Murphy, S., Blitz, C., & Novotny, R. (2006). Pacific Tracker (PacTrac): an interactive dietary assessment program at the CRCH website. *Hawaii medical journal, 65*(6), 175-178.
Murphy, S. P., & Barr, S. I. (2011). Practice paper of the American Dietetic Association: using the Dietary Reference Intakes. *Journal of the American Dietetic Association, 111*(5), 762-770. doi: 10.1016/j.jada.2011.03.022
Nicklas, T. A., O'Neil, C. E., & Liu, Y. (2011). Intake of added sugars is not associated with weight measures in children 6 to 18 years: National Health and Nutrition Examination Surveys 2003-2006. *Nutrition research, 31*(5), 338-346. doi: 10.1016/j.nutres.2011.03.014
Novotny, R., & Daida, Y. (2009). Methodology Paper- Blended ethnicity and health. *Hawaii Journal of Public Health, 2*(1), 1 - 6.
Novotny, R., Daida, Y. G., Acharya, S., Grove, J. S., & Vogt, T. M. (2004). Dairy intake is associated with lower body fat and soda intake with greater weight in adolescent girls. *The Journal of nutrition, 134*(8), 1905-1909.
Novotny, R., Nigg, C., McGlone, K., Renda, G., Jung, N., Matsunaga, M., Karanja, N. (2012). Pacific Tracker 2 – Expert System (PacTrac2-ES) behavioural assessment and intervention tool for the Pacific Kids DASH for Health (PacDASH) study. *Food Chemistry*.
Novotny, R., Oshiro, C. E., & Wilkens, L. R. (2013). Prevalence of Childhood Obesity among Young Multiethnic Children from a Health Maintenance Organization in Hawaii. *Childhood obesity, 9*(1), 35-42. doi: 10.1089/chi.2012.0103
Ogden, C. L., Carroll, M. D., Kit, B. K., & Flegal, K. M. (2012). Prevalence of obesity and trends in body mass index among US children and adolescents, 1999-2010. [Comparative Study]. *JAMA : the journal of the American Medical Association, 307*(5), 483-490. doi: 10.1001/jama.2012.40
Page, K. A., Seo, D., Belfort-DeAguiar, R., Lacadie, C., Dzuira, J., Naik, S., . . . Sinha, R. (2011). Circulating glucose levels modulate neural control of desire for high-calorie foods in humans. *The Journal of clinical investigation, 121*(10), 4161-4169. doi: 10.1172/JCI57873
Palou, A., Bonet, M. L., & Pico, C. (2009). On the role and fate of sugars in human nutrition and health. Introduction. *10*, 1-8. doi: DOI 10.1111/j.1467-789X.2008.00560.x
Prentice-Dunn, H., & Prentice-Dunn, S. (2012). Physical activity, sedentary behavior, and childhood obesity: a review of cross-sectional studies. *Psychology, health & medicine, 17*(3), 255-273. doi: 10.1080/13548506.2011.608806
Reedy, J., & Krebs-Smith, S. M. (2010). Dietary sources of energy, solid fats, and added sugars among children and adolescents in the United States. *Journal of the*

American Dietetic Association, 110(10), 1477-1484. doi: 10.1016/j.jada.2010.07.010

Schwartz, M. B., & Puhl, R. (2003). Childhood obesity: a societal problem to solve. *Obesity reviews : an official journal of the International Association for the Study of Obesity, 4*(1), 57-71.

Sievenpiper, J. L., de Souza, R. J., Mirrahimi, A., Yu, M. E., Carleton, A. J., Beyene, J., . . . Jenkins, D. J. (2012). Effect of fructose on body weight in controlled feeding trials: a systematic review and meta-analysis.*Annals of internal medicine, 156*(4), 291-304. doi: 10.1059/0003-4819-156-4-201202210-00007

Sigman-Grant, M., & Morita, J. (2003). Defining and interpreting intakes of sugars. [Review]. *The American journal of clinical nutrition, 78*(4), 815S-826S.

Song, W. O., Wang, Y., Chung, C. E., Song, B., Lee, W., & Chun, O. K. (2012). Is obesity development associated with dietary sugar intake in the U.S.? *Nutrition, 28*(11-12), 1137-1141. doi: 10.1016/j.nut.2012.03.008

Storey, M. L., Forshee, R. A., Weaver, A. R., & Sansalone, W. R. (2003). Demographic and lifestyle factors associated with body mass index among children and adolescents. *International journal of food sciences and nutrition, 54*(6), 491-503. doi: 10.1080/09637480310001622350

Thompson, F. E., McNeel, T. S., Dowling, E. C., Midthune, D., Morrissette, M., & Zeruto, C. A. (2009). Interrelationships of added sugars intake, socioeconomic status, and race/ethnicity in adults in the United States: National Health Interview Survey, 2005. *Journal of the American Dietetic Association, 109*(8), 1376-1383. doi: 10.1016/j.jada.2009.05.002

Tooze, J. A., Midthune, D., Dodd, K. W., Freedman, L. S., Krebs-Smith, S. M., Subar, A. F., . . . Kipnis, V. (2006). A new statistical method for estimating the usual intake of episodically consumed foods with application to their distribution. [Research Support, N.I.H., Extramural]. *Journal of the American Dietetic Association, 106*(10), 1575-1587. doi: 10.1016/j.jada.2006.07.003

Trumbo, P., Schlicker, S., Yates, A. A., Poos, M., Food, & Nutrition Board of the Institute of Medicine, T. N. A. (2002). Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids. *Journal of the American Dietetic Association, 102*(11), 1621-1630.

Welsh, J. A., Sharma, A. J., Grellinger, L., & Vos, M. B. (2011). Consumption of added sugars is decreasing in the United States. *American Journal of Clinical Nutrition, 94*(3), 726-734. doi: DOI 10.3945/ajcn.111.018366

Whitaker, R. C., Wright, J. A., Pepe, M. S., Seidel, K. D., & Dietz, W. H. (1997). Predicting obesity in young adulthood from childhood and parental obesity. *The New England journal of medicine, 337*(13), 869-873. doi: 10.1056/NEJM199709253371301

Whitlock, E. P., Williams, S. B., Gold, R., Smith, P. R., & Shipman, S. A. (2005). Screening and interventions for childhood overweight: a summary of evidence for the US Preventive Services Task Force. [Review]. *Pediatrics, 116*(1), e125-144. doi: 10.1542/peds.2005-0242