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ADDED SUGAR AND DIET QUALITY IN RURAL NATIVE AMERICAN AND NON-HISPANIC WHITE CHILDREN

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ADDED SUGAR AND DIET QUALITY IN RURAL NATIVE AMERICAN AND NON-HISPANIC WHITE CHILDREN

By

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ABSTRACT

ADDED SUGAR AND DIET QUALITY IN RURAL NATIVE AMERICAN AND NON-HISPANIC WHITE CHILDREN

By

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Intake of added sugar in the American diet increased approximately 40 percent from 1950-59 to 2000 and children are increasingly becoming overweight. Added sugar intake may also negatively affect diet quality by replacing nutrient-dense foods. The Institute of Medicine recommends that intake of added sugar not exceed 25 percent of total energy intake, whereas, the World Health Organization recommends that intake not exceed 10 percent. In this study we examined the association between added sugar intake and diet quality among a representative sample of Native American and non-Hispanic white children aged 1-6 (n=329), living in rural Oklahoma. Nutritional data were collected by two 85-item food frequency questionnaire given in-person to caregivers of 1-3 and 4-6 year old children. Median intakes of foods and nutrients and percent meeting recommendations were calculated across categories of added sugar intake. Children who were older, male, not enrolled in Women Infants and Children, and white were more likely to be in the highest categories of added sugar intake. Intakes of all micronutrients except for iron, vitamins C and E, as well as dairy and grain food groups, significantly decreased as added sugar intake increased in both age groups ($p<0.05$). Meeting recommendations for nutrients, however, did not vary significantly across added sugar intake. In conclusion, increased intake of added sugar substantially negatively affected diet quality in this population of rural Native American and white 1-6 year old children.

This project along with future work is in honor of my niece, April Michelle Sullivan, who taught me the true meaning of perseverance and to my grandfather, Earl Wesley Bliss, who taught me the importance of working hard.

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CHAPTER 1

INTRODUCTION

Based on food supply data, intake of added sugar increased 39% from 1950-59 to 2000 to an estimate of 149 pounds per year for each American (1). Intake of added sugar reached a peak in 1999 and has since slightly decreased (1). Even with the slight decrease the 2000 average of 32 teaspoons of added sugar intake per day is still greatly above the United States Departments of Agriculture (USDA) recommendation of 8 teaspoons per day (approximately 6% of total energy) for a 2,000 calorie diet (1, 2). Using national data, intakes of added sugar were reported (Guthrie 2000) at 15.2 teaspoons (15.9% of total energy) per day for children aged 2-5 years and 22.5 teaspoons (18.6% of total energy) per day in adolescence aged 6-11 years living in United States (3). These estimates were consistent with another study using national data published in 2005 that reported children aged 2-3 years consumed an average of 13.5 teaspoons (14.9% of total energy) per day and children aged 4-5 years consumed 17.2 teaspoons (16.5% of total energy) per day (4). Both studies report an intake of added sugar in children at nearly twice the amount that is recommended by the USDA. More specific literature review information regarding added sugar intake is available in chapter 2 of this thesis (see chapter 2, sections 1-4).

The term *added sugar* was developed by the USDA and refers to sugar that does not naturally occur in foods such as fruit or milk; it is sugar that is used for processing

and preparing food and that is added to foods directly before consuming (2). A few names of added sugar that are found in the food supply include: white sugar, brown sugar, corn syrup, dextrose, glucose, honey, high fructose corn syrup, molasses, raw sugar. It is found in many items such as breads, milk products, soft drinks, candy and ice cream (1). Data from the United States Department of Agriculture (USDA) 1994-96 Continuing Surveys of Food Intakes by Individuals (CSFII) found that the top contributor of added sugar in all Americans is soft drinks (33%) followed by sugars and candy (16%), other major contributors are depicted below (3). In children aged 2-5 years sugars/sweets (20.9%) was the top contributor followed by soft drinks (14.6%) in adolescences aged 6-11 years soft drinks was the number one contributor at 21.9% of total added sugar (3).

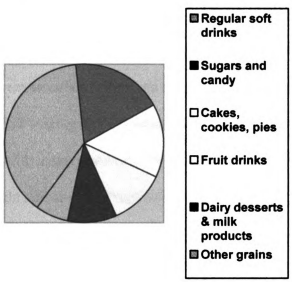

Figure 1. Contributors of added sugar to the diets of all Americans using national data (Guthrie and Morton 2000). The key to the pie chart starts with regular soft drinks as the largest section then follows clockwise going down the list.

Potential Consequences of Added Sugar Intake

According to the 2005 Dietary Guidelines Advisory Committee Report, people with a high intake of added sugar consume more calories and less nutrients than people with a low intake of added sugar (2). The report also states that sugar-sweetened beverage are associated with weight gain.. The increased intake of added sugar in children living in the United States is concurrent with the dramatic rise in childhood obesity and type 2 diabetes (5,6). Among children aged 2-5 years the prevalence of overweight (defined as at or above the 95th percentile of body mass index for age and gender) was 5.0% in 1971-74 and has increased to 13.9% in 2003-2004 (6,7). The prevalence of overweight for children aged 6-11 years has increased from 4% to 18.8% (6,7). In addition, the prevalence of persons at-risk of overweight (defined as at or above the 85th percentile and less than the 95th percentile for age and gender) aged 2-19 years was 33.6 in 2003-04, children aged 2-5 years was 26.2 and for 6-11 years 37.2 (5). Even though a direct association between total added sugar intake and weight status in young children is still lacking it is important to investigate this possibility. Moreover, Native American children have been shown to be more likely than all US children combined to be overweight and at-risk of overweight (8). Another concern is the increase in Type 2 diabetes among young children with Native Americans experiencing a disproportionate number of cases (6,9).

Recommendations and Guidelines

To monitor intakes of nutrients and food groups as well as to promote a healthy diet, recommendations and guidelines have been developed by organizations such as the

Institute of Medicine (IOM) and the USDA, in the US and by the World Health Organization, internationally. The USDA Food Guide MyPyramid (10) and the Institute of Medicine (IOM) Dietary Reference Intakes (DRIs) are current recommendations used in the United States (11). Due to increases in added sugar intake and overweight/obesity recommendations for *sugar* and *added sugar* have been debated (12). Scientists argue that since the body cannot distinguish between the two sugars a specific recommendation for added sugar may be misleading (13). However, according to the Dietary Guidelines for Americans 2005 foods high in added sugar should be limited because usually they lack nutrients whereas foods such as fruit and milk that contain naturally occurring sugar provide many nutrients (2, 13). Research has noted that consuming foods high in added sugar and calories replace more nutrient dense foods in the diet, thus causing a nutrient dilution effect (14). Another argument for distinguishing between *sugar* and *added sugar* is that added sugar is in many processed and ready to eat foods and consumers may not be aware of how much they are consuming. Furthermore, a group of health experts petitioned the FDA in 1999 to include information on food labels regarding total added sugars (15). The group also wanted the FDA to provide consumers with a guide similar to that of the USDA's Food Guide for added sugar.

DRIs & Added Sugar

Dietary Reference Intakes were more recently developed by the Institute of Medicine (IOM). They are a modified version of the Recommended Dietary Allowance (RDA) developed by the Food and Nutrition Board of the National Academy of Sciences/National Research Council in 1941 (11). DRIs consist of four values that may

be used for assessing nutrient intake adequacy in individuals and groups (Table 1). The Estimated Average Requirement (EAR) and Adequate Intake (AI) are used to measure adequacy in groups, RDA is used to measure individual intake and the Tolerable Upper Intake Level (UL) is the highest average nutrient intake level that will not cause harm to an individual. The official definitions are noted below.

Table 1. Definitions of Dietary Reference Intakes *

Estimated Average Intake (EAR)	The average daily nutrient intake level estimated to meet the requirement of half the healthy individuals in a particular life stage and gender group.
Recommended Dietary Allowance (RDA)	The average daily nutrient intake level sufficient to meet the nutrient requirement of nearly all (97 to 98 percent) healthy individuals in a particular life stage and gender group.
Adequate Intake (AI)	A recommended average daily nutrient intake level based on observed or experimentally determined approximation or estimates of nutrient intake by a group (or groups) of apparently healthy people that are assumed to be adequate-used when an RDA cannot be determined.
Tolerable Upper Intake Level (UL)	The highest average daily nutrient intake level likely to pose no risk of adverse health effects to almost all individuals in the general population. As intake increases above the UL, the potential risk of adverse effects increases.

*These definitions were taken directly from the Institute of Medicine (National Academy Press; 2000 (11)

In 2002 the IOM released the Dietary Reference Intakes for macronutrients including a recommendation for *added sugar.* The recommendation states that the daily intake of added sugar should not exceed 25% of total energy because of potential adverse health effect such as dental caries, obesity and inadequate intakes of nutrients. However, a tolerable upper intake level (UL) for added sugar was not set (16). This recommendation came shortly after a request by The Dietary Guidelines Advisory

Committee (DGAC) for more research to be conducted on the potential adverse health effects of intakes of *sugar* and *added sugar* (17). Other groups such as The World Health Organization (WHO) (18) and the USDA Food Guide MyPyramid (10) have recommended limits much lower than the IOM recommendation, <10% of total energy and between 6-10% of total energy, respectively. The American Heart Association Dietary Guidelines recommends reducing intake of added sugar (12).

Food Group Servings

The Food group servings defined by the USDA have changed slightly over the past ten years. MyPyramid formerly known as The Food Guide Pyramid is a tool used to promote healthy eating (www.MyPramid.gov). The six food categories and the suggested servings for the MyPyramid are: Grains (6 ounces), Vegetable (2 ½ cups), Fruit (2 cups), Milk (2 cups for children aged 2-8 years), Meat and beans (5 ½ ounces), and Oils (3-7 teaspoons depending on age and gender) (10). However, since this is a secondary data analysis and the data was collected in 1997 the study collaborators used the Food Guide Pyramid for Young Children. The suggest servings for five main food groups are slightly different, and are as follows: Grains (6 servings i.e. one serving equals 1 slice of bread or ½ cup of rice), Vegetable (3 servings i.e. one serving equals ½ cup raw or cooked), Fruit (2 servings i.e. one serving equals 1 piece of fruit or ¾ cup of juice), Milk (2 servings i.e. one serving equals 1 cup milk or 2 ounces of cheese), and Meat (2 servings i.e. one serving equals 2 to 3 ounces of cooked meat or ½ cup of dry beans)(10).

Brief Summary of Literature

Added Sugar and Nutrient Intake, Food Group Servings, Diet Quality

Recent data has suggested an association of added sugar and nutrient intake in children living in Australia, Germany, Great Britain, Norway and the United States (4,19-25). Mean intake of added sugars as percent of total energy of children aged 2-18 years range from 12.4% to 18.4% (4, 21, 22, 24). The range for children less than 18 years old living in the United States is 5.6% to 26.7% (4, 13, 21, 24). Significant decreases in intakes of calcium, fiber, folate, iron, and vitamin A were found as total added sugar intake increased (4, 20, 21). Food groups such as vegetables and fruits showed a significant decrease with increasing intakes of total added sugar (4, 20, 21, 23). When reporting total added sugar and nutrient intake for children, six out of seven articles reviewed for this thesis reported that the category with the highest added sugar intake had the lowest intake of all micronutrients, except for vitamin C (4, 20-23, 25).

Sugar Sweetened Beverages and Nutrient Intake, Food Group Servings, Diet Quality

According to Morton and Guthrie using national data, the consumption of soft drink (including carbonated water and carbonated juice drinks) increased from 198 grams in 1998-91 to 279 grams in 1994-95 (26). Many studies have examined the association between beverages and nutrient intake due to the dramatic increase in consumption of non-diet soft drinks (27-31). Of five studies that investigated the affect of beverage consumption on nutrient intake in children four showed a negative association between non-diet soft drinks and calcium (28-30). Two studies that examined the association

between adequacy of nutrients or diet quality and sugar-sweetened beverages found a negative association (28, 30).

Added Sugar and Weight

Little research has been reported on added sugar intake and weight in young children. However, reports on sugar-sweetened beverages and weight in children (aged 1-6 years) has not shown consistent results (32-34). Two prospective cohort studies that examined children found associations between small changes in BMI and sugar-sweetened beverages (33,34). A 2006 literature review that examined 30 publications found that epidemiologic evidence does indicate an association between sugar-sweetened beverages and weight gain/obesity (32). More specifically, soda was shown in the promotion of overweight and weight gain in children and adolescents (32).

Nutrient Intake, Food Group Servings and Diet Quality in Young, Low-Income, Native Americans Living in Rural America

The increasing intakes of added sugar in children living in the United States coincide with reports of inadequate intakes of important nutrients and food groups among low-income and minority populations (35-37). Calcium is an important nutrient for growth especially in children and has been reported to be below recommended levels (26,27). Knol et al. examined dietary patterns of children from low-income families living in the United States and concluded that out of 2,748 children aged 2-8 years not one child had a dietary pattern that followed a balanced diet as recommended by the USDA Food Guide Pyramid (FGP) (35). Munoz et al. reported that of a representative

sample of 3,307 youth aged 2-19, years only 1% met the recommendations of the FGP (34). In addition, among the 2-11 year olds meeting recommendations for vegetable and fruit intake ranged from 17.8% to 35.4% (37).

Specific Aims

Most studies that have reported on diet/diet quality involving children use national data and very few studies report on low-income, rural, or Native American children. Meanwhile these populations experience a disproportionately higher prevalence of overweight and many diseases (5, 9). To my knowledge, no study has yet examined the intake of total added sugar and nutrient and food group servings among Native American children.

The purpose of this study is to examine the potential association of total added sugar on diet quality (defined in this study as meeting recommendations) and health behaviors (median intake of nutrients, food groups, and beverages, BMI-for-age, and hours played outside) of Native American and non-Hispanic white children from low-income families living in rural United States.

The specific aims of this study are the following:

Aim 1) To examine the association between sociodemographic and health behavior characteristics with added sugar intake as percent of total energy among Native American and non-Hispanic white children aged 1-6 in rural Oklahoma. Given differences in added sugar recommendations between IOM (≤25% of total energy) and WHO (<10% of total energy) we will categorize the data into 4 groups (<10%, 10-<16%, 16-≤25%, >25%).

Aim 2) To examine the potential association between intake of added sugar and measures of diet quality among Native American and non-Hispanic white children aged 1-6 in rural Oklahoma. We will report median intake as well as the percent of children meeting the DRIs for macronutrients (carbohydrate, protein, fat and fiber), micronutrients (calcium, iron, folate, zinc, vit. A, vit B1, vit B6, vit C, and vit E) and food groups (grains, meat, vegetable, fruit and dairy) within each category of added sugar.

This introduction (chapter 1) is followed by a literature review (brief summary followed by literature review summary tables) (chapter 2), manuscript for publication (chapter 3), conclusions/public health implications (chapter 4) and appendices. Some of the information may be repeated due to chapter 3 (manuscript).

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CHAPTER 2

BACKGROUND & LITERATURE REVIEW

Relevant articles that examined the relationship between added sugar intake, nutrient intake and food group servings in children were identified for this literature review. Using Medline, the following key words and phrases were used to obtain articles: "added sugars and children," "added sugars and CSFII," "added sugars and NHANES," "added sugar and diet quality," "sweetened beverages and children," "soft drinks and children," "DRI and children," "sweetened beverages and weight," "diet quality and children," "nutrients and children," and "Food Guide Pyramid and children." Additional articles were found by cross-checking the references of key articles. Inclusion criteria were: published in English, published between 1990 and 2006, the study population had to be of children, exposure variable of "added" sugar (defined as sugars not naturally occurring in foods) and meeting nutrient or food group recommendations. In addition to the main exposure (added sugar) and outcome (diet quality), I also used the key words: sugar sweetened beverages and weight.

Most identified articles were based on data from United States national data (Continuing Survey of Food Intake in Individuals (CSFII) or The National Health and Nutrition Examination Survey, (NHANES), use only two days of diet data which may not be accurate, are cross-sectional in design and include a wide range of children's ages. Few articles report nutrient intake, food group servings or diet quality in low-income, rural and Native American children.

In total I identified twenty-three articles that examined the association between added sugar and nutrient or food group intake, diet quality and weight in children. Twenty-one of these studies are cross-sectional and four are cohorts. This literature review is divided into four sections, articles may be used in more than one section: I. Association of added sugar in children (ages 1-6 years) with nutrient intake, food servings and diet quality (8 articles) II. Association of sweetened beverage consumption in children (ages 1-6 years) with nutrient intake, food servings and diet quality (5 articles) III. Association of sweetened beverage/added sugar with weight in children (ages 1-6 years) (6 articles, 2 are reviewed in another section also) IV. Nutrient intake/food servings/diet quality in rural, low-income and/or Native American in children (ages 1-6 years) (6 articles). Each section begins with the most recently published article in that section.

Table 2.1 Added Sugar and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Kranz S et al.[1] 2005 J Pediatr Cross-sectional, population-based *Key Article	2-5 year olds CSFII 1994-96, and 1998 N=5437	Added sugar consumption for five categories (≤10%energy from added sugar, 11-15%, 16% to 20%, 21 %to 25% and >25%) Added sugar is defined as all caloric carbohydrate sweeteners (sugars added during processing, eaten separately or added at the table) Diet measured by 2 averaged 24-hour recalls	Diet quality: Mean nutrient and food group consumption and proportion of children not meeting the DRI (AI or EAR)	Income and ethnicity: (non-Hispanic white (non-Hw), non-Hispanic black (non-Hb) and Hispanic), stratified by age	Trends of energy, nutrient, and food group intakes with increasing added sugar consumption (a) 2-3 year olds (b) 4-5 year olds reporting p-value, test for trend (followed by direction) nutrients (a) (b) Energy (kcal) .01 (+) <.71 (+) Carbohydrate <.001(+) <.001(+) Protein <.001 (-) <.001 (-) Fat <.001 (-) <.001 (-) Fiber <.001 (-) <.001 (-) Calcium <.001 (-) <.001 (-) Iron <.001 (-) <.001 (-) Folate <.001 (-) <.001 (-) Vitamin A <.001 (-) <.001 (-) Vitamin B12 <.001 (-) <.001 (-) Vitamin C .09 (-) .02 (-) Food groups Grains <.07 (-) <.001 (-) Vegetable <.07 (-) <.001 (-) Fruit <.001 (-) <.001 (-) Dairy <.001 (-) <.001 (-)	(+) large sample (+) nationally representative -trends for intake of almost all nutrients and food groups with increasing levels of added sugar consumption are significant

Table 2.1 Added Sugar and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6 con't.						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Frary C et al.[2] 2004 Journal of Adolescent Health Cross-sectional, Population-based	6-17 year olds CSFII 1994 - 96, and 1998 6-11: N =1913 12-17: N=1125 Response rate=day1 80%, day2 76%	Added sugar foods and beverages 5 categories identified :1) Sugar-sweetened beverages, 2) sugars and sweets, 3) sweetened grains, 4) sweetened dairy and 5) presweetened cereals, broken down into 4 groups: (a) nonconsumers (b) low consumers (c)moderate consumers (d) high consumers 2 averaged 24-hour recalls	DRIs (Adequate Intakes (AI), Recommended Daily Allowance (RDA))	Age, gender, race and total energy intake	Calcium: only 6-11 year olds group (a) met the AI Folate: 6-11 year olds met DRI except for nonconsumers of presweetened cereals and high beverage consumers, one group among the 12-17 year olds met DRI, high consumers of presweetened cereals Iron: all groups had mean iron intakes that met DRI, however, intakes decreased with an increase in beverages, sugars & sweets and sweetened grains Fiber: fiber decreased as added sugar consumption increased, except as sweetened dairy products and presweetened cereal consumption increased Food Guide Pyramid servings: fruit and vegetable decreased by more than a half and almost a full for children and adolescents respectively as sugars and sweets increased, no group met the servings for dairy	(+) population-based (+) large sample size (-) 4 groups of consumption not clearly defined (-) results are confusing; p-values are not reported, hence the summary in the results column

Table 2.1 Added Sugar and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6 con't.						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Alexy et al. [3] 2003 British Journal of Nutrition Cross-sectional analyses from a Longitudinal cohort Population-based	Children and adolescents aged 2-18 yrs old N=849 Dortmund Nutritional and Anthropometric Longitudinally Designed (DONALD) Study Data collected from 1985-2001	Added sugars defined as all refined sugars used in processing or added at the table, fortified food and energy intakes, time and age 3-days of averaged dietary records (1-16 records per participant were used)	median intakes of nutrients and food groups	Time trends, age, and gender	Association of increasing intakes added sugar, and nutrients and food groups, reporting p-values for 2-18 year olds, followed by direction <u>Nutrient</u> Fat (% E) <0.0001(-) Vitamin A <0.0001(-) Vitamin C <0.0001(-) Thiamin 0.0378(-) Folate <0.0001(-) Calcium <0.0001(-) Iron 0.0002(-) <u>Nutrient (% total food intake)</u> Dairy 0.9302 (-) Meat, fish and eggs <0.0001(-) Fats and oils <0.0001(-) Grain <0.0001(-) Fruits and vegetables <0.0001(-) Beverages <0.0001(+) Sugary foods <0.0001(+)	(+) nutrient density - nutrient intakes are associated with added sugar consumption

Table 2.1 Added Sugar and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6 con't.						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Overby et al.[4] 2003 Public Health Nutrition Cross-sectional Population-based *Key Article	Children and adolescents in Norway 4 year olds: N=391 9 year olds: N=810 13 year olds: N=1005	Added sugar defined as refined or industrially produced sugar used as an ingredient in processed or prepared foods (cakes, cookies, soft drinks); not sugar in fruits and milk 4-day food diary	Mean intakes of nutrients and food groups and data on weight and height	Stratified by age; 3 groups, gender	For 4 yr-olds, 9 yr-olds and 13 yr-olds had a mean added sugar intake 15.1%, 16.8%, 18.4% of energy respectively ANOVA to test differences between Added sugar split into quartiles (% from energy , <11.4, 11.4-14.6, 14.6-18.4, >18.4) reporting p-values 4-yr-olds Energy 0.447 Protein (% E) 0.000 fat, sat. (% E) 0.000 fat (% E) 0.000 carbohydrate (% E) 0.000 added sugar (% E) 0.000 fiber 0.000 Retinol equivalents 0.006 α-tocopherol 0.083 vitamin D 0.050 thiamin 0.000 riboflavin 0.000 vitamin C 0.470 calcium 0.000 iron 0.001	(+) weight and height recorded (self reported) -intakes of all nutrients except α-tocopherol and vitamin C decreased with increasing consumption of added sugar

Table 2.1 Added Sugar and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6 con't.						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Forshee et al.[5] 2001 Journal of the American College of Nutrition Cross-sectional, population-based	1994-96 CSFII ages 2-19 years 3 groups: over 2 years 6-11 years 12-19 years	Added sugars defined as sugars not naturally occurring in foods 2 averaged 24-hour recalls	Food groups in Food Guide Pyramid (FGP) and % of RDA of selected vitamins and minerals	Age, gender, stratified by age	Ages over 2 yr: Nutrients (-) association w/vit. A, and calcium @ 0.05 level, (+) association w/iron and folate @ 0.05 level Food groups: (-) association with vegetable ($p<0.01$), fruit and dairy @ 0.05 level, (+) association w/grain & lean meat @ 0.05 level 6-11 years old The only significant findings include (+) association w/vit c and grain @ 0.05 level	(-) large range of ages (+) population based -children that consumed more sugar consumed less dairy

Table 2.1 Added Sugar and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6 con't.						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Bowman, SA[6] 1999 Family Economics and Nutrition Review Cross-sectional Population-based	United States 1994-96 CSFII Population ≥2 years old N=14709	Calories from added sugar, defined as ingredients in processed and prepared foods or added to foods at the table 1-24 hour recall Divided into 3 groups (% energy from added sugars): less than 10%, 10-18% and > 18%	Mean intakes of macro and micronutrients	None reported	Mean (std. error) intakes % energy from added sugars(AS) nutrients \<10% 10-18% >18% Energy 1860,15.0 2040,18.1 2049,17.2 Total fat(g) 73,0.9 78,0.1 70,0.8 Sat fat 24,0.3 27,0.4 25,0.3 Carb(g) 211,1.7 256,2.2 292,2.4 Protein 81,0.7 78,0.7 66,0.7 Dietary fib(g)17,0.2 16,0.2 13,0.2 % of calories from fat 35.3 34.4 30.7 % of energy AS 5.6 13.9 26.7 Thiamin(mg) 1.6,0.01 1.7,0.02 1.5,0.02 Riboflavin(mg) 1.9,0.02 2.0,0.02 1.8,0.02 VitA 1080,23.0 1031,26.8 850,20.2 Vit E 8.3,0.13 8.4,0.15 7.1,0.12 Vit C 106,2.2 101,1.8 90,1.5 Niacin 23,0.2 23,0.3 20,0.3 Vit B6 1.9,0.02 1.9,0.02 1.6,0.02 Folate 275,3.6 272,3.8 228,3.6 Vit B12 5.4,0.18 5.2,0.23 4.3,0.13 Calcium 788,8.1 838,10.1 745,11.0 Phosphorus 1251,9.4 1277,12.51130,11.4 Magnesium 285,2.4 277,3.1 233,2.6 Iron 15.6,0.14 16.1,0.19 14.1,0.18 Zinc 11.5,0.15 11.6,0.15 10.1,0.13 Copper 1.2,0.01 1.2,0.01 1.1,0.01	(-) all ages were grouped together (+) large sample size -Group 3 w/the highest consumption of added sugar had the lowest mean intake of all nutrients

Table 2.1 Added Sugar and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6 con't.

Author Date Journal Study Design	Population/ Sample Size	Exposure	Outcome	Confounders	Results	Comments
Farris et al.[7] 1998 Journal of the American College of Nutrition Cross-sectional Population-based	10 yr olds black & white population N=568 Data collected (1984-85 or 1987-88) Bogalusa Heart Study	Total sugar* (not added sugar) Collected by 24-hour dietary recalls Quartiles of total sugar	Vitamins, minerals (RDA) and food groups	Nothing was controlled for, however the distribution of race and gender were reported	Sugar intake ranged from 10-183 g/1000 kcal, mean intake of 75 g/1000 kcal Mean % of added sugar from energy was 15.2% and ranged from 9.2% to 22.8% Reporting p-value for trend for increasing total sugar intake and nutrients (Quartiles) Mean/1000kcal Energy (kcal) 0.0001 Protein(%E) 0.0001 Fat (%E) 0.0001 Carb 0.0001 Vit B6 0.0001 Vit E 0.0001 Calcium 0.05 Iron 0.0001 Zinc 0.0001	(+) fairly large sample of 10 yr olds (-) total sugar (-) one 24-hour recall used
Gibson, SA[8] 1997 British Journal of Nutriton Cross-sectional, population-based *Key Article	Children aged 1.5 to 4.5 years N=1675 boys and girls	Non-milk extrinsic sugars (NMES)	Micronutrient intakes, food groups, breakfast cereals, bread, vegetables, fruit juice, soft drinks & confectionery	Boys and girls reported separately	**NMES** Boys Girls Mean (% of energy) 18.9 18.6 Median (% of energy) 17.5 18.2 P-value Boys Girls direction Energy 0.033 NS (+) Calcium <0.0001 <0.0001 (-) Iron 0.0018 NS (-) Zinc <0.0001 <0.0001 (-) Thiamin <0.0001 0.0009 (-) Riboflavin <0.0001 <0.0001 (-) Niacin 0.0005 0.0006 (-) Folate 0.032 0.006 (-) Vitamin C <0.0001 <0.0001 (+)	

Table 2.2 Sugar Sweetened beverages and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Forshee et al.[9] 2006 Journal of the American College of Nutrition Cross-sectional, Population-based	5 age groups 6-11 years 12-19 years 20-39 years 40-59 years 60+ years 1994-96, 1998 CSFII & NHANES 1999-2002	Beverage consumption: Non-milk beverage & fluid milk 2-24 hour recalls	Calcium intake	Race/ethnicity, age, total calories, beverages were added in one at a time to the regression models	Reporting for 6-11 yr olds only Mean intake males Calcium (mg) 993.5 regular carbonated soft drinks (RCSD)(g) 283.7 Females Calcium (mg) 858.2 RCSD (g) 212.7 Multivariate regression beverages on calcium intake RCSD - 0.03 (-0.87) Fruit juice 0.2 (3.10)	(-) sample size not reported -consumption of fruit juice was positively associated w/calcium consumption and RCSD was negatively associated with calcium consumption
Marshall et al.[10] 2005 Journal of the American College of Nutrition Cross-sectional, Population-based	Children aged 1-5 N=645 Participants of the Iowa Fluoride Study	food and beverage intake 3-day food dairy	Diet quality (nutrient adequacy ratios calculated as the nutrient intake to RDA/AI ratio)y	Ages reported both separately and together, total energy	Due to the nature of my research question I am reporting added sugar beverages (ASB)on adequacy ratio only Adequacy ratio p-value (ASB) Protein <0.001 Riboflavin <0.001 Niacin <0.001 Vitamin B-6 <0.001 Vitamin B-12 NS Vitamin C NS Vitamin A <0.001 Vitamin D NS Vitamin E <0.01 Calcium <0.01	(+) young age group -added sugar beverages and 100% juice decrease diet quality in children

Table 2.2 Sugar Sweetened beverages and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6, con't.

Author Date Journal Study Design	Population/ Sample Size	Exposure	Outcome	Confounders	Results	Comments
Rodriguez-Artalejo et al. 11 2003 British Journal of Nutrition Cross-sectional, population based	Spanish children aged 6-7 years in four Spanish cities N=1112 Response rate=85%	Bakery products (biscuits, ensaimadas, doughnuts, croissants, cakes and pastries,churros, chocolates, cookies and mantecados), sweetened soft drinks (carbonated and non-carbonated but excluding 100% fruit juice) and yogurt 77-item FFQ	Nutrient intake and diet quality (healthy-eating index, HEI)	Matched on sex and socio-economic level in recruitment to obtain similar numbers of both in sample, results are not stratified	Bakery products, sweetened soft drinks & yogurt broken down into quintiles Reporting sweetened soft drinks Q1 Q2 Q3 Q4 Q5 BMI 17.1 16.5 16.9 16.9 17.5 Total energy 8433 8605 8930 9086 9343 Fat (%E) 47 45 46 46 46 Sat fat (%E) 17 17 17 16 17 Carb (%E) 37 39 39 38 38 Sugars (%E) 20 22 21 21 21 Protein (%E) 18 17 17 17 17 Cholesterol 175 162 166 170 175 Niacin 2608 2509 2733 2766 3061 Calcium 1560 1560 1582 1591 1586 Vitamin A 641 646 667 682 687 Vitamin C 185 197 197 211 202 Folic acid 199 205 207 218 210 Fruits g 291 284 336 330 355 Vegetables 308 344 334 346 307 Milk ml 389 385 388 383 346 Dairy product (minus milk) 93 84 95 104 144 Fruit juice 175 135 162 181 214 HEI 64 66 65 65 62	-milk consumption decreased with increasing consumption of sweetened soft drinks. BMI was highest among Q5

Table 2.2 Sugar Sweetened beverages and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6, con't.						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Ballew et al.[12] 2000 Arch Pediatr Adolesc Med Cross-sectional, Population-based	children aged 2-5, 6-11, and 12-17 participating in CSFII 1994-96 n=4070 2-5 yr (1800) 6-11 yr (1282)	Beverage choices (milk, 100% juice, fruit-flavored drinks or carbonated sodas) one 24-hour recall	DRIs	Total nutrient intake, age, gender, race/ethnicity and household income expressed as poverty income ratio	Reporting for the 2-5 and 6-11 yr olds, the adjusted OR (99% CI) of achieving recommended intakes of nutrients w/intake of carbonated drinks <u>2-5 yr olds</u> Vitamin A — Vitamin C 0.97(0.94, 0.99) — 0.97 (0.95, 0.99) Folate — Vitamin B12 0.99 (0.96, 1.02) — 0.99 (0.89, 1.10) Calcium — Magnesium 0.96 (0.91, 0.99) — 0.90 (0.79, 1.04) 2-5 yr olds fruit-flavored drinks Vitamin A — Vitamin C 1.01(0.98, 1.04) — 1.24 (1.18, 1.30) Folate — Vitamin B12 1.01 (0.97, 1.05) — 1.01 (0.95, 1.08) Calcium — Magnesium 1.03 (0.97, 1.08) — 1.05 (0.94, 1.17)	-carbonated soda consumption significantly decreased consumption of milk and juice for all ages, intakes of all nutrients decreased with consumption of carbonated soda

Table 2.2 Sugar Sweetened beverages and Nutrient Intake, Food Group Servings, Diet Quality in Children Aged 1-6, con't.

Author Date Journal Study Design	Population/ Sample Size	Exposure	Outcome	Confounders	Results	Comments
Harnack et al.[13] 1999 JADA Cross-sectional, Population-based	United States Children aged 2-18 yrs 1994 CSFII N=1,810 3 separate age groups 2-5 yrs old 6-12 yrs old 13-18 yrs old Response rate=76.2%	Carbonated soft drink 2 24-hour recalls were used	Consumption of milk, fruit juice and nutrients in these beverages	Age, race, gender and energy intake	2-5 yr olds mean±standard error (3 groups of soft-drink consumption) Nutrient **nonconsumers (nc)** **0.1 to 8.9oz/d** Energy 1448±39.5 1483±42.3 Fat(% of E) 33.0±0.63 33.5±0.66 Carb(% of E) 53.0±0.69 52.9±0.99 Protein(% of E) 15.3±0.21 14.7±0.22 Riboflavin 1.67±0.04 1.54±0.04 Folate 188.8±9.7 187.4±10.0 Vit A 3467±351.4 3147±371.0 Vit C 81.7±6.39 74.3±6.62 Calcium 722.0±18.7 635.2±20.4 Phosphorus 949±14.0 872±15.2 2-5 yr olds **≥9 oz/d** **(nc)** Energy 1704±59.8 1830±58.7 Fat(% of E) 33.43±0.86 32.6±0.54 Carb(% of E) 54.6±0.99 52.5±0.73 Protein(% of E) 13.1±0.33 16.0±0.28 Riboflavin 1.30±0.06 1.98±0.05 Folate 147.7±12.5 242.2±10.9 Vit A 2404±507.5 4228±465.4 Vit C 62.3±8.27 94.3±6.14 Calcium 527.6±31.0 845.6±30.3 Phosphorus 771±23.0 1172±25.2	(+) large sample size (+) dietary data collected using 2 nonconsecutive days -children who consumed the most soft drinks consumed the least milk

Table 2.3 Added Sugar and Weight in Children Aged 1-6

Author Date Journal Study Design	Population/ Sample Size	Exposure	Outcome	Confounders	Results	Comments
O'Connor et al.[14] 2006 Pediatrics Cross-sectional, Population-based	Children aged 2-5 years N=1160 73.8 % response rate for these analyses NHANES 1999-02	Beverage consumption 1-24 hour recall	Weight status (BMI percentile for age and gender ased on CDC definition)	Age, gender, ethnicity, household income, energy intake, physical activity	Association between fruit juice & BMI p=.30 Association between fruit drinks & BMI p=.81 Association between regular soda & BMI p=.88	(-) self reported (parent report) height and weigh
Welsh et al.[15] 2005 Pediatrics Retrospective cohort Children were sampled from WIC participants in Missouri	Low-income children aged 2-3 years N=10,904 Missouri Pediatric Nutrition Survellance Systen (PedNSS) and Missouri Demonstration Project	Sweet drinks, including all sugar-sweetened and naturally sweet drinks 3 24 hour recalls (Harvard Service FFQ)	Overweight (BMI ≥95% percentile for age and gender)	Age, gender, race/ethnicity (model 1), dietary factors (intake of high fat foods and sweets) (model 2), and total energy intake (model 3)	0-<1 drink is the reference Reporting the adjusted OR & 95% CI1.5 (0.9-2.4) Sweet drinks/day Model 1 Model 2 Model 3 Normal or underweight at baseline 1-<2 1.5 (0.9-2.4) 1.5 (0.9-2.4) 1.3 (0.9-2.4) 2-<3 1.4 (0.8-2.4) 1.4 (0.8-2.2) 1.4 (0.8-2.3) >3 1.3 (0.8-2.1) 1.2 (0.8-2.0) 1.3 (0.8-2.1) at risk of overweight 1-<2 1.8 (1.2-2.9) 2.0 (1.3-3.2) 2.0 (1.3-3.2) 2-<3 1.9 (1.2-3.0) 2.1 (1.3-3.4) 2.0 (1.2-3.2) >3 1.7 (1.1-2.7) 1.9 (1.2-3.0) 1.8 (1.1-2.8) overweight 1-<2 1.7 (1.1-2.7) 2.1 (1.3-3.3) 2.1 (1.3-3.4) 2-<3 1.9 (1.2-3.0) 2.2 (1.4-3.7) 2.2 (1.4-3.7) >3 1.6 (1.0-2.4) 1.8 (1.1-2.8) 1.8 (1.1-2.9)	(-) parent defined servings (+) large sample size (+) measured height and weight

Table 2.3 Added Sugar and Weight in Children Aged 1-6 con't.						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Newby et al.[16] 2004 JADA Prospective cohort participants of WIC in North Dakota	Children aged 2-5 years N=1,345	Beverages (reporting sweetened drinks, fruit drinks, soda non-diet) FFQ assessing usual intake (1 month time frame)	Weight change	Gender, age, baseline weight and change in height and energy	Reporting BMI change/year ß± standard error followed by P-value Fruit drinks -0.01±0.01 .39 Soda -0.01±0.02 .58	(+) measured height and weight -sweetened beverages not associated w/ BMI change
Overby et al.[4] 2003 Public Health Nutrition Cross-sectional Population-based	Children and adolescents in Norway 4 year olds: N=391 9 year olds: N=810 13 year olds: N=1005	Soft drinks/lemonade 4 day food dairy	BMI	Stratified by age; 3 groups, gender	Low vs. high added sugar consumers (drinks and foods combined) 4 year old Girls Q1 Q4 p-value BMI 15.7 (1.5) 16.1 (1.7) 0.341 Overweight 13.8 9.1 0.529 4 year old Boys Q1 Q4 p-value BMI 15.7 (1.3) 16.3 (1.4) 0.055 Overweight 5.7 13.3 0.290	(-) weight and height recorded (self reported)

Table 2.3 Added Sugar and Weight in Children Aged 1-6 con't.						
Author Date Journal Study Design	**Population/ Sample Size**	**Exposure**	**Outcome**	**Confounders**	**Results**	**Comments**
Forshee and Storey [17] 2003 International Journal of Food Sciences and Nutrition Cross-sectional Population-based	Children aged 6-19 years CSFII 1994, 96 and 98	Beverage consumption 2-24 recalls	BMI	Age, race/ethnicities and gender	Reporting regression coefficients, significant at 5% level reporting **Regular soft drinks** Boys BMI 4.8 (1.29) not significant Age 51.3 (10.52) significant African American -1481.1 (-3.74) significant Girls BMI 0.4 (0.21) not significant Age 23.2 (7.99) significant African American 92.0 (3.22) significant	(-) self-reported height and weight -Individuals in the first decile drink 212.9 grams of beverages/day and in the tenth 2036.2 grams/day
Rodriguez-Artalejo et al. [11] 2003 Bristish Journal of Nutrition Cross-sectional	Children aged 6-7 years N=1112 Living in four Spanish cities	Sweetened soft drinks FFQ-times per day, week, month and year were obtained	BMI	Energy intake	Sweetened soft drinks BMI (kg/m^2) $\leq$ 1 ml 17.1 >1 and $\leq$ 13 ml 16.5 >13 and $\leq$28 ml 16.9 >28 and $\leq$59 ml 16.9 >59 and $\leq$801 ml 17.5 difference of fifth minus first quintile BMI 0.4, significant without adjustment for total energy	(+) measured height and weight

Table 2.4 Nutrient Intake, Food Group Servings and Diet Quality in Young, Low-Income, Native Americans Living in Rural America

Author Date Journal Study Design	Population/ Sample Size	Exposure	Outcome	Confounders	Results	Comments
Knol et al.[18] 2005 JADA Cross-sectional Population-based	2-3 yr olds (n=1,242) 4-8 yr olds (n=1,506) Low-income population CSFII 1994-96, 98	Dietary variables from Food Guide Pyramid (main and subgroups) including added sugars 2 24-hour recalls	Dietary patterns using cluster analysis	Results reported separately by age	Reporting intake of added sugars (% of energy) only for 4 dietary patterns separated by age (2-3, 4-8yrs) mean (SEM) 2-3 yrs / 4-8 yrs Big: 14.97(0.50) / Big: 18.61(0.68) Light: 14.23(0.47) / Light: 16.15(0.34) Bean eaters: 14.16(0.70) / Meat & green: 12.64(1.06) Substituters: 16.09(1.29) / Substituters: 20.32(0.72)	(+)low-income children population (-)dietary patterns are empirically defined mean added sugar consumption (% of total energy) varied from 14.16 to 20.32, no cluster meet the Food Guide Pyramid Recommendations
Stroehla et al.[19] 2005 JADA Cross-sectional Population-based	Rural non-Hispanic white and Native American children aged 1-6 years living in Oklahoma (1997) N=329 Response rate 61%	Dietary nutrient and food group intake modified Full Block/National Cancer Institute FFQ (previous month time frame)	Ranked lists of food sources of energy, macronutrient and micronutrients	Age and race/ethnicity reported separately	Ranked food and beverage sources of energy, macronutrients and fiber % of energy / rank Nondiet soft drinks: 6 Candy, all kinds: 9 Sweetened fruit drinks: 10 Cake, cookies: 12 % of carbohydrates Nondiet soft drinks: 1 Sweetened fruit drinks: 3 Candy: 9 Jelly, jam, honey: 12	(+) first study to examine contributions of macro and micronutrients in the diets of rural, low-income children (+) same study population as in my research

Table 2.4 Nutrient Intake, Food Group Servings and Diet Quality in Young, Low-Income, Native Americans Living in Rural America Con't.

Author Date Journal Study Design	Population/ Sample Size	Exposure	Outcome	Confounders	Results	Comments
Champagne et al.[20] 2004 JADA Cross-sectional Population-based	Children aged 3-18 yrs of age (n=485) Lower Mississippi Delta of Louisiana, Arkansas, and Mississippi Data collected In 2000	Food intake 1 24-hour recall	Comparison with national survey data	Age and race/ethnicity reported separately Delta white (D-W), Delta black (D-B), US white (US-W), US black (US-B)	children and mean added sugar intake (tsp) (D-W) (D-B) (US-W) (US-B) Mean (SEM) 30(1.4) 26(1.2) 26(0.6) 23(0.7) p-value for significance of added sugar and race/ethnicity D-W vs US-W: 0.0194 D-B vs US-B: NS D-W vs D-B: NS	((+) rural population (-)only one 24 hour recall (-)wide range of ages (3-18 yrs) (-)added sugar is not in % of energy
Kranz et al.[21] 2004 Am J Public Health Cross-sectional, population-based	American children (2-5 yr olds) US Dept of Agriculture's National Food Consumption (NFCS77) Survey 1977-79 N=2342 CSFII 1989-91 N=858 (CSFII94) N=5355	Nutrients, foods and food groups	Diet quality; measured by Diet Quality Index for Children (C-DQI)	Year of data collection, race/ethnicity, urbanicity, maternal employment and education status	CSFII94 Low / high AS %E: 17.6+0.20520 / 13.2+0.361 Total fat: 33.2+0.1846 / 31.3+0.2033 Sat fat%E: 12.8+0.0963 / 11.7+0.013 Grains: 5.1+0.0720 / 7.3+0.0816 Fruit: 1.9+0.0633 / 2.9+0.0774 Vegetables: 1.8+0.0345 / 2.7+0.0588 Excess juice: 1.0+0.0437 / 0.7+0.0649 Dairy: 1.9+0.0485 / 2.0+0.0253 Iron, mg: 10.4+0.1363 / 13.9+0.1805 Energy: 1476.1+1.1823 / 1631.7+2.2301	(+) the authors created an index to determine diet quality (+) large sample Size (-) different dietary assessment methods used in surveys

Table 2.4 Nutrient Intake, Food Group Servings and Diet Quality in Young, Low-Income, Native Americans Living in Rural America Con't.

Author Date Journal Study Design	Population/ Sample Size	Exposure	Outcome	Confounders	Results	Comments
Brady et al.[22] 2000 British Journal of Nutrition Cross-sectional, population-based	Black and white children Aged 7-14 years N=110 Birmingham, AL enrolled in an longitudinal study of childhood obesity	Dietary intake 3 24-hour recalls	National Recommendations (Food Guide Pyramid)	Social class (determined by the Hollingshead 4-factor index of social class) and total energy	Food Guide Pyramid: mean values w/the standard error (reporting unadjusted) Food group Servings/d white black Grain 6.9(0.30) 6.2(0.40) Vegetable 2.3(0.20) 2.4(0.20) Fruit 0.70(0.10) 1.0(0.10) Dairy 1.4(0.60) 0.80(0.10) Meat 3.7(0.30) 4.7(0.30) Added sugar in (MJ/d)=AS 1.6 (0.10) 1.4(0.08) Discretionary fat (MJ/d) 2.1(0.10) 2.1(0.10)	(-)small sample size (+) black/white participants (+)ethnic differences for added sugar intake disappeared after controlling for confounders
Munoz et al.[23] 1997 Pediatrics Cross-sectional, Population-based	2-19 year olds United States CSFII 1989-91 N=3307 (CSFII94) N=5355	Food intake 3 days of diet intake	Food Guide Pyramid recommendations	Race/ethnicity, gender and income level	Proportion of children meeting recommendations Males grain veg fruit 2-5 22.2 (.04) 17.8 (.03) 33.8 (.04) 6-11 36.2 (.04) 35.4 (.04) 27.8 (.03) Females 2-5 13.7 (.03) 20.4 (.03) 30.2 (.04) 6-11 35.1 (.03) 34.3 (.03) 34.1 (.04) Race/ethnicity W, non-Hisp 33.7 (.02) 34.4 (.02) 26.6 (.02)	(+/-)wide range of ages, results are not always stratified by age

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CHAPTER 3

MANUSCRIPT

Introduction

Based on food supply data intake of added sugar increased 39% from 1950-59 to 2000 to an estimate of 149 pounds per year for each American (1). Intake of added sugar reached a peak in 1999 and has since slightly decreased. Even with this slight decrease the 2000 average of 32 teaspoons of added sugar intake per day is still greatly above the United States Departments of Agriculture (USDA) recommendation of 8 teaspoons per day (approximately 6% of total energy) for a 2,000 calorie diet (1,2). Using national data intakes of added sugar were reported (Guthrie 2000) at 15.2 teaspoons (15.9% of total energy) per day for children aged 2-5 years and 22.5 teaspoons (18.6% of total energy) per day in adolescence aged 6-11 years living in United States (3). These estimates were consistent with another study using national data published in 2005 that reported children aged 2-3 years consumed an average of 13.5 teaspoons (14.9% of total energy) per day and children aged 4-5 years consumed 17.2 teaspoons (16.5% of total energy) per day (4). Both studies report an intake of added sugar in children at nearly twice the amount that is recommended by the USDA. Added sugar intake has also been associated with inadequate intakes of important nutrients and food groups among children (4-7).

"Added sugar" refers to sugar that does not naturally occur in foods, such as fruit or milk; it is sugar used for processing and preparing food and sugar added to foods at the table (8). Added sugar includes white sugar, brown sugar, cane sugar, corn syrup, honey,

high fructose corn syrup and is found in items such as soft drinks, candy, ice cream, and syrup. The top contributors of added sugar to children's diet have been found to be soft drinks, fruit drinks and desserts (2, 4). Data from the United States Department of Agriculture (USDA) 1994-96 Continuing Surveys of Food Intakes by Individuals (CSFII) demonstrate that consumption of soft drinks was the number one contributor to total added sugar intake in children aged 2-5 years at 14.6% and 21.9% of total added sugar in children aged 6-11 years (2).

Multiple studies have shown that added sugar intake and consumption of sweetened beverages, are associated with inadequate micronutrient intake and diet quality in children (4, 5, 9-12). Using national data Kranz et al. reported that for most micronutrients mean intake significantly decreased as added sugar consumption increased in American children aged 2-5 years. This was also true of the fruit and dairy food groups (4). Results similar to the above study were found in children living in Germany, Australia, Great Britain and Norway (6, 7,13,14). Similar negative associations between soft drinks and most micronutrients, fruits, vegetables and dairy have been observed with increased intake of soft drinks (9-12).

To monitor intakes of nutrients and food groups of children in the United States researchers, nutritionists and public health officials depend on guidelines developed by the USDA Food Guide Pyramid for young children (15) and the Institute of Medicine (IOM) Dietary Reference Intakes (DRIs) (16). In 2002 the IOM released DRIs for macronutrients, where the recommendation for *added sugar* is for intake to not exceed 25% of total energy, and a tolerable upper intake level (UL) for sugars was not set (16). This recommendation was developed in response to a request by The Dietary Guidelines

Advisory Committee (DGAC) for more research to be conducted on the potential adverse health effects on intakes of *sugar* and *added sugar* (17). The World Health Organization (WHO) (18) and the USDA Food Guide Pyramid (19) have recommended limits much lower than the DRI, <10% of total energy and between 6-10% of total energy, respectively. The 2000 American Heart Association Dietary Guidelines recommended avoiding foods that contain a lot of sugar; no limit was set (19). Recommendations were made due to possible adverse health effects of a high consumption of added sugar such as increased incidence of obesity and dental caries, inadequate intakes of calcium, fruit and vegetables (16, 18).

Due to the established association between childhood nutrition and adverse health outcomes in both childhood and adulthood (20) the DRI currently set for added sugar needs to be evaluated. In addition, most data reported on nutrient intake, food group servings and diet quality involving children use national data, very few studies report on low-income, rural, or Native American children who experience disproportionately higher prevalence's of overweight and diseases (23, 24). Further, to our knowledge no study has yet examined the intake of added sugar on nutrient and food group servings in Native American children.

The purpose of this research is to examine the association of increasing intake of added sugar on medium intakes of nutrient and food group servings as well as diet quality (defined as meeting recommendations for DRIs and food group servings) among Native American and non-Hispanic white children.

Methods

Study population

Data were collected in 1997 as part of a community-based lead intervention study conducted in northeastern rural Oklahoma (25). The data are from a representative cross-sectional sample of Native American and non-Hispanic white caregivers of children aged 1 to 6 years that were living in Miami, OK.

Families were eligible for the study if they had a white or Native American child aged 1-6 years and lived in one of the 31 census block groups that were part of the study area. To recruit the desired number of Native American families, researchers tried a variety of tactics including attending tribally-sponsored events and visiting tribal housing. Teams visited 5,572 residences and identified 550 eligible families. Out of 550 families 137 refused to participate, 77 families could not be interviewed, and 5 did not give complete information, leaving 331 families, of which one child was randomly selected per family for a response rate of 60.2%. Of the final sample that agreed to participate, 43.5% were Native American (n=144) and 56.5% were non-Hispanic white (n=187). Two children were considered ineligible for from these nutritional analyses because one child ate exclusively baby food and another had Phenylketonuria and were excluded from analyses. The final sample size for this study included 329 children aged 1-6. The research protocol was approved by the University of Oklahoma Health Sciences Center Institutional Review Board, and for this analysis the Institutional Review Board at Michigan State University.

Nutritional Data

An extensive questionnaire to assess sociodemographic, physical activity, height, weight and diet was administered in-person at the child's home by trained interviewers.

To determine average daily dietary intake, an 85-item modified Block/NCI Food Frequency Questionnaire (FFQ) was administered to caregivers of study children. The questionnaire collected information on the child's "usual" intake of food in the month prior to the interview as the time frame. The FFQ was modified to include certain foods and exclude others (not on the original Block/NCI) after consultation with key study informants and dieticians from the local population concerning dietary habits of these rural children. An open-ended section was also included in the questionnaire so that the caregivers could add any foods that were not listed. Specific brand names of breakfast cereals consumed were also recorded. To assess portion-size, two questionnaires were developed: one for the 1 and 2-year-old children and another for the 3 to 6 year-old children. For each food item, small, medium, large, and extra-large portions were developed. These portion sizes were estimated from existing national data as well as information collected from local key informants including local dieticians.

Added Sugar Intake

Information on each food items added sugar content was added to the FFQ software DIETSYS nutritional database by a study investigator (Berrit Stroehla). Values were estimated by the software "THE FOODPROCESSER" (http://www.esha.com/) to come up with the added sugar content of each food (grams per day). Primary contributors to 'added sugar intake' included items such as non-diet soft drinks, Kool-Aid, candy, sweetened fruit drinks, cakes and cookies. For these analyses, to standardize on total energy intake, added sugar intake was examined as percent of energy from added sugar, calculated by taking the total gram intake, multiplied by four to obtain energy intake (26). This quotient was then divided by total calories and multiplied by 100.

Percent of energy from added sugar intake was categorized as follows: <10%, 10-<16%, 16-≤25%, >25%. These categories were chosen to reflect the recommendations made by the WHO (World Health Organization; 2003) and the IOM (National Academy Press; 2002).

Variables

We examined the median intakes of each nutrient from foods within each category of percent of energy from added sugar, vitamin supplement intake was not examined. Next, we examined the median intake of food group servings from the USDA Food Guide Pyramid for Young Children. (http://www.usda.gov/cnpp/KidsPyra) within each category of percent of energy from added sugar. To determine diet quality we looked at the percent meeting the recommendations for the following nutrients and food group servings. For iron, folate, zinc, magnesium, vitamin A, vitamin B6, vitamin C and vitamin E we used the Estimated Average Requirements (EAR) cut-point method (16). Simply, the EAR cut-point method is the percent of the population that meets the requirement and that percent is reported. For fiber and calcium we used the Adequate Intake (AI), this measurement examines the mean intake of the group for each nutrient and if that is not met than the group intake is inadequate. For fat, carbohydrate and protein the acceptable macronutrient distribution ranges, these ranges are used to assess adequacy, were examined. The recommendations for food group servings are from the United States Department of Agriculture Food Guide Pyramid for Young Children (15). To examine nutrient intakes we standardized the diets of the study population to 1000 kcal.

Sociodemographic and health behavior variables, including body mass index were examined. BMI was examined using the Centers for Disease Control gender specific growth charts; (http://www.cdc.gov/growthcharts). The following health behaviors were assessed: the number of months the child was breastfed (three categories 0, ≤1, >1), BMI-for-age (two categories <85th, 85th percentile and above) and hours played outside per day (three categories 0-3, > 3). These cut-points were established after reviewing the distribution of data. The following demographic information was also assessed: federal poverty threshold (<100, 100-185 and >185), primary caregiver enrolled in the federal program for Women, Infants and Children (WIC) (yes, no) and race/ethnicity (Native American or non-Hispanic white).

Statistical analyses

For all analyses Statistical Analysis System (SAS) version 9.1was used. We first examined the distribution of each variable to identify outliers. Descriptive statistics were computed and reported for sociodemographic variables and health. Given differences in added sugar recommendations between IOM (≤25% of total energy) and WHO (<10% of total energy) we analyzed the data by 4 categories (<10%, 10-<16%, 16-≤25%, >25%). To test for trend between mean and median intakes of macro and micronutrients as well as food groups and added sugar intake (% of total energy) we used the nonparametric Kendall test (data retained as continuous variables). To determine if there was a trend between added sugar and diet quality (defined here as meeting recommendations either DRIs or USDA) we used the Cochran Armitage test for trend (2-sided test). Where sample size permitted we also examined results stratified by gender and race/ethnicity using the Wilcoxon-Mann-Whitney test for median intakes and Chi-square for diet

quality. Analyses are reported separately for two age groups, 1-3 and 4-6 year olds to align with the recommended DRIs, except where specified and 2-6 year olds are grouped for analyses of BMI-for-age and the USDA Food Guide Pyramid (FGP) for Young Children.

Results

The total study population had approximately an equal number of males and females 50.8% (n=167) and 49.8% (n=162), respectively, comparable number of children in each age group (1-3 years =50.8% and 4-6 years=49.8%, respectively) and slightly more non-Hispanic white children (56.8%) than Native American children (43.2 %) (Table 1). A total of 54.5% and 53.1% of caretakers of 1-3 and 4-6 year olds, respectively, were living at < 100% of poverty ($16,400 in 1997, http://www.census.gov). Over half of the population was enrolled in the Federal program for Women, Infants and Children (WIC) (73.6% 1-3 and 42.0% 4-6 year olds) and 15.5% of 2-6 year olds in the study population was either at-risk of overweight or overweight (85th percentile and above) at the time of the questionnaire administration.

Added Sugar and Beverages

Due to sweetened beverages being identified as one of the major contributors to added sugar intake in children (Guthrie 2000, 2), we examine the association between added sugar categorist and median intake of groups of beverages (Table 2). We examined three overlapping groups of beverages: group 1 (juices and soft drinks, not including diet), group 2 (Kool-Aid and soft drinks), and group 3 (carbonated drinks, both diet and regular). The highest intake reported was for 1-3 year olds at 1954.3 grams/day

of group 1 (juices and soft drinks) in the highest category of added sugar. While this estimate seems very high it is consistent with a previously reported intake of 2036.2 grams/day that used national data (Forshee 2003, 35).

Added Sugar and Covariates

Overall, the median percent of energy from added sugar in the children aged 1-3 years was 9.8% (10.1% in females, 9.1% in males) and in children aged 4-6 years was 14.1% (12.9% in females, 14.2% in males). Children that consumed < 10% of their calories from added sugar and therefore were least likely to consume added sugar were more likely to be aged 1-3 years (50.9% vs. 29.0% 4-6 year olds), female (43.2% vs. 37.1% males), < 100 % federal poverty (44.1% vs. 34.5% in 100-185% and 30.8% in >185%), enrolled in WIC (48.7% vs. 27.7% not enrolled), played less outside (50.0% vs. 34.4% in >3 hours), Native American (43.7% vs. 37.5% in non-Hispanic white.) (see Table 3). Children enrolled in WIC were also less likely to be in the highest two categories of added sugar consumption (20.4% combined) then those who were not enrolled (38.7% combined).

Added Sugar and Median Nutrient Intake

Next we examined median nutrient intake within categories of added sugar intake (percent of total energy) (Table 4). With the exception of carbohydrates (% of total energy), energy (kcal) and vitamin C median intakes of all other nutrients decreased with increasing intake of added sugar for both age groups (Table 4). Nutrients except energy (kcal), fiber and vitamin E were significantly negatively associated with increasing added sugar intake for the 1-3 year olds. For 4-6 year olds the only non-significant negative associations were for energy (kcal) and vitamin C. Most notable in this study was the

intake of calcium, which decreased by almost half from the lowest to highest added sugar category in both age groups (p=<0.0001).

We also looked at median intakes of nutrients within each age group by intake of added sugar and by race/ethnicity and gender (appendices 4.1 and 4.2). Native Americans consumed more energy in both age groups then did non-Hispanic white children as intake of added sugar increased the same was true for males in the 1-3 age group, whereas females consumed more energy in the older age group (4-6 years). Significant differences were seen in the 1-3 year olds for total calories (p=0.02),iron (p=0.03) and for 4-6 year olds calcium (p=0.04) phosphorus (p=0.04), vitamin A (p=0.01), protein (p=0.01), vitamin B1 (p=0.01), for gender (appendix 4.2). No significant differences were noted between race/ethnicities.

Added Sugar and Median Intake of Food Groups

Next we examined the median intake of servings from the USDA Food Guide Pyramid for Young Children with increasing intakes of added sugar (Table 5). Negative associations were significant for grains (p=0.047), total fruit (p=0.001) and dairy (p=<0.001). Only median intakes of dairy and meat met the recommended servings of 2/day in any category of added sugar for all children aged 2-6 years. The only significant differences by race/ethnicity was for servings of meat (p=0.04) (appendix 5.1). Gender was significantly associated with servings of vegetables (p=0.05) (appendix 5.2).

Added Sugar and Diet Quality

To determine diet quality we examined the percent of children meeting recommendations for nutrients and servings of food groups within category of added sugar intake. The percent of children meeting recommendations in the group of 4-6 year olds experienced a

significant decrease for folate and magnesium as the intake of added sugar increased (Table 6). The mean intake in each category of added sugar for fiber and calcium were compared to the AI to determine if the DRI was met. Not one category of added sugar in either age group had a mean intake that met the AI for fiber (data not shown). The mean intake for calcium in the 1-3 year olds in the highest two categories of added sugar did not meet the AI, and in the older children not one category of added sugar had a mean intake that was adequate (data not shown). Due to small numbers in each category of added sugar and meeting or not meeting recommendations statistics for race/ethnicity and gender were not available.

Next we looked at the percent of children meeting national FGP recommendations. For each food group there was a reduction in those meeting recommendations as intake of added sugar increased (Table 7). Not one food group had 100% of the children meeting recommendations. In the highest category of added sugar (25% or more of total energy) zero percent of the children met recommendations for grains, vegetables and fruit. Due to small numbers in each category of added sugar and meeting or not meeting recommendations statistics for race/ethnicity and gender were not available.

Discussion

We identified significant decreases in median intake of almost all micronutrients with increasing intake of added sugar in this population of rural Native American and non-Hispanic white children aged 1-6 years. Calcium, folate, phosphorus and vitamins A

and E intake were particularly at risk of decreasing with increasing added sugar intake. Median servings of every food group were lowest in the highest category of added sugar compared to the lowest; this was most true for dairy and fruit. Median intakes of some beverages in the highest added sugar category were approximately 8 times that of the lowest category. Children in the youngest age group (1-3 years) did not meet adequate intakes fiber in category of added sugar and for calcium when intake of added sugar was greater than 16% of total energy. The percent population of 4-6 year olds meeting national DRI recommendations significantly decreased as added sugar increased for folate and magnesium and the percent meeting recommendations for the food groups dairy and total fruit significantly decreased as added sugar increased. Among older children group intakes were inadequate for calcium and fiber in every added sugar category. Among the 4-6 year olds energy decreased slightly as added sugar increased (a similar finding was reported by Overby et al. 2003, 14). Fat significantly decreased in both age groups as intake of added sugar increased, this finding is consistent with published research (4, 13, 14). Overall, very few children are consuming the recommended number of servings for grains, vegetables and fruit regardless of which added sugar category they were in.

The negative association found between added sugar and key nutrients such as calcium, fiber, folate, iron, and vitamin A in this study are similar to other research (4, 9, 13, 14). Kranz et al. stratified data from the Continuing Survey of Food Intake by Individuals (CSFII), 1994-96 and 1998 into 5 categories of added sugar with the highest category >25% of total energy from added sugar. They found that among 2-5-year-olds mean intakes of all the micronutrients examined (calcium, iron, folate, vitamin A, B_{12}, C)

were the lowest in the highest category of added sugar (4). Bowman et al. using national data also reported that intake of all micronutrients were the lowest in the highest category of added sugar (>18% of total energy)(9).

Research has also shown decreases in servings of food groups such as grains, vegetables and fruit as total added sugar consumption increased (4, 9,14,). National data showed that fruit decreased by at least one whole serving (recommended amount is 2 servings) from the lowest to the highest category of added sugar in 2-5 year olds (4). This is very important since these foods are believed to offer health benefits beyond the positive health effects of vitamins.

Studies that examine consumption of sugar sweetened beverages and diet have also found a negative association between sweetened beverages and calcium, milk, folate and vitamin A (10, 11, 27). National data from 1994-96 showed a negative association with carbonated soda consumption and intakes of calcium and vitamin A in children aged 2-5 years (12). Harnack et al using national data reported that of children aged 2-18 years those who consumed the most soft drinks compared to those who consumed the least had the lowest intake of milk and fruit juice (27).

Fortification of foods such as cereal may also have an impact on added sugar and diet quality. Alexy et al.reported a positive association between intakes of added sugar and fortified foods (28). Relying on vitamin supplements or fortification is not recommended by the Dietary Guidelines 2005 for two reasons (8). First of all, foods have benefits other than nutrients such as phytochemicals that may be important to health. Secondly, consuming vitamin supplements or fortified foods may increase risk for over consumption of certain micronutrients, which can be harmful (8).

Research has also identified a potential relationship between consuming sugar-sweetened beverages and weight gain in children (29). However, a study that examined children aged 2-5 years using data from Nutritional Health and Nutrition Examination Survey (NHANES) 1999-2002 did not find an association of consumption of soda and BMI (30). They concluded that prospectively studying these children may provide a clearer answer since overweight is a result of consuming more calories than is exerted over time and the age of these children may be too young for conclusive results (30). We found that the prevalence of children in this study population at or above the 85th percentile (BMI-for-age) was nearly 15.5% at the time of the study. Our data does not show a significant number of overweight children in the highest two added sugar categories.

An important strength of this study is that it is the first to our knowledge to examine the association between added sugar consumption and nutrient intake, servings of food and diet quality in rural Native American children. The use of a FFQ in this study is a strength because it has the ability to capture the total 'usual' diet of an individual rather than their diet on one day. The FFQ was modified for this study population and was administered in the participant's home by two trained interviewers. Children's height and weight were also measured, not self-reported.

Limitations in this study must also be considered. Recall bias may be present here since the data collected by the FFQ used a month prior for the interview timeframe; caregivers may not be able to remember everything that the child ate. Studies have validated the use of the FFQ in capturing diets of young children by comparing multiple FFQ's with diet records and biomarkers (33, 34). Although interviewers were trained

and monitored to insure the accurate collection of data there is a possibility of foods left out because a participant may have had more than one caregiver.

Our study, along with others that examined national data, does show an association between intake of added sugar and decreased intakes of micronutrients, servings of fruit, vegetables and dairy. We also found that children did not have an adequate intake of calcium when intake of added sugar was greater than 16%. In addition, median intakes of all micronutrients with the exception of vitamin C were lowest in the highest category of added sugar. Due to the ubiquitous nature of added sugar in our society and the significant decreases in intakes of nutrients and food groups, the DRI for added sugar should be evaluated.

Due to the significant negative associations between intake of nutrients and food groups and added sugar the DRI of 25% may need to be lowered. Other organizations such as the WHO and the American Heart Associations recommend limits lower than the DRI. According to the data reported here limiting sugar to 10% of total energy would assist in keeping nutrient levels at maximum intake.

Table 3.1 Selected Characteristics of the Study Population of Rural Native American and Non-Hispanic White Children, 1-6 years, OK 1997 (n=329)

Characteristics	1-3 yr olds		4-6 yr olds	
	N	N=167 %[a]	N	N=162 %[a]
Gender				
Female	87	52.1	75	46.3
Male	80	47.9	87	53.7
Race/Ethnicity				
Native American	69	41.3	73	45.1
White, non-Hispanic	98	58.7	89	54.9
Federal poverty threshold (%)				
<100	91	54.5	86	53.1
100-185	58	34.7	58	35.8
>185	12	7.2	14	8.6
Missing	6	3.6	4	2.5
Enrolled in WIC[b]				
Yes	123	73.6	68	42.0
No	44	26.4	93	57.4
Missing	-	-	1	0.6
Vitamin supplement use month prior to interview				
Yes	55	32.9	55	33.9
No	112	67.1	107	66.1
Hours played outside /day				
0-3	86	51.5	34	21.0
>3	81	48.5	128	79.0
Breastfed (months)				
Never	111	66.5	111	68.5
≤1	11	6.6	12	7.4
>1	45	26.9	39	24.1
Received Commodities in past 12 months				
Yes	20	12.0	24	14.8
No	147	88.00	137	84.6
Missing	-	-	1	0.6

BMI-for-age (CDC)	**2-6 yr olds**	
	N	%
Less than 5% (underweight)	57	20.7
5 to less than 85% (healthy weight)	176	63.8
85 to less than 95% (at risk of overweight)	21	7.6
95% and above (overweight)	22	7.9

[a] Column percents add to 100, [b]Federal program for Women, Infants and Children

Table 3.2 Median Intakes of Beverage Groups That Are Contributors To Total Added Sugar by Age Group (1-3 years and 4-6 years), of Study Population of Rural Native American and Non-Hispanic White Children Within Each Category of Added Sugar, OK 1997 (N=329)

	Added Sugar (% of total energy)				
	0-<10%	**10%-<16%**	**16%-≤25%**	**>25%**	**P-value[a]**
1-3 year olds	1-3	1-3	1-3	1-3	
Sample size	(n=85)	(n=50)	(n=22)	(n=10)	
Beverage groups[b]					
Juices & soft drinks	251.9	440.0	700.0	1954.3	<.0001
Sugar drinks	99.0	388.4	595.8	1904.3	<.0001
Carbonated drinks	26.6	159.5	372.0	651.0	<.0001
4-6 year olds	(n=47)	(n=55)	(n=47)	(n=13)	
Juices & soft drinks	240.0	400.2	755.3	1368.9	<.0001
Sugar drinks	124.0	276.7	684.5	1368.9	<.0001
Carbonated drinks	66.4	132.9	248.0	620.0	<.0001

[a]Kendall test for trend (data retained as continuous)

[b]Groups are not mutually exclusive

Table 3.3 Sociodemographic and Health Behavior Characteristics of Rural Native American and Non-Hispanic White Children,1-6 Years, OK 1997 (Within Each Category of Added Sugar, n=329)

	Added Sugar (% of total energy)							
	0-<10%		10-<16%		16-≤25%		>25%	
	N		N		N		N	
Total sample	132	%[a]	105	%[a]	69	%[a]	23	%[a]
Age in years								
1-3	85	50.9	50	29.9	22	13.2	10	6.0
4-6	47	29.0	55	34.0	47	29.0	13	8.0
Gender								
Female	70	43.2	54	33.3	32	19.8	6	3.7
Male	62	37.1	51	30.5	37	22.2	17	10.2
Race/Ethnicity								
Native American	62	43.7	44	31.0	28	19.7	8	5.6
Non-Hispanic White	70	37.5	61	32.6	41	21.9	15	8.0
Federal poverty threshold %								
<100	78	44.1	56	31.6	32	18.1	11	6.2
100-185	40	34.5	39	33.6	27	23.3	10	8.6
>185	8	30.8	8	30.8	9	34.6	1	3.8
Enrolled in WIC[b]								
Yes	93	48.7	59	30.9	28	14.7	11	5.7
No	38	27.7	46	33.6	41	29.9	12	8.8
Vitamin supplement use month prior to interview								
Yes	46	41.8	34	30.9	23	20.9	7	6.4
No	86	39.3	71	32.4	46	21.0	16	7.3
Hours played outside per day								
1-3	60	50.0	36	30.0	17	14.2	7	5.8
>3	72	34.4	69	33.0	52	24.9	16	7.7
Breastfed (months)								
Never	85	38.3	73	32.9	48	21.6	16	7.2
≤1	9	39.2	10	43.5	3	13.0	1	4.3
>1	38	45.3	22	26.2	18	21.4	6	7.1
BMI-for-age[c]	98		92		64		22	
0-<85%	82	35.2	81	34.8	52	22.3	18	7.7
85th and above	16	37.2	11	25.6	12	27.9	4	9.3

[a]Row percents add to 100, [b]Federal program for Women, Infants and Children
[c]Analayses subset to 2-6 year olds (n=276)

Table 3.4 Median Intakes of Nutrients of Study Population of Rural Native American and Non-Hispanic White Children, 1-6 Years, Within Each Category of Added Sugar, OK 1997 (N=329)

	Added Sugar (% of total energy)				
	0%-<10%	10%-<16%	16% ≤25%	>25%	P-value[a]
1-3 year olds	(N=85)	(N=50)	(N=22)	(N=10)	
Macronutrients		**Median Intake**			
Energy (kcal)	1507.1	1763.3	1893.5	2262.5	0.014
Carbohydrate (% energy)	40.3	42.8	48.3	54.9	<.0001
Protein (% energy)	15.9	14.2	12.3	11.6	<.0001
Fat (% energy)	42.7	44.0	40.8	34.8	0.0003
Added sugar (% energy)	6.6	12.4	19.8	31.4	<.0001
Fiber (g/1000kcal)	4.4	4.1	3.7	3.6	0.029
Micronutrients					
Calcium (mg/1000kcal)	656.5	514.7	464.4	321.7	<.0001
Iron (mg/1000kcal)	4.8	5.1	4.4	4.1	0.419
Folate (µg/1000kcal)	96.5	82.6	81.9	74.8	0.0003
Zinc (mg/1000kcal)	5.1	4.9	4.2	4.1	<.0001
Magnesium (mg/1000kcal)	120.6	100.6	99.4	84.9	<.0001
Phosphorus (mg/1000kcal)	743.7	648.3	592.2	457.8	<.0001
Vitamin A (µg/1000kcal)	379.4	348.4	286.3	219.1	<.0001
Vitamin B1 (µg/1000kcal)	0.5	0.5	0.4	0.4	<.0001
Vitamin B6 (µg/1000kcal)	0.6	0.6	0.6	0.5	<.0001
Vitamin C (mg/1000kcal)	30.1	26.9	25.5	26.6	0.1743
Vitamin E (mg/1000kcal)	3.1	3.1	3.2	2.4	0.248
4-6 year olds	(N=47)	(N=55)	(N=47)	(N=13)	
Macronutrients					
Energy (kcal)	2133.0	1919.5	1916.0	1827.8	0.395
Carbohydrate (% energy)	41.2	44.1	48.0	56.9	<.0001
Protein (% energy)	16.0	14.7	13.2	11.2	<.0001
Fat (% energy)	43.8	41.3	39.8	34.4	<.0001
Added sugar (% energy)	7.4	13.3	20.4	28.5	<.0001
Fiber (g/1000kcal)	5.0	4.6	4.5	3.6	0.0009
Micronutrients					
Calcium (mg/1000kcal)	630.9	471.2	442.0	374.9	<.0001
Iron (mg/1000kcal)	5.7	5.3	4.7	4.6	<.0001
Folate (µg/1000kcal)	109.5	92.5	95.3	72.7	0.0002
Zinc (mg/1000kcal)	5.3	5.0	4.4	4.3	<.0001
Magnesium (mg/1000kcal)	119.5	106.4	97.0	74.4	<.0001
Phosphorus (mg/1000kcal)	744.3	618.8	560.0	497.7	<.0001
Vitamin A (µg/1000kcal)	418.9	326.6	338.0	242.5	<.0001
Vitamin B1 (µg/1000kcal)	0.6	0.5	0.5	0.4	<.0001
Vitamin B6 (µg/1000kcal)	0.6	0.6	0.6	0.5	<.0001
Vitamin C (mg/1000kcal)	29.2	26.0	33.4	29.3	0.560
Vitamin E (mg/1000kcal)	3.6	3.4	3.8	2.8	0.426

[a] P-value test for trend, Kendall (data retained as continuous variable)

Table 3.5 Median Intakes of Servings of Food Guide Pyramid Food Groups of Rural Native American and Non-Hispanic White Children Within Each Category of Added Sugar, OK 1997(2-6 year olds only n=276)

	Added sugar (% of total energy)				
Total Sample	**0%-<10%** (n=98)	**10%-<16%** (n=92)	**16%-≤25%** (n=64)	**>25%** (n=22)	p-value[a]
			Median Intakes (servings)		
Food Groups[b]					
Grains (servings/day)	3.30	3.55	3.15	2.50	0.047
Vegetable (servings/day)	0.80	0.80	0.80	0.50	0.177
Fruit (servings/day) not including fruit juice	0.50	0.50	0.50	0.40	0.484
Total Fruit (servings/day)	1.40	1.00	1.20	0.75	0.001
Dairy (servings/day)	4.35	3.30	3.20	2.85	<.0001
Meat (servings/day)	2.60	2.50	2.30	2.25	0.232

[a]P-value test for trend, Kendall (data retained as continuous variable)

[b]Food Guide Pyramid Recommendations for Young Children (2-6 year olds), grains= 6 servings; vegetables=3 servings; fruit=2 servings; dairy=2 servings; meat=2 servings

Table 3.6 Percent of Study Population of Rural Native American and Non-Hispanic White Children, 1-6 years, Meeting the DRIs for Nutrients Within Each Category of Added Sugar, OK 1997 (N=329)

	Added Sugar (% of energy)								p-value[b]
	0%-<10%		10%-<16%		16%-≤25%		>25%		
1-3 year olds	Percent Meeting Recommendations[a]								
Macronutrients	N[c]	%	N[c]	%	N[c]	%	N[c]	%	
Carbohydrate[d] (% energy)	15	17.7	18	36.0	16	72.7	10	100.0	<.001
Protein[d] (% energy)	84	98.8	49	98.0	22	100.0	10	100.0	0.026
Micronutrients									
Iron (mg/d)	80	94.1	48	96.0	21	95.5	10	100.0	0.436
Folate (µg/d)	57	67.1	34	68.0	16	72.7	7	70.0	0.665
Zinc (mg/d)	81	95.3	48	96.0	22	100.0	10	100.0	0.258
Magnesium (mg/d)	83	97.6	50	100.0	22	100.0	10	100.0	0.242
Phosphorus (mg/d)	83	97.6	48	96.0	22	100.0	10	100.0	0.586
Vitamin A (µg/d)	85	100.0	50	100.0	22	100.0	10	100.0	0.523
Vitamin B6 (µg/d)	81	95.3	48	96.0	22	100.0	10	100.0	0.258
Vitamin C (mg/d)	82	96.5	50	100.0	22	100.0	10	100.0	0.150
Vitamin E (mg/d)	37	43.5	27	54.0	13	59.1	6	60.0	0.108
4-6 year olds									
Macronutrients									
Carbohydrate[d] (% energy)	11	23.4	22	40.0	36	76.6	12	92.3	<.001
Protein[d] (% energy)	47	100.0	55	100.0	47	100.0	13	100.0	0.042
Micronutrients									
Iron (mg/d)	46	97.9	55	100.0	44	93.6	13	100.0	0.462
Folate (µg/d)	37	78.7	34	61.8	30	63.8	4	30.8	0.005
Zinc (mg/d)	46	97.9	55	100.0	44	93.6	13	100.0	0.462
Magnesium (mg/d)	45	95.7	53	96.4	41	87.2	9	69.2	0.004
Phosphorus (mg/d)	47	100.0	55	100.0	45	95.7	13	100.0	0.202
Vitamin A (µg/d)	47	100.0	54	98.2	46	97.9	13	100.0	0.235
Vitamin B6 (µg/d)	46	97.9	55	100.0	45	95.7	12	92.3	0.202
Vitamin C (mg/d)	45	95.7	54	98.2	46	97.9	13	100.0	0.374
Vitamin E (mg/d)	29	61.7	38	69.1	28	59.6	6	46.2	0.367

[a] Estimated Average Requirement

[b] Cochran-Armitage Trend Test, 2-sided P-value

[c] Number of children not meeting the recommendation within each category of added sugar consumption

[d] Acceptable Macronutrient Distribution Ranges

Table 3.7 Percent of Rural Native American and Non-Hispanic White Children Within Each Category of Added Sugar Meeting The Recommended Servings of the Food Guide Pyramid for Young Children, OK 1997 (2-6 year olds only n=276)

	Added Sugar (% of Total Energy)								
	0%-<10%		**10%<16%**		**16%-≤25%**		**>25%**		**p-value[a]**
Total Sample	(n=98)		(n=92)		(n=64)		(n=22)		
	Percent Meeting Recommendations								
	N[b]	%	N[b]	%	N[b]	%	N[b]	%	
Food Groups[c]									
Grains (servings/day)	6	6.1	6	6.5	3	4.7	0	0	0.323
Vegetable (servings/day)	3	3.1	3	3.3	4	6.3	0	0	0.829
Fruit (servings/day)not including juice	5	5.1	4	4.4	3	4.7	0	0	0.450
Total Fruit(servings/day)	31	31.6	22	23.9	13	20.3	2	9.1	0.016
Dairy (servings/day)	93	94.9	80	87.0	51	79.7	14	63.6	<.0001
Meat (servings/day)	66	67.4	62	67.4	39	60.9	12	54.6	0.209

[a]Cochran-Armitage Trend Test, 2-sided test

[b]N=number of children meeting the recommendations

[c]USDA Food Guide Pyramid Recommendations for Young Children (2-6 year olds), grains= 6 servings; vegetables=3 servings; fruit=2 servings; dairy=2 servings; meat=2 servings

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CHAPTER 4

CONCLUSIONS AND PUBLIC HEALTH IMPLICATIONS

In conclusion, this research is consistent with published reports that examine intakes of added sugar and diet in children. This population of young, rural, Native Americans and non-Hispanic white children does not differ from national data (1-3). High intakes of added sugar have been shown to be associated with decreased intakes of micronutrients and servings of major food groups in children (1-3). Nutrients such as calcium, fiber, magnesium and vitamin E are important for the health of children and in this study these nutrients were the lowest in the highest added sugar category which is consistent with other research (1,4). It is also important that children consume a sufficient amount of food from each major food group in the MyPyramid and in this study servings of all food groups were lowest in the highest added sugar category.

Attention has been focused on beverage intake specifically sugar-sweetened beverages or regular soft drinks and nutrition. This is due to the major role regular soft drinks play on total added sugar intake in the diets of Americans (5). It has been reported that sugar-sweetened beverages are associated with intakes of nutrients and diet quality (6,7). A significant association is seen between total added sugar intake and sugar drinks (including Kool-Aid and regular soft drinks) in this population.

The percent of children meeting the EAR for nutrients was not associated with intakes of added sugar. This may be because of the measurement itself, even if the

Estimated Average Requirement is 100% in a group this means that only approximately half of the population is getting the required amount of that nutrient. This measurement may not be the best way to measure adequacy of a nutrient intake among groups.

The participants of WIC had a lower overall intake of added sugar than those children who did not participate in the federal program. In this study population we can conclude that WIC had a negative affect on added sugar intake and therefore may be beneficial to nutrition. This relationship needs to be evaluated further to say with certainty that there is an association. Demographic variables associated with lower intakes of added sugar in this study were: younger age (1-3 vs. 4-6), female, Native American, and <100% federal poverty (vs. 100-185%, >185%). The association between added sugar intake with younger age and lower percent federal poverty have been reported elsewhere (1).

Public Health Implications

To reduce the risk of adverse health outcomes such as overweight and type 2 diabetes intake of added sugar may need to be limited. The prevalence of overweight in children is already much higher than it was twenty years ago and if the contributing factors to overweight are not identified and prevented this trend may continue. Type 2 diabetes has also risen considerably in children, especially Native Americans (8,9). Chronic diseases that are associated with poor nutrition and becoming overweight may continue to rise as the prevalence of overweight increases, resulting in an economical, as well as a psychological burden on the American people. I believe that food labels should

clearly list the amount of total added sugar in the product as well as provide a guide to how much should be consumed as was suggested to the FDA in 1999.

Future Research

Future research is needed to find out ways to encourage children to limit their intake of added sugar and sugar-sweetened beverages. Research that focuses on different ways to educate parents/caregivers and the children the benefits of consuming a healthy diet and what a healthy diet is, are necessary. Further ways to educate target populations on how to grow fruits and vegetables in different communities, the importance of exercise and the adverse effects of a poor diet may aid in the reduction of intake of total added sugar.

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APPENDICES

Table 3.4.1 P-values for Median Intakes of Nutrients of Study Population of Rural Native American and Non-Hispanic White Children Within Each Category of Added Sugar by Race/Ethnicity, OK 1997, (N=329)

	0%-<10%	10%-<16%	16% ≤25%	>25%
1-3 year olds				
Macronutrients		P-value[a]		
Energy (kcal)	0.72	0.19	0.80	0.32
Carbohydrate (% of energy)	0.52	0.30	0.36	0.50
Protein (% of energy)	0.48	0.54	0.95	0.50
Fat (% of energy)	0.92	0.23	0.40	0.50
Added sugar (%of energy)	0.92	0.84	0.90	1.00
Fiber(g/1000kcal)	0.82	0.37	0.33	0.74
Micronutrients				
Calcium (mg/1000kcal)	0.64	0.31	0.30	0.20
Iron (mg/1000kcal)	0.43	0.48	0.20	0.20
Folate (μg/1000kcal)	0.98	0.48	0.95	0.74
Zinc (mg/1000kcal)	0.34	0.65	0.60	1.00
Magnesium (mg/1000kcal)	0.56	0.73	0.69	0.32
Phosphorus (mg/1000kcal)	0.64	0.35	0.43	0.32
Vitamin A (μg/1000kcal)	0.11	0.30	0.20	1.00
Vitamin B1 (μg/1000kcal)	0.82	0.87	0.95	0.32
Vitamin B6 (μg/1000kcal)	0.80	0.33	0.84	1.00
Vitamin C (mg/1000kcal)	0.80	0.97	0.55	1.00
Vitamin E (mg/1000kcal)	0.49	0.15	1.00	0.20
4-6 year olds				
Macronutrients				
Energy (kcal)	0.13	0.07	0.10	0.83
Carbohydrate (% of energy)	0.33	0.78	0.64	0.37
Protein (% of energy)	0.22	0.33	0.64	0.53
Fat (% of energy)	0.40	0.64	0.72	0.45
Added sugar (%of energy)	0.33	0.86	0.11	0.83
Fiber (g/1000kcal)	0.32	1.00	0.46	1.00
Micronutrients				
Calcium (mg/1000kcal)	0.57	0.61	0.72	0.83
Iron (mg/1000kcal)	0.09	0.76	0.74	0.63
Folate (μg/1000kcal)	0.56	0.83	0.61	0.73
Zinc (mg/1000kcal)	0.74	0.68	0.58	0.63
Magnesium (mg/1000kcal)	0.11	0.82	0.58	0.73
Phosphorus (mg/1000kcal)	0.29	0.71	0.60	1.00
Vitamin A (μg/1000kcal)	0.74	0.10	0.53	0.73
Vitamin B1 (μg/1000kcal)	0.71	0.73	0.42	0.20
Vitamin B6 (μg/1000kcal)	0.86	0.54	0.89	0.63
Vitamin C (mg/1000kcal)	0.74	0.82	0.18	0.31
Vitamin E (mg/1000kcal)	0.23	0.42	0.51	0.16

[a]Wilcoxon-Mann-Whitney, reporting 2-sided P-value

Table 3.4.2 P-values for Median Intakes of Nutrients of Study Population of Rural Native American and Non-Hispanic White Children Within Each Category of Added Sugar by Gender, OK 1997, (N=329)

	0%-<10%	10%-<16%	16% ≤25%	>25%
1-3 year olds				
Macronutrients		P-value[a]		
Energy (kcal)	0.02	0.75	0.84	0.27
Carbohydrate (% of energy)	0.55	0.53	0.18	0.76
Protein (% of energy)	0.90	0.98	0.84	0.76
Fat (% of energy)	0.45	0.74	0.12	0.61
Added sugar (%of energy)	0.34	0.45	0.27	0.20
Fiber(g/1000kcal)	0.33	0.28	0.40	0.36
Micronutrients				
Calcium (mg/1000kcal)	0.33	0.45	0.74	0.76
Iron (mg/1000kcal)	0.36	0.03	0.80	0.14
Folate (μg/1000kcal)	0.25	0.16	0.60	0.14
Zinc (mg/1000kcal)	1.00	0.80	0.43	0.36
Magnesium (mg/1000kcal)	0.19	0.80	0.74	0.27
Phosphorus (mg/1000kcal)	0.38	0.77	0.95	0.61
Vitamin A (μg/1000kcal)	0.94	0.50	0.22	0.20
Vitamin B1 (μg/1000kcal)	0.79	0.30	0.84	0.07
Vitamin B6 (μg/1000kcal)	0.26	0.16	0.08	0.76
Vitamin C (mg/1000kcal)	0.12	0.43	0.27	0.92
Vitamin E (mg/1000kcal)	0.36	0.34	0.36	0.20
4-6 year olds				
Macronutrients				
Energy (kcal)	0.77	0.58	0.91	1.00
Carbohydrate (% of energy)	0.88	0.91	0.78	0.63
Protein (% of energy)	0.66	0.31	0.01	0.16
Fat (% of energy)	0.94	0.49	0.25	0.39
Added sugar (%of energy)	0.12	0.93	0.49	0.50
Fiber (g/1000kcal)	0.51	0.42	0.97	0.39
Micronutrients				
Calcium (mg/1000kcal)	0.13	0.04	0.37	0.50
Iron (mg/1000kcal)	0.81	0.90	0.25	0.50
Folate (μg/1000kcal)	0.24	0.06	0.78	0.22
Zinc (mg/1000kcal)	0.79	0.51	0.12	1.00
Magnesium (mg/1000kcal)	0.62	0.09	0.24	0.30
Phosphorus (mg/1000kcal)	0.28	0.04	0.16	0.50
Vitamin A (μg/1000kcal)	0.16	0.01	0.97	0.50
Vitamin B1 (μg/1000kcal)	0.76	0.11	0.01	0.30
Vitamin B6 (μg/1000kcal)	0.92	0.31	0.18	0.77
Vitamin C (mg/1000kcal)	0.84	0.12	0.53	0.63
Vitamin E (mg/1000kcal)	0.19	0.62	0.96	1.00

[a]Wilcoxon-Mann-Whitney, reporting 2-sided p-value

Table 3.5.1 P-values for Median Intakes of Servings of Food Guide Pyramid Food Groups of Rural Native American and Non-Hispanic White Children, 2-6 Years Olds, Within Each Category of Added Sugar by Race/Ethnicity, OK 1997 (n=276)

	Added Sugar (% of total energy)			
	0%-<10%	**10%-<16%**	**16%-≤25%**	**>25%**
		p-value[a]		
Food Groups[b]				
Grains (servings/day)	0.75	0.08	0.90	0.65
Vegetable (servings/day)	0.09	0.70	0.56	0.48
Fruit (servings/day) not including fruit juice	0.99	0.14	0.68	0.84
Total Fruit (servings/day)	0.80	0.46	0.44	0.77
Dairy (servings/day)	0.90	0.79	0.52	0.75
Meat (servings/day)	0.09	0.04	0.82	0.77

[a] Wilcoxon Mann-Whitney

[b] Food Guide Pyramid Recommendations for Young Children (2-6 year olds), grains= 6 servings; vegetables=3 servings; fruit=2 servings; dairy=2 servings; meat=2 servings

Table 3.5.2 P-values for Median Intakes of Servings of Food Guide Pyramid Food Groups of Rural Native American and Non-Hispanic White Children, 2-6 Year Olds, Within Each Category of Added Sugar by Gender, OK 1997, (n=276)

	Added Sugar (% of total energy)			
	0%-<10%	**10%-<16%**	**16%-≤25%**	**>25%**
		p-value[a]		
Food Groups[b]				
Grains (servings/day)	0.09	1.0	0.46	0.12
Vegetable (servings/day)	0.72	0.08	0.05	0.40
Fruit (servings/day) not including fruit juice	0.62	0.31	0.22	0.62
Total Fruit (servings/day)	0.80	0.98	0.37	0.60
Dairy (servings/day)	0.72	0.50	0.29	0.65
Meat (servings/day)	0.06	0.98	0.86	0.40

[a]Wilcoxon Mann-Whitney

[b]Food Guide Pyramid Recommendations for Young Children (2-6 year olds), grains= 6 servings; vegetables=3 servings; fruit=2 servings; dairy=2 servings; meat=2 servings