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ACHIEVING FAT AND FIBER RECOMMENDATIONS WITH FOODS CONSUMED FROM THE USDA SCHOOL MEAL PROGRAMS

By

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ABSTRACT

ACHIEVING FAT AND FIBER RECOMMENDATIONS WITH FOODS CONSUMED FROM THE USDA SCHOOL MEAL PROGRAMS

By

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Objectives: 1) to identify clusters of foods and food components consumed by USDA school meal program participants by total fat, saturated fat and dietary fiber, 2) to assess dietary fiber intakes of U.S. school children by age, gender, ethnicity, family income, student eligibility for free or reduced price school meals and participation in USDA school meal programs, 3) to determine % of U.S. school children consuming vended foods/beverages by grade, race, gender, eligibility for subsidized meals and participation in USDA meal programs and determine differences in *Dietary Guideline* (DG) and RDA achievement between vended food consumers and nonconsumers.

Methods: The USDA School Nutrition Dietary Assessment Study (SNDA) data with a nationally representative sample of 3,381 children in grades 1-12 from the 48 contiguous states were examined. Food codes from the 24 hr. recalls of children were matched with the dietary fiber updated USDA Nutrient Database for Individual Intake Survey Analysis version 4 to obtain dietary fiber composition of foods and intakes of children and composition of vended foods. The SNDA assessed DG achievement as fat (<30% energy), saturated fat (<10% energy) and cholesterol (<300 mg/d) as a categorical variable. RDA achievement (for protein, iron, calcium, magnesium, vit. A, C, B6, B12, folate, niacin, thiamin, and riboflavin) was also a categorical variable in the SNDA data.

The American Health Foundation=s (AHF) dietary fiber intake recommendations [age (yr.) + 5 g/d] were used to assess fiber intakes. Fuzzy K-means cluster analysis of foods consumed by USDA meal program participants was performed. Chi-square analyses, Tukey-Kramer t-tests, & correlations were used to assess differences between groups of children, using SAS, SUDAAN and JMP.

Results: 1890 foods and food components low in fat and saturated fat and high in dietary fiber were identified by the cluster analysis. These foods included, hot chocolate and chocolate milk and ready-to-eat breakfast cereals. The % of children achieving AHF dietary fiber recommendations ranged from over 60% of 6 yr. old males to less than 10% of 18 yr. old females. Females 12-18 yr. of age had significantly lower mean fiber intakes than males of the same ages ($p<0.001$). African-American children had significantly lower mean dietary fiber intakes at most ages than Caucasian children. Hispanic adolescents had significantly higher mean dietary fiber intakes than Caucasian adolescents of the same ages ($p<0.05$). Dietary fiber intakes did not differ significantly by eligibility for subsidized meals. Dietary fiber intakes of USDA school breakfast program (14.1 vs. 17.3 g/d, $p<0.001$) and National School Lunch Program participants (13.3 vs. 16.6 g/d, $p<0.001$) were significantly lower than that of nonparticipants. An average of 11.4% of school children consumed vended foods/beverages. These items contributed approx. one third of the daily energy intake of those who consumed them. Male and female vended food consumers were significantly less likely to have achieved age appropriate RDAs than nonconsumers of the grade and gender ($p<0.001$), but often more likely to have achieved DGs than nonconsumers.

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Introduction

Significance

At present, more than half of children get at least one of their three major meals in school (Burghardt, 1995). One in ten children get two out of three meals per day at school (Burghardt, 1995). The current political atmosphere is one that questions both the efficacy of school meal programs in achieving their original objective of "safeguarding the health and well being of the nation's children" and the amount and distribution of the programs' funds (USDA, 1994). Therefore, it is of vital importance to improve school meal program ability to provide nutrition, without contributing to excess consumption of dietary components associated with chronic disease risk. Possible methods of improving the total fat, saturated fat, dietary fiber and other nutrient content of meals offered in these programs to better meet the *United States Department of Agriculture and Department of Health and Human Services'(USDA-DHHS) Dietary Guidelines for Americans* must be identified (USDA-DHHS, 1989).

The USDA School Nutrition Dietary Assessment Study (SNDA), published in October 1993, assessed demographics and dietary information on a nationally representative sample of over 3,000 children in grades 1-12 in 545 schools across the country (Burghardt, 1993). The findings included a partial nutritional analysis of School Breakfast Program (SBP) and National School Lunch Program (NSLP) participants and nonparticipants' diets with respect to the *National Research Council Recommended*

Dietary Allowances (RDA) and *USDA-DHHS Dietary Guidelines for Americans* recommendations on total fat, saturated fat, and cholesterol intake (National Academy of Sciences, 1989; USDA-DHHS, 1989; Burghardt et al., 1993; Burghardt et al., 1993; Devaney et al., 1993). However, all diets were analyzed with respect to the *Recommended Dietary Allowances* for selected nutrients of interest, not within the context of food group serving schemes, as the SBP and NSLP meals were defined. Neither the impact of vended foods on nutrient intake of children nor dietary fiber intake were examined using SNDA data. The proposed analysis will yield timely food-based recommendations to assist schools and school children to meet *USDA-DHHS's Dietary Guidelines*. It will also provide valuable data on vended foods impact on the diets of children.

Legislative Context of Proposed Study

The USDA's June 1995 final ruling on *School Meal Initiatives For Healthy Children* requires school meal program conformance to the *1990 USDA-DHHS Dietary Guidelines for Americans* by the 1996-97 school year (USDA, 1995). While it is important to ensure the nutritional quality of school meals, it is equally important to make the process of planning, preparing, serving and selecting nutritious meals cost efficient and user-friendly. For this reason, the USDA, in response to food service personnel concerns, offered three options: 1) nutrient analysis based menu planning (known as NuMenus), 2) assisted nutrient analysis based menu planning (Assisted NuMenus) and 3) food group based menu planning (USDA, 1995).

Another issue of importance is the dietary fiber intakes of U.S. school children.

The USDA=s nutrient goals for the school meal programs do not include dietary fiber as part of their nutrient goals at present (Burghardt, 1995). This was due in part to the lack of adequate information on the dietary fiber content of foods in computerized nutrient analysis software and to the lack of appropriate pediatric dietary fiber intake recommendations at the time of the initial USDA legislation regarding nutrient goals for the school meal programs (USDA, 1990). However, with the release of USDA=s nutrient database version 4 with dietary fiber content of foods and the American Health Foundations= age-specific dietary fiber intake recommendation (age + 5 g/day) it is now appropriate to examine dietary fiber intake of school children (USDA, 1990; Williams et al., 1995).

The USDA, in their June 1995 final ruling on school meal programs, stated that significant concern regarding lack of regulation of vended foods has been expressed by parents, health professionals and school officials (USDA, 1995). The USDA currently has no jurisdiction, however, over vending machine offerings or the use of vending machines outside cafeterias in schools (USDA, 1995). The impact of vended foods must be examined in order to determine whether regulation of vended foods is warranted.

Statement of the Problem

The SNDA study has data collected which can be used to answer several key previously unanalyzed questions.

1) What specific foods currently offered to and selected by children in the school meals programs have low total fat, and saturated fat and high dietary fiber contents?

2) What are the dietary fiber intakes of U.S. school children and how do they compare to

the American Health Foundation (age + 5 g/day) recommendation?

3) What impact do competitive foods (such as those sold in vending machines) have on nutrient intake and the dietary guideline achievment of school children?

Research Objectives

This project aims to use fuzzy cluster mathematical modeling to identify specific low fat, low saturated fat, high dietary fiber foods which increase likelihood of achieving the *Dietary Guidelines for Americans* recommendations for total and saturated fat, and the American Health Foundation=s recommendation for dietary fiber (Windham et al., 1985). The percent of U.S. school children achieving American Health Foundation recommendations for dietary fiber intake will be examined by gender, age and ethnicity.

Although the USDA legislation prohibits the service of "foods of minimal nutritional content" in cafeterias during school meal hours, little data are available on the impact of vended foods on nutrient intake of school children (USDA, 1995). This project proposes to examine the impact of vended foods on children's nutrient intakes. Relation of participation in school meal programs to vended food consumption will also be examined. Healthful foods which could be offered via vending machines will be identified.

Research Questions

Descriptive analyses were conducted to assess any gender, ethnic, or age differences in dietary fiber intakes and vended food consumption. For children in grades 1-12 who participated in the School Nutrition Dietary Assessment Study (SNDA):

1) What cluster of low fat and saturated fat and high dietary fiber foods is associated with achieving the dietary recommendation for:

    a) fat (<30% energy)?

    b) saturated fat (<10% energy)?

    c) dietary fiber (age + 5 g/d)?

2) What are the 24 hr. dietary fiber intakes of U.S. school children by age, gender and ethnicity?

3) What percent of U.S. school children achieve American Health Foundation (age + 5 g/day) dietary fiber intake recommendation?

4) How does participation in SBP or NSLP relate to vended food and beverage consumption in schools?

5) For all students who consumed vended foods, what is the total fat, saturated fat and dietary fiber derived from vended foods and beverages?

6) Do vended foods consumers differ from nonconsumers in 24 hr. mean intakes of the following nutrients:

    a) total fat

    b) saturated fat

c) dietary fiber

Null Hypotheses:

For children in grades 1-12 who participated in the School Nutrition Dietary Assessment Study:

1) No clusters of foods are associated with achieving the dietary recommendation for

a) fat (< 30% energy),

b) saturated fat (<10% energy),

c) dietary fiber (age + 5 g/d).

2) Mean 24 hr. dietary fiber intakes of U.S. school children do not differ by age, gender or ethnicity.

3) U. S. school children achieve the American Health Foundation (age + 5g/day) dietary fiber intake recommendation.

4) Participation in SBP does not relate to using vended food and beverage consumption in schools.

5) For all students who consumed vended foods, no total fat, saturated fat or dietary fiber was derived from these foods or beverages.

6) Vended food consumers do not differ from nonconsumers in total 24 hr. intakes of the following nutrients:

a) total fat

b) saturated fat

c) dietary fiber

Variable Definitions

1) Dietary fat: total fat g/day; percent of energy from total fat; g/1000 kcal in foods.

2) Saturated fat: saturated fat g/day; percent of energy from saturated fat; g/1000 kcal in foods.

3) Dietary fiber: total dietary fiber g/day; g/kcal in foods.

4) Vended foods or beverages: any foods or beverages purchased from a vending machine or on campus school store.

5) Vended food consumers: those who reported any food or beverage from a vending machine in their 24 hr. recall.

6) Vended food nonconsumers: those who did not consume any foods or beverages from vending machines or school stores.

Chapter Two

Review of Literature

The goal for implementing national school meal programs was initially to safeguard the health and well being of school children (USDA, 1995). This includes the impact that the meals themselves have upon health, nutrition, growth, physiology, and cognition of school children. Therefore, the following historical review of the literature will focus on the impact of breakfast on various outcomes. Since meals are offered through the school systems, it is of value to examine the specific effects of breakfast upon school performance, as well.

Physiologic effects of breakfast

Most of the research focusing on the effect of breakfast on physiologic response was conducted in the early 1950's. It is important to review, however, because of the relevance of the findings to the proposed study.

Kate Daum and her colleagues conducted several controlled metabolic trials, in the 50's, examining the effects of various types of breakfast on physiologic response (Daum et al., 1950), utilization of nitrogen, phosphorus, calcium and iron (Daum et al., 1951) and thiamine and nitrogen excretion (Daum et al., 1951). One study focused on how several different breakfast compositions impacted neuromuscular tremor, maximum work output, and choice reaction time (Daum et al., 1950). Ten university women aged 18-25 years consumed one of the following for five weeks: a) a heavy breakfast (bacon, cereal, toast, egg, fruit, etc.) vs. a light breakfast (toast, butter and fruit), or b) a basic breakfast (toast, cereal, fruit and milk) vs. no breakfast, or c) no breakfast vs. black coffee only, or d) basic breakfast with coffee. Test meals were administered between 7 and 8 a.m. No breakfast indicated no food or beverage intake from 8 p.m. of the night before until noon on the test day. Physiologic response data were collected between 10:30 A.M. and noon.

Heavy vs. light breakfast showed no significant differences in neuromuscular tremor or choice reaction time (maximum work output was not tested for this). Basic breakfast vs. no breakfast showed neuromuscular tremor to be greater and maximum work output significantly less with no breakfast than with the basic breakfast. The results for choice reaction time were conflicting. Interestingly, having black coffee only was found to be worse than having nothing at all; maximum work output was lower, neuromuscular tremor greater and choice reaction time longer with coffee only in the morning (Daum et al., 1950).

In the study which examined nitrogen, phosphorus, calcium and iron in ten male students (aged 21-35 years), Daum et al. compared to consumption of a cereal breakfast with a bacon and egg breakfast for 4 to 6 weeks; other meals were controlled and constant in approximate composition (Daum et al., 1951). They found no meaningful differences in nitrogen balance, phosphorus, calcium or iron utilization between the two groups. When thiamin and niacin excretion was measured in the same men, they found that thiamin and niacin excretion was the same, regardless of type of breakfast eaten (Daum et al., 1951).

It is important to examine the effect of breakfast on nutrient content of the diet as a whole to understand how breakfast might impact nutrient excretion. Numerous studies examined the impact of breakfast consumption on nutrient content of the total diet. Several key studies from the past 15 years are reviewed here.

Breakfast and nutritional content of diet

Theresa Nicklas and colleagues examined breakfast consumption patterns in 467 10-year-old children from the Bogalusa Study sample (Nicklas et al., 1993). They found that 16% skipped breakfast. The average total daily energy and macronutrient intake was significantly lower for children who did not consume breakfast and for children who consumed breakfast at home, when compared with children who consumed breakfast at school. Percentage of energy from fat was lower in children who ate no breakfast compared with those who did (34% vs. 37-39%). Perhaps the most interesting result was that children who did not eat breakfast did not make up the difference in nutrient intake through the balance of the day. Breakfast skippers were more likely to fail to achieve two thirds of the *National Research Council's Recommended Dietary Allowances* for vitamins and minerals (Nicklas et al., 1993 a).

In a separate analysis of 393 10-year old children from the Bogalusa sample, Nicklas et al. (1993) found that home breakfasts provided more animal protein and sucrose than did school breakfasts (Nicklas et al., 1993 b). School breakfasts, compared to home breakfasts, contributed significantly higher percentage of total nutrient intake for energy (26% vs. 19%), protein (30% vs. 18%), carbohydrate (30% vs. 20%) and sodium (27% vs. 18%). Differences were attributed to foods commonly consumed at home (grits, pancakes, oatmeal, cereal, ham, bologna, etc.) compared to foods consumed at school (breads, dairy, bacon, sausage and fruits) (Nicklas et al., 1993).

Karen Morgan and colleagues examined specifically the impact of ready-to-eat (RTE) cereal breakfast consumption on nutrient intake of 657 American children aged 5-12 years (Morgan et al., 1981). From 7-day food diaries, Morgan et al. noted that breakfast consumption contributed significantly to daily nutrient intake. Only 1.5% of the sample skipped breakfast. Children who had RTE cereal breakfasts 3 or more times in the 7-day period were found to have consumed significantly less ($p<0.001$) fat and cholesterol and significantly more ($p<0.001$) fiber, thiamin, niacin, riboflavin, iron, folacin, pyridoxine, and vitamins B12, A and D than those who had no RTE cereal at breakfast. Breakfasts which did not contain RTE cereal had a higher average content of energy, protein, fat, cholesterol and sodium (Morgan et al., 1981).

More recently, in 1993, Albertson and Tobelmann also examined impact of RTE cereal consumption on the diets of children 7-12 years old in 4,000 households (Albertson et al., 1993). Their results also indicated that frequent cereal eaters consumed fewer calories from fat at breakfast, as well as for the total day. They also had higher average daily vitamin and mineral intakes than less frequent cereal eaters and noncereal eaters (Albertson et al., 1993).

In the Bogalusa Heart Study sample of 568 10-year-old children from whom 24-hour recalls were collected, no significant differences were noted in macronutrient, cholesterol, calcium, sodium, potassium, phosphorus or vitamin D intake over the 24-hour period (Nicklas et al., 1994). However, iron, vitamins A, B6, B12, thiamin, niacin, riboflavin, and folate intake were significantly higher ($p<0.05$) for children consuming cereal breakfast compared with those who did not eat cereal (Nicklas et al., 1994).

Ruxton et al. (1993), in their sample of 7-8 year-old Scottish children, also found RTE cereal breakfasts contributed more vitamin B2, niacin, vitamin B6, and folate than breakfasts consisting of other foods (Ruxton et al., 1993). However, this study found no significant differences in mean energy intake between cereal and noncereal breakfast eaters (Ruxton et al., 1993).

Although the previously reviewed literature indicates that consumption of breakfast, in general, is associated with increased micronutrient content of the diet, it does not address the success of providing school breakfast on improving nutrient intake of school children. The following study specifically assessed the impact of the national SBP on school children's nutrient intake.

School Breakfast Program (SBP) and nutrition

Hanes et al. (1984) assessed specifically the impact of participation in the United States Department of Agriculture School Breakfast Programs on 24-hour nutrient intake in 5212 children in grades 3-12 (Hanes et al., 1984). Data from 1089 children in grades 1 and 2 were collected at home from parents. Nutrient analyses were performed using the Highland View Hospital-Case Western Reserve University nutrient database. This study used least squares regression analysis and controlled extensively for: age, gender, anthropometric measurements, activity level, ethnicity, family education, and other demographic variables (Hanes et al., 1984).

Hanes et al. found that children in schools where the SBP was available were significantly ($p<0.05$) more likely to consume breakfast than those children who did not have SBP availability. Children who skipped breakfast had lower nutrient adequacy ratios for energy and all nutrients over the 24-hour period than children who ate breakfast. When the sample data were projected for the United States school-aged population, approximately 3 million children were estimated to skip breakfast on any given day. Hanes et al., further estimated that an additional 600,00 children, who would otherwise skip breakfast, would eat breakfast if the SBP were available to them (Hanes et al., 1984).

Given this information on the impact of breakfast consumption on nutrient intake and physiology, it is logical to question the impact of breakfast on performance. This literature review will first examine key studies on the following aspects: mood; physical performance; short-term recall; and specific task performance. Later, the broader response of cognitive performance in school, which includes the previously listed aspects, will be examined.

Breakfast and performance

Pollitt et al. (1981) described the effects of skipping breakfast on selected aspects of cognition in children and showed that fasting adversely affects the accuracy of problem solving ability (as tested by Hagan Central-Incidental Task), but beneficially impacts immediate recall in short-term memory (Pollitt et al., 1981). However, initial studies conducted on French adolescents failed to show any effects of breakfast skipping (Michaud et al., 1989).

Therefore, Claude Michaud and colleagues (1991) decided to examine specifically the effect of breakfast size on short-term memory, concentration, mood and blood glucose in 319 free living adolescents, aged 13-20 years (Michaud et al., 1991). Michaud et al. found that a 63% mean increase in energy intake (compared to habitual intakes) had no effect on blood glucose or late morning mood as assessed by the Herbert visual analogue scale. High breakfast energy intake did have a beneficial effect on average immediate recall in short-term memory (2 minute gap between initial display of test items and test recall). However, concentration on a word puzzle (finding the word in a group of letters) was impaired by high calorie breakfasts (Michaud et al., 1991).

This seemed to support Pollitt's earlier conclusion that high energy breakfast consumption positively influenced short term recall but negatively affected long term or sustained attention activities. Variation in blood glucose can not explain these observed differences in performance, because both Michaud et al. and Pollitt et al. found blood glucose to remain stable, despite differences in energy content of breakfast or breakfast skipping (Pollitt et al., 1981; Michaud et al., 1991).

Craig points out that numerous studies, including studies conducted by Craig himself, show a post-lunch dip in performance (Craig, 1986). However, such a dip in performance was not observed following breakfast consumption in a study conducted by King and colleagues as early as 1945. This early study found that levels of both visual and motor functioning were poorer when breakfast was not eaten than when it was. However, the tests were performed 2-3 hours following breakfast and may not assess the acute effects of breakfast (King et al., 1945).

Pollitt and colleagues (1981) have shown that, in the late morning, school children are more likely to make errors on a picture identification task (Matching Familiar Figures Test) when they had missed breakfast (Pollitt et al., 1981). However, breakfast was not found to affect mean efficiency on the Continuous Performance Test (CPT). Conners and Blouin (1982/1983) also found no impact of breakfast on CPT (Conners et al., 1982/83).

Spring et al. (1983) reported that on a sustained dichotic shadowing task - a task that requires selectively attending to and repeating out loud words entering one ear while ignoring those arriving at the other ear - omission errors were greater, and overall accuracy lower, after a meal that was high in carbohydrate compared to a high-protein meal (Spring et al., 1983). For younger people (<40 years old), the difference seemed greater at breakfast than at lunch. For older people the differential effect was found to be noticeably larger after lunch. The shadowing task took 20 minutes to complete and a brief (2 to 3 minute) reaction time test failed to show any differences due to meal type or time of meal (Spring et al., 1983).

Clarke et al. (1990) compared the nutrition and health of 167 passing versus 158 failing 5th grade children from five randomly selected primary schools in Kingston, Jamaica (Clarke et al., 1990). Academic performance was tested with the Wide Range Achievement Test, which had been previously used in Jamaica. Failing children had lower heights-for-age, weights-for-height, hemoglobin levels and poorer breakfasts than passing children. However, this study classified breakfast intake into only three categories: solid, fluid, or none. Only 6% of the passing children (compared to 19% of failing children) skipped breakfast or consumed a fluid breakfast. Poor nutrition and health parameters were found to have a negative impact school achievement, even after controlling for socio-economic factors (Clarke et al., 1991). Many researchers have examined the effect of breakfast consumption on total daily nutrient intake and adequacy.

Angus Craig detailed some of the reasons for discrepancies in research on breakfast consumption and performance (Craig, 1986). The delay between consumption of breakfast and the measurement of performance, the instrument used to assess cognitive efficiency or performance, quantity, volume and quality of the food consumed, individual's previous history or habit of breakfast consumption/skipping and the nature of the individual responding to the breakfast meal (diurnal rhythm) can all affect the observed response to breakfast (Craig, 1986).

The early part of the waking day is a period that is generally associated with the upward phase of the circadian rhythm, when there is a rapid increase in alertness, arousal and activation. Therefore, endogenous time-of-day effects could mask any effects that are directly caused by eating breakfast (Craig, 1986). All of these factors must be born in mind when evaluating and interpreting breakfast research.

Current evidence is still insufficient, in both quantity and quality, to permit firm conclusions about the influence of breakfast on performance. The mechanisms by which breakfast is hypothesized to impact performance is through its influence, if any, on concentration, mood, satiety, nutritional status and general health. If breakfast does influence these variables, what is its effect on educational performance?

Alan Meyers and colleagues examined the broader response of cognitive performance in school, specifically the effect of participation in the SBP on academic performance and attendance, of children in grades 3-6 in six elementary public schools in

Lawrence, Massachussetts (Meyers et al., 1989). Differences in scores on the annually administered standardized test, Comprehensive Test of Basic Skills (CTBS), were used as a measure of academic performance. While this was an improvement over the use of teacher evaluation of changes in behavior and performance in nonblinded studies of impact of breakfast or morning supplements on performance, this parameter has its own limitations. Meyers' sample consisted of a significant proportion of Hispanic children in transitional bilingual classes, who might have been adversely assessed on a standardized test designed for children with proficiency in English. However, the researchers attempted to control for environmental variables like family influence, as well as genetic variability in intelligence by using the differences in children's scores between two years. Thus, the children served as their own individual controls (Meyers et al., 1989).

Meyers et al. found that, after controlling for other variables, participation in the SBP positively impacted CTBS total battery ($p<0.01$), reading ($p<0.05$) and mathematics ($p<0.01$) scores. Increases in CTBS scores from 1986 to 1987 were significantly greater for children participating in the SBP than those who did not participate in the SBP ($p<0.01$). Tardiness rates decreased from 1986 to '87 for SBP participants while increasing for nonparticipants ($p<0.01$). SBP participation contributed significantly to the prediction of 1987 CTBS battery total scale scores ($P<0.05$), and followed only grade in school and 1986 battery total scale score in the weight of its contribution (Meyers et al., 1989).

Lopez and collegaues examined the effect of breakfast omission on cognitive performance in 279 normal, wasted and stunted schoolchildren (Lopez et al., 1993).

Subjects ranged in age from 8 to 12 yr. Short-term visual memory, problem solving and attention were found to be unaffected by 14 hr. fasting when compared with subjects who consumed a standard breakfast (Lopez et al., 1993). However, several studies conducted by Sally Grantham-McGregor and colleagues have shown an association between breakfast skipping and poor nutritional status in Jamaican schoolchildren (Grantham-McGregor, 1993; Grantham-McGregor et al., 1991). Both wasted and stunted children were found to perform more poorly on cognitive tests when breakfast was omitted. Breakfast skipping was one of the most powerful predictors of school failure, along with measures of socioeconomic status and attendance and illness measures (which could be correlated with poor nutrition as well) (Clarke et al., 1991). The discrepancy between these two researcher's results could partially be accounted for by the effect of motivation or stimulation on cognitive performance in the testing situation.

Michaud et al. also found an association between breakfast and cognitive performance, although not mood in a group of 319 well-nourished French adolescents (Michaud et al., 1991). The tests used were the scale test of short-term memory and word test of concentration and the Herbert Analogue Mood Rating Scale for mood. This was, however, a univariate analysis not a multivariate model.

The prevalence of breakfast skipping must be assessed to understand the impact of breakfast consumption or skipping on outcomes including health and performance. Child health advocates must be aware of not only the prevalence of meal skipping but also negative health outcomes associated with such eating patterns.

Prevalence of breakfast skipping

In a review of breakfast habits in children published in Nutrition and Food Science, Carrie Ruxton and colleagues (1993) commented that children under 12 years of age and adults over 65 are the most likely to consume breakfast, while young adults displayed the highest tendency to omit breakfast (Ruxton et al., 1993). In this study of 136 Scottish children, only 1.5% of children were found to skip breakfast regularly (Ruxton et al., 1993). Another study documenting the diets of 278 junior high school home economics students in Rhode Island found that, on average, both male and female students skipped breakfast 3 days per week (Brown et al., 1979).

Walker and colleagues examined breakfast consumption and prevalence of skipping in 4717 South African: Black, Indian, European and African-Malay adolescents (16-18 years old), using 24-hour recalls (Walker et al., 1982). Percent of the sample skipping breakfast ranged from 13% in Europeans and Indians to 21% in Blacks. However, this study failed to find significant differences in weight/height, academic class rank or attendance in individuals who were consuming a liquid (porridge) breakfast versus a breakfast of cooked food with or without cereal (Walker et al., 1982). This was due, in part, to the manner in which breakfast groups were defined. There was no calorie restriction on liquid breakfasts and porridge can be a substantially nutritive food.

Breakfast size and skipping breakfast are considered by health educators as a major problem in nutrition of adolescents (Bull, 1988; Stewart-Truswell, 1985). Breakfast skipping is hypothesized to be motivated by the concern for weight loss prevalent in many adolescents and young adults. However, evidence suggests that consuming high fiber foods, decreases not only the energy consumed at breakfast but also up to three and a half hours later (Levine et al., 1989). Resnicow and colleagues found that children who skip breakfast tend to consume greater amounts of high fat snacks (Resnicow et al., 1991).

Regular breakfast skipping is often seen in dieters and is associated with increased prevalence of obesity. The following study examines the effect of breakfast skipping on weight loss efforts.

Breakfast and obesity

In a study conducted by Schlundt et al. (1993), 52 moderately obese adult women were stratified according to their baseline breakfast-eating habits and randomly assigned to a weight-loss program (Schlundt et al., 1993). The no-breakfast group ate two meals per day and the breakfast group ate three meals per day. The energy content of the two weight-loss programs was identical. After the 12 week treatment, baseline breakfast eaters lost 8.9 kg in the no-breakfast treatment and 6.2 kg in the breakfast treatment. Baseline skippers lost 7.7 kg in the breakfast treatment and 6.0 kg in the no-breakfast treatment. Substantial changes from previously established patterns seemed to improve weight-loss. Schlundt and his group found that eating breakfast helped reduce dietary fat intake and minimize impulsive snacking and, therefore, may be an important part of a weight-reduction program (Schlundt et al., 1993).

Fricker and colleagues (1990) also examined circadian rhythm of energy intake and obesity status in 1312 adults seeking medical advice for weight loss (Fricker et al., 1990). The categories of obesity (non-obese, mildly obese and massively obese) were defined according to National Health and Nutrition Examination Survey II criteria, while dietary intake was assessed with a diet history. The 24 hour energy intake was found to increase with degree of obesity. Quantity and quality of breakfast consumed was found to have an inverse association with degree of obesity, while lunch was the opposite ($p<0.001$). The relationships of obesity with breakfast and lunch persisted after correction for nutrient intake. No relationships were observed with dinner or snacks (Fricker et al., 1990).

Implications of reviewed literature for proposed research

Given the relation of school meals to over all nutrient intake, health and performance of school children, it is important for school meals to conform to health and nutrient goals including the *USDA-DHHS Dietary Guidelines* and RDAs (USDA-DHHS, 1989; National Academy of Sciences, 1989). It is also important to examine dietary fiber intake of school children with the newly available computerized nutrient databases containing dietary fiber information (USDA, 1990). Vended foods are being offered in competition with school meals and, therefore, also deserve attention as part of efforts to ensure diet quality for U.S. school children.

Sample Design and Method of Statistical Analysis – Standard Error Calculation

The School Nutrition Dietary Assessment Study used a multistage stratified sampling plan. The Study sampled school districts, schools within the sampled school districts and students within the selected schools. First, districts were separated into four distinct types. Within each district type, the districts were separated into 10 census regions. Then districts were selected using probability proportional to size.

Each sampled district was assigned to one of two types of data collection, in-person visits (IP); or meals offered (MO). Those in the IP data collection sampled students while those in MO did not sample students. Three schools were sampled from the selected districts in the IP collection using probabilities proportional to size.

Ten students were sampled from each of the three chosen schools, totaling 30 students per district. In small districts for eg. those with only one school, 30 students were chosen at random from the school. In districts with two schools, 15 students were chosen at random from each school.

When the data are collected as part of a complex multistage plan a method is needed to produce unbiased estimates of the sampling variance. Most statistical programs such as SAS and SPSS base their methods of estimating standard error on the assumption that the data was collected using a simple random sampling plan. The standard error, used in creating confidence intervals of means, regression coefficients, etc and in inferential statistics, will be underestimated if the sampling design is not taken into consideration in the analysis.

The statistical analysis program SUDAAN utilizes design statements, plus an optional DESIGN parameter on the PROC (procedure) statement to describe the input data file. Three types of sample designs with equal or unequal probability and with or without replacement can be accommodated by SUDAAN. Variance estimation for the statistics computed by SUDAAN procedures is based on either the Taylor series linearization method (equivalent to GEE in regression procedures) or replication methods such as BRR and Jackknife.

For this analysis, Taylor linearization with replacement (WR) at the first stage, subsequent stages and equal probabilities of selection at both the first and subsequent stages was used. For a WR design, SUDAAN uses the between-PSU within-stratum variance component to estimate the variances. This corrects for the stratified multistage sampling design used for the School Nutrition Dietary Assessment Study data collection when calculating the standard error measures.

Chapter Three

Clusters of High Fiber, Low Fat Foods Selected by Children in USDA School Meals Programs

ABSTRACT

Objectives: To identify clusters of foods and food components consumed by USDA school meal program participants by total fat, saturated fat, and dietary fiber content and determine percent of program participants vs. nonparticipants achieving dietary recommendations (DR) for total fat (<30% energy), saturated fat (<10% energy) and dietary fiber (age + 5 g/d).

Methods: The USDA School Nutrition Assessment Study data set is a nationally representative sample of 3,381 students from 329 schools across the country, grades 1-12 and food composition data on 38,380 foods and food components selected by school children. Dietary fiber content of these items was estimated by USDA Nutrient Analysis of Individual Intake Surveys, version 4. High fiber, low fat items consumed by children were identified using fuzzy K-means cluster analysis from the Statistical Analysis Software, version 6.03. Percentage of children achieving DR was determined by participation in the school breakfast program (SBP), and/or national school lunch program (NSLP).

Results: Five main clusters of foods consumed by school children were identified. Cluster #1 contained 1,890 foods high in dietary fiber and low in fat and saturated fat, including sugar free hot chocolate, ready-to-eat breakfast cereal, whole wheat bagels, baked snack chips, etc. Three clusters contained foods high in fat and low in fiber such as pizza, cheese, ice cream, hamburgers, etc. and one cluster had items low in all three nutrients. Significantly more children who did not participate in USDA school meal programs achieved DR for fat, saturated fat and dietary fiber (5.7%, p<0.001), than those who participated in the SBP only (2.9%), NSLP only (1.8%) or both SBP and NSLP (2.8%). **Conclusions:** Many high fiber, low fat foods popular with children are already

available in school meals programs. Cluster analysis is a powerful, flexible tool to identify such foods from existing school offerings. Increasing the number of times these foods are offered in meals programs may be one way to increase DR achievement by school meal program participants.

Clusters of High Fiber, Low Fat Foods Consumed by Children in USDA School Meals Programs

INTRODUCTION

Presently over half of U.S. children get at least one of three major meals per day in school. Ten percent of children receive two out of three meals per day at school (Nicklas et al. 1993). Therefore, it is of vital importance to evaluate the school meal program efficacy in offering children choices to encourage achievement of the United States Department of Agriculture=s (USDA) and Department of Health and Human Services= (DHHS) *Dietary Guidelines for Americans* recommendations for total fat (<30% energy) and saturated fat (<10% energy) and dietary fiber. The American Health Foundation=s recommendation for daily dietary fiber intake (g/day) is equal to at least the child's age plus five grams of fiber (Williams et al. 1995). These three nutrients play key roles in the prevention of coronary artery disease, some cancers, and gastrointestinal problems such constipation (Osganian et al. 1995).

The Child Nutrition Act was first ratified in 1946, establishing the National School Lunch Program in an effort to meet the nutrition needs of underprivileged children in the U.S. (Dwyer 1995). In 1966, this act was amended to begin the service of breakfast (School Breakfast Program) in schools in particularly poverty stricken areas. Congress recently modified this legislation as part of the Welfare Reform Act of 1996 in an attempt to streamline the program's funding and regulations (Johnson 1996).

Dietitians and other health professionals are lobbying to update dietary recommendations for the NSLP and SBP to be consistent with chronic disease prevention rather than merely the original goal of prevention of undernutrition (USDA 1995).

In June of 1995, the USDA proposed to change the existing food group-based menu planning system used in school meals programs to a nutrient-based system in order to promote achievement of dietary guidelines for selected nutrients such as fat, saturated fat, calcium, iron, etc. (USDA 1995). While the *USDA School Meals Initiative for Healthy Children* was greeted with approval from parents and health professionals, it inspired nearly unanimous concern and disapproval from school food service personnel. School food service personnel were concerned primarily about the training and cost of computer technology required to change the menu planning system to meet the dietary guidelines (USDA 1995). USDA later permitted the schools to keep existing menu planning or nutrient based planning to meet DR (USDA 1997). Federal policy mandates that school meals meet dietary recommendations (DR) by 1997/98 (US DHHS 1990). One of the few suggestions given to schools by the USDA to help them meet these goals is to make healthful foods widely available (USDA 1997).

The goal of our study was to identify high fiber, low fat and saturated fat foods consumed by children in the USDA school meal programs. In order to analyze simultaneously the content of several nutrients in items consumed by children in USDA school meals programs, we chose a statistical analysis tool not widely used in dietary analysis, Fuzzy Clustering. Fuzzy Clustering is a flexible, powerful analysis tool permitting examination of multiple nutrients in the natural distribution, without investigators setting cut points a priori for the number of groups of foods or high/low nutrient contents (Aldenderfer et al. 1984). The fuzzy K-means algorithm identifies natural clusters of foods from the distribution of foods in several dimensions; here we chose total fat, saturated fat and fiber (Aldenderfer et al. 1984). Not only are the foods identified by this study ones already offered by school food service system menus, but ones that children consumed voluntarily. Increasing the availability of these identified foods could, then, be one practical means by which school food service systems could move toward achieving the USDA dietary recommendations with little additional cost or training.

METHODS

Sample and Data set

We used the USDA School Nutrition Dietary Assessment Study (SNDA) data set collected in 1991-1992, a nationally representative sample of 3,381 children in grades 1-12 (approx. 250 students per grade) from 329 schools across the U.S. (Burghardt et al. 1993). Students not attending school on the day of data collection, those enrolled in programs offering self-contained classes for students with disabilities, students from Alaska or Hawaii, and students enrolled in kindergarten were not included in the sample (Burghardt et al 1993). Food intake data for a 24 hour period were collected by trained interviewers administering questionnaires. To collect dietary intake data for children in grades 1-3, parents were interviewed along with the child. Nutritional composition data were included on foods consumed by children from the USDA National School Lunch Program (NSLP) and School Breakfast Programs (SBP) at each school, as well as foods purchased

in vending machines or in campus snack shops (Burghardt et al. 1993).

Although the SNDA study also included dietary information on students who did not participate in USDA school meal programs, we examined only foods consumed by program participants for the cluster analysis. For the assessment of DR achievement we included all SNDA children. All data were coded to maintain anonymity of participants. Analysis by ethnicity was not possible due to errors in the coding for the variable Arace≅ in the SNDA data set.

Analysis

The initial USDA analysis of the SNDA data did not address dietary fiber, due to incomplete information on dietary fiber content of foods in USDA computerized nutrient databases and lack of established recommendations for pediatric dietary fiber intake at the time of data collection (Burghardt et al. 1993). However, a subsequent release of the USDA Nutrient Database for Analysis of Individual Intake Surveys version 4 in 1991 made our analysis possible (USDA 1990). SNDA data were obtained from USDA on IBM mainframe magnetic reel tapes in Statistical Analysis for the Sciences (SAS) ASCII files with accompanying SAS programs to label data. Five relevant files with participants= 24 hour nutrient intakes, diet recalls, demographic information and food composition were downloaded to SAS version 6.03 personal computer files (SAS Institute 1988). Food composition of items from school sources such as cafeteria, vending machines, and on campus snack shops, consumed by children was determined from product labels, recipe analyses, food service nutrient profile databases by the SNDA study. Foods brought from home were not included in our analysis. Foods listed more than once were entered only once, however, similar foods were kept separate. For example, milk 2% fat and milk 1% fat were counted as different foods. The large number of foods in the database is due to separation of mixed dishes such as spaghetti into component foods (i.e., spaghetti sauce, pasta, cheese, ground meat, etc). Food codes from all SNDA children's diets were matched with USDA dietary fiber updated Nutrient Database for Individual Intake Surveys version 4 to determine dietary fiber content of foods, as well as to calculate total 24 hr. dietary fiber intake of children (USDA 1990).

Fuzzy cluster analysis was used to determine which foods selected and consumed by children in USDA school meal programs were low in fat, saturated fat and high in dietary fiber. Then, items in the high fiber, low fat cluster most popular with DR achievers was determined and compared to the high fat, low fiber items most popular with those who did not achieve DR. Popularity was defined as the number of children consuming these items. Grams/1000 kcal of total fat, saturated fat and dietary fiber in each food were used for clustering foods. Extreme values for these three nutrients in the data (> 2 standard deviations from the mean) were removed from the analysis to prevent skewing of the clusters (Aldenderfer et al. 1984). Fuzzy cluster analysis by the SAS Fastclus procedure utilizes a Fuzzy K-means algorithm to determine the appropriate number of groups of foods based upon their content of multiple nutrients and calculates a cluster center nutrient profile for each group (SAS Institute 1988). This clustering is based upon Euclidean distances between observations (those distances within groups being less than distances between groups). The program, then, generates an association value ranging between 0 and 1 for each food in the cluster compared to the cluster center as a goodness of fit measure (SAS Institute 1988).

Variables describing participants used for analysis included age, participation in school meal programs, percent of energy from total fat and saturated fat and total grams of dietary fiber consumed in 24 hr. Descriptive analyses of percent of children achieving DR for nutrients of interest (total fat, saturated fat and dietary fiber) based upon USDA meal program participation were run using SAS version 6.03 (SAS Institute 1988).

RESULTS

The cluster analysis of foods consumed from school sources by children yielded five main clusters (of greater than 1,000 foods per cluster) based upon nutrient density (g/1000 kcal) for dietary fiber, total fat and saturated fat. Clusters with less than 1,000 items are not reported here. The results shown in **Table 1** indicate that approximately 1,890 low total fat, low saturated fat, and high fiber foods were identified (Cluster #1). **Table 2** shows the high fat, low fiber items in Clusters # 2, 4 & 5 compared to Cluster #1. These items were determined by assessing which foods in the low fat, high fiber cluster (#1) were consumed most frequently by children achieving the DR and which high fat, low fiber foods (clusters 2, 4, & 5) were most frequently consumed by children not achieving the DR. The high fat, low fiber foods included hot dogs, hamburgers, ice cream, high fat desserts, cheese, etc., while the high fiber, low fat foods included some surprises as sugarfree hot chocolate (with skim milk and soluble gum thickener) and baked snack chips along with the expected high fiber ready-to-eat breakfast cereals and whole wheat bread. Cluster # 3 consisted of foods low in all three nutrients such as beverages, some condiments, etc. The largest number of foods and food components fell into Cluster #3.

A complete list of foods in each cluster is available to interested parties on disk by contacting the first author.

The percentage of children achieving DR for total fat, saturated fat and dietary fiber in 24 hr based upon USDA meal program participation is shown in **Table 3**. Of those children who did not participate in either the USDA SBP or NSLP, 5.7% achieved DR for the nutrients of interest. This was significantly more ($p<0.001$) than those who only participated in the SBP but not NSLP (of whom only 2.9% achieved DR) as well as those who participated in the NSLP but not SBP (of whom only 1.8% achieved DR). A significantly greater percentage of children who did not participate in either the SBP or NSLP achieved DR compared to children who participated in both programs (5.7% vs. 2.8%, $p<0.001$).

DISCUSSION

The USDA=s analysis of the SNDA found that the mean percentage of energy from fat was 34% when the nutrient intakes of all study participants was included, while saturated fat constituted 13% of energy (Devaney et al. 1995). However, fat intake of school meal program participants alone averaged 37% of energy with 14% energy from saturated fat (Devaney et al 1995). This high average fat intake could reflect the lack of enough food choices which are appealing, low fat sources of dietary fiber in the USDA school meals programs, or lack of popularity of those items when children make their own food selections.

The Child and Adolescent Trial for Cardiovascular Health (CATCH) included the Eat Smart Program which targeted school food service staff and aimed to lower fat, saturated fat and sodium content of school meals (Osganian et al. 1996). There was a significantly greater mean reduction in the percentage of energy from fat (-4.1%; p<0.001) and saturated fat (-1.3%; p=0.003) in response to USDA=s mandate to meet DR), in the 56 schools where the intervention was conducted over a two and half year period compared to control schools (Osganian et al. 1996). This indicates that nutrition and education for food service staff about low fat food preparation leads to improved compliance of school meals with DR. However, the CATCH study did not address dietary fiber content of foods (Osganian et al. 1996).

Our study found that hot chocolate and chocolate milk, with carageenan thickener were popular sources of dietary fiber in the SNDA children=s diets. The other major sources of dietary fiber in the SNDA children=s diets were whole grain products such as baked snack chips and high fiber ready-to-eat breakfast cereal. Beans and vegetables were significant contributors to dietary fiber, but far less popular in the self-selected diets of these school children. Interestingly, from the Bogalusa study, Nicklas et al. also found that the milk group (including mixed dairy products) was a significant contributor of dietary fiber especially in the form of carageenan found in low fat chocolate milk (Nicklas et al. 1995). The two categories of food contributing most to dietary fiber intake in the Nicklas et al. study were vegetables/soups and breads/grains.

Substitution of foods high in dietary fiber and complex carbohydrates for foods high in total fat and saturated fat is important in the prevention and treatment of constipation, obesity, hyperlipidemia, diabetes mellitus and some cancers in children and adults (Nicklas et al. 1995). Nicklas et al. argue that a shift toward greater consumption of whole grains, vegetables, legumes and fruits will be necessary to reach this goal (Nicklas et al. 1995). In 1991, the National Cancer Institute began the 5 A Day for Better Health Program to encourage Americans to consume more fruits and vegetables to increase their likelihood of obtaining not only adequate dietary fiber but essential micronutrients such as antioxidant vitamins (Nicklas et al. 1996). Such food-based recommendations appeal to consumers more than nutrient based recommendations, as nutritionists and other health professionals are well aware (Nicklas et al. 1996).

Only a very small percentage of children in the SNDA sample achieved the dietary recommendations for total fat, saturated fat and dietary fiber (5.7% of those who participated in neither the NSLP or the SBP). Participation in the school meals programs was associated with a significantly lower percentage of children achieving DR. More children were unable to achieve the AHF recommendation for dietary fiber than the recommendations for fat and saturated fat. Our study categorized children into DR achievers or nonachievers based upon the 24-hour recalls from the SNDA sample. Due to day to day variation of intake, it is possible that achievement of DR over time may be different from the low percentage we found.

The Bogalusa Heart Study found that 15-22% of school age children achieved DR for total fat (<30% energy) between 1973 and 1988 respectively. The percentage of children achieving saturated fat recommendations (<10% energy) ranged from 8% in 1973 to 22% in 1988 in the Bogalusa study (Nicklas et al. 1996). The average dietary fiber intake did not vary in the Bogalusa trials from 1973 to 1988, remaining at approximately 12g/day (Nicklas et al. 1996).

Wirfat et al. used fuzzy cluster analysis to group people according to specific foods consumed, for example meat and pastry consuming groups, and related those groupings to nutrient content of the diet (Wirfat et al. 1997). For example, individuals whose diet contained most foods from the meat and pastry group were found to have a higher average total daily fat intake than foods in other groups (Wirfat 1997). In the current analysis, we looked at the opposite relation. We identified categories or clusters of low fat, high dietary fiber foods from the diets of children achieving DR for fat and fiber.

We found Fuzzy Cluster analysis to be a valuable tool for finding patterns of foods which can be used for framing food-based recommendations rather than nutrient recommendations. However, cluster analysis is limited by its sensitivity to extreme values in a data set. Therefore, data must be cleaned carefully prior to employing this technique. For example, the SNDA data set had errors showing individuals to have unusual nutrient intakes, for example 154 g of dietary fiber intake in a 24 hr. period due to a data entry error of a misplaced decimal on portion size of chilli consumed. Each diet record and food composition profile had to be reviewed for such errors by a trained dietitian to remove such cases from the analysis.

Dietitians often teach that foods are not inherently good or bad. However, the encouragement of consumption of specific foods promoting health (e.g. fruits and vegetables as promoted by the National Cancer Institute) is an effective manner of translating nutritional science into advice easily accessible to target audiences (National Cancer Institute 1994). The US Dietary Guidelines are difficult for some food service directors to recall and apply. For example, Hurd et al. reported that while 76% of the food service directors in Texas reported awareness of the Dietary Guidelines, only 59% could name at least two (Hurd et al. 1996). The school cafeteria can be a good place to display point-of-selection educational graphics showing the foods contributing to achievement of DR for optimum health (Nicklas et al. 1995).

IMPLICATIONS FOR HEALTH PROFESSIONALS

Many (n=1,890) low fat, high dietary fiber foods popular with school children are already available within USDA school meal programs offerings. Perhaps, an easily applicable measure to help children increase their likelihood of achieving dietary recommendations for fat and fiber is to offer such foods more frequently. Another important step would be to identify these food choices, at the point of selection, with colorful graphic messages stating that they are foods likely to promote optimum health. Nutritionists can help train food service staff to plan creative menu combinations incorporating such existing low fat, high fiber foods and promote selection by appropriate nutrition education point-of-selection nutrition education. Cluster analysis is a powerful technique for identifying food patterns that promote DR and optimum health.

Table 1. Cluster center profiles for clusters of foods consumed by USDA school meal program participants based upon the food's dietary fiber, total fat and saturated fat content.

Cluster	Type	No. of Foods	Dietary Fiber g/1,000 kcal	Total Fat g/1,000 kcal	Saturated Fat g/1,000 kcal
1	High fiber, low fat	1,890	4.7	1.3	0.3
2	Low fiber, mod.fat	4,874	0.6	10.9	4.5
3	Low fiber, low fat	29,467	0.5	1.9	0.7
4	Low fiber, high fat	1,475	1.4	17.4	4.9
5	Low fiber, high fat	1,043	1.1	24.9	8.3

Table 2. High dietary fiber, low fat & saturated fat cluster of foods consumed most frequently by dietary recommendation (DR) achievers in USDA school meal programs compared to foods in the high fat & saturated fat, low dietary fiber cluster consumed most frequently by school meal program participants not achieving DR for fat, saturated fat and dietary fiber.

Cluster #1 (high dietary fiber/ low fat)	Cluster # 5 (low fiber/ high fat)
Sugar Free Hot Chocolate	Cheese
Chocolate milk	Hot Dogs
Baked Snack Chips	Hamburgers
Ready-to-Eat Breakfast Cereals	Ice Cream
Whole Wheat Bagels	Pizza
Whole Fresh Apples	Butter/Margarine
Carrots	Macaroni and Cheese
Baked Beans	Salad dressings
Baked Potato Strings	Gravy
Pinto Beans	Mayonnaise
Chili	High Fat Dessert Items
Green Peas	Lasagna

* frequency was determined by counting the number of DR achievers and nonachievers consuming these foods

Table 3. Percentage of children who achieved dietary recommendations (DR)* for dietary fiber, total fat, and saturated fat in 24 hr., by USDA meal program participation

Group	Unweighted n	Percent achieving DR
National School Lunch Program only	1744	1.8%
School Breakfast Program only	319	2.9%
Participants in both SBP and NSLP	145	2.8%
Students not participating in either program	1637	5.7%**

* Less than 30 % energy from total fat, less than 10% energy from saturated fat and equal to or greater than age (yr.) plus five grams per day of dietary fiber.

** p<0.001 different from all other groups, based on weighted tabulations from the SNDA data.

Chapter Four

Dietary Fiber Intakes of U.S. School Children Do Not Meet American Health Foundation Recommendations

ABSTRACT

Objectives: To assess dietary fiber intakes of U.S. school children by age, gender, ethnicity, family income, student eligibility for free or reduced price school meals and participation in USDA school meal programs.

Methods: The USDA School Nutrition Dietary Assessment Study (SNDA) data with a nationally representative sample by grade of 3,381 children in grades 1-12 were used. Dietary fiber intakes were calculated using the dietary fiber data of updated USDA Nutrient Database for Analysis of Population Based Surveys, version 4 released in 1990. Descriptive analyses, Tukey-Kramer t-tests, Chi-square analyses and correlations were run using SAS version 6.03 and JMP from the SAS Institute and SUDAAN. American Health Foundation (AHF) recommendation [age (yr.) + 5 g/day] was used as the reference standard for dietary fiber intake. All analyses were weighted to make the results nationally representative.

Results: Dietary fiber intakes of U.S. school children, particularly adolescents, do not meet AHF recommendations. Percent of U.S. school children achieving AHF recommendation ranged from 61.7% of males age 6 to 9.1% of females age 18. Fewer females age $\geq$ 12 yr. achieved AHF recommendations than males of the same age. Black children had significantly lower mean dietary fiber intakes than white children at nearly

all ages, while Hispanic adolescents had significantly higher mean intakes than white adolescents at most ages. Annual family income was only weakly correlated with dietary fiber intakes ($r=0.06$, $p<0.01$) and dietary fiber intakes did not differ significantly by student eligibility for free or reduced price school meals. Signficantly fewer students who participated in School Breakfast Program (52% vs. 61%, $p<0.05$) or National School Lunch Program (42% vs. 48%, $p<0.05$) achieved AHF daily dietary fiber intake recommendations than children who did not participate in USDA school meal programs. **Conclusions**: Dietary fiber intakes of children, especially adolescent females fail to meet AHF recommendations. Given the availability of dietary fiber content of foods and guidelines for pediatric dietary fiber intake, dietary fiber should be included in the nutrient goals for USDA school meal programs. Physicians and other health professionals should educate parents and children on the importance of consistently making high fiber food choices to reduce risk of chronic diseases in adulthood.

Dietary Fiber Intakes of U.S. School Children Do Not Meet American Health Foundation Recommendations

INTRODUCTION

Optimizing the diet of children is important in order to meet the following goals: 1) to support adequate growth and development (American Academy of Pediatrics 1983; Dwyer 1987; American Academy of Pediatrics 1981, American Heart Association 1983), 2) to reduce the risk of diet-related chronic diseases such as coronary artery disease (Williams 1992; Wynder et al. 1989, National Cholesterol Education Program 1991), some cancers (Williams et al. 1993, National Cancer Institute 1987), stroke, adult-onset diabetes, obesity and hypertension (Public Health Service 1991) , and 3) to establish healthy eating habits in early life (Kleinman et al. 1996). Recommendations for micro nutrient, macro nutrient, and energy intake for children of various ages have been established by the National Academy of Sciences and recently updated for selected micro nutrients (National Academy of Sciences 1989). These Recommended Dietary Allowances are the levels of intake of essential nutrients that are deemed adequate to meet the known nutrient needs of practically all healthy persons (National Academy of Sciences 1989). The current paradigm of optimizing diets seeks to not only ensure nutritional adequacy and good health for the present but also to minimize future risk of diet-related chronic disease (Public Health Service 1991).

With this aim of disease prevention, initial recommendations for dietary fiber intakes in children ranged from 0.5 g/kg of body weight to 10 g/1000 kcal (American Academy of Pediatrics 1993). The 0.5 g/kg body weight recommendation, put forth by the American Academy of Pediatrics, resulted in fiber recommendations for obese adolescents in excess of 40 g/day, placing individuals with borderline or low mineral intake at risk for nutrient deficiency (American Academy of Pediatrics 1993). In 1994, the American Health Foundation's age-specific recommendation for dietary fiber intake in children, age plus five grams per day, was accepted as safe and adequate for health promotion and disease prevention by nutritional and medical scientists (Williams et al. 1995).

Dietary fiber has important health benefits in childhood, including promoting bowel regularity (Fulgoni et al. 1991). Adequate dietary fiber intake throughout life has been related to reduced risk of some adult onset cancers, such as breast, colon, pancreas, ovary, endometrium and prostate cancer (Williams et al. 1993, National Cancer Institute 1987). Dietary fiber moderates blood glucose concentration in adult onset diabetes, reduces blood cholesterol and even helps maintain a healthy weight for height by inducing satiety without increasing calories content (Public Health Service 1991). Because the methodology for analyzing dietary fiber was only developed within the past decade, nutrient databases used for population dietary survey analysis did not have complete, accurate and consistent information on dietary fiber until the early 1990s (Slann 1987, United States Department of Agriculture 1990). For this reason, relatively little information about the dietary fiber intakes of children is available in the literature.

The United States Department of Agriculture (USDA) collected extensive data on a nationally representative sample of children's diets and nutrient composition of foods offered in the National School Lunch Program (NSLP) and School Breakfast Program (SBP) as part of their School Nutrition Dietary Assessment Study (SNDA) in 1991-92 (Burghardt 1995). However, they were unable to examine dietary fiber intakes of their study participants due to inadequacy of dietary fiber information in computerized databases and the lack of dietary fiber intake guidelines at the time of data collection (Burghardt 1995). The objectives of our study were to assess dietary fiber intakes of U.S. school children using dietary fiber updated databases to examine SNDA data. Secondarily, we examined differences in dietary fiber intake by age, gender, ethnicity, family income, student eligibility for free or reduced price meals, and participation in USDA school meal programs.

METHODS

Sample and Data set

The SNDA data set (1991-92) includes 24 hour recall dietary data collected from a nationally representative sample of 3,381 children in grades 1-12 in a nationally representative subsample of 329 from a total of 545 schools from the 48 contiguous states from which school level data were collected (Burghardt 1995). The nationally representative children were selected in a multistage sampling design. Food intake recall data for a 24 hour period, including a school day, were collected by trained interviewers administering questionnaires. Children in grades 1-3 were interviewed with their parents to obtain dietary intake data. Children in grades 4-12 reported their own intakes. Student level data were weighted to adjust for selection bias. All data were coded to maintain anonymity of participants (Burghardt 1995).

Food composition data on all foods from the USDA National School Lunch Program (NSLP) and School Breakfast Programs (SBP) were coded by nutritionists from the Minnesota Nutrition Coordinating Center. Lists of foods purchased from vending machines, A La Carte programs, and on campus snack shops at each school were collected from school food service administrators (Burghardt 1995) . The race of the student was identified and recorded by the interviewer collecting the data, rather than student self report. Family income was obtained from a questionnaire assessing demographic information and student/parent attitudes toward USDA meal programs mailed to the parents of each child in the study. School administrators reported each student=s eligibility for free (annual family income <135% Poverty Index) or reduced price (family income between 135% and 185% of Poverty Index) school meals (Burghardt 1995). Student participation in the school meal programs was determined from students= 24 hr. diet recalls. The source from which each item was obtained was recorded as part of the diets recalls. Students were considered SBP participants if they consumed 2 of the 4 food group components required for USDA reimbursable breakfasts. NSLP participants were defined as those students who consumed at least 3 of the 5 meal pattern components required for a USDA reimbursable lunch (Burghardt 1995).

Analysis

SNDA data were obtained from the USDA on IBM mainframe magnetic reel tapes in Statistical Analysis for the Sciences (SAS) ASCII files with accompanying SAS programs to label data. Five relevant data files (stanal.dat, strecipe.dat, stchar.dat, stfcomp.dat, and scvend.dat) were downloaded to SAS version 6.03 personal computer files (SAS Institute 1998). Food codes from the SNDA participants= diets were matched with USDA dietary fiber updated Nutrient Database for Analysis of Population Based Dietary Surveys version 4 to determine dietary fiber content of foods to calculate 24 hour dietary fiber intake of children (USDA 1990) . These 24 hour dietary fiber intakes were compared to the age-specific American Health Foundation dietary fiber guideline [age (yr.) plus five grams per day] (Williams 1995). For the analyses by age, children aged 5, 19, and 20 yr. (n = 20 total) were not included due to insufficient power (small cell number). For the comparisons by ethnicity only white (n=2188), black (n=544) and hispanic (n=459) students= diets were included due to small samples with inadequate power in the mixed race and other categories (n=190 total). Comparisons by ethnicity were performed with students collapsed across gender because the gender distribution of students within each ethnic category did not differ significantly.

Variables used for analyses included total grams per day of dietary fiber in each student=s 24 hr. intake, participation in school meals programs, age, race, annual family income, and eligibility for free or reduced price meals. Family income was a continuous variable in the SNDA data. Relationship of family income to dietary fiber intake was assessed with a simple regression. Chi-square analyses including all children, regardless of race or age, were used for comparions by USDA meal program participation and eligibility for free or reduced price meals. Weighted descriptive analyses of mean fiber intakes and differences in fiber intakes by various factors were conducted using SAS version 6.03 and JMP from the SAS Institute (SAS Institute 1998) and SUDAAN . Differences in mean dietary fiber intakes of various groups were tested using Tukey-Kramer t-tests. This technique utilizes a conservative family based alpha level for multiple comparisons resulting in a reduced power but greater assurance of finding true differences between groups (Tukey 1960). This was preferable to a multiple regression because dietary data available were only for one 24 hr. recall rather than diet over time.

RESULTS

The percent of children achieving the American Health Foundation recommendation of age plus five grams or more of dietary fiber per day is represented in **Figure 1**. Note the steady decline in fiber recommendation achievement with increasing age, especially in adolescent females. A significantly smaller percent of females met the AHF fiber recommendations compared to males (36% vs. 49%, $p<0.001$). The 24 hour mean dietary fiber intakes by age and gender are shown in **Table 1**.

Interestingly, mean fiber intakes were significantly but only weakly correlated to family income ($r=0.06$, $p<0.001$). Children eligible for free or reduced price school meals were not significantly more likely to achieve dietary fiber recommendations than those ineligible (43% of those eligible vs. 42% of those ineligible for low cost or free meals). Significantly fewer children who participated in the USDA School Breakfast Program (SBP) achieved AHF fiber intake recommendations than children who had a breakfast other than USDA SBP (52% vs. 61%, $p<0.05$). Significantly fewer children who participated in USDA National School Lunch Program (NSLP) achieved AHF fiber intake recommendations than nonparticipants (42% vs. 48%, $p<0.05$). Low fat food sources of dietary fiber in the SNDA children's diets are described elsewhere (Yagalla et al. 1998) . **Table 2** shows differences in mean fiber intakes between white, black and hispanic children. Black children had significantly lower mean fiber intakes than white children at nearly all ages. Hispanic adolescents, however, had significantly higher mean fiber intakes than white adolescents. These ethnic differences in fiber intake do not seem likely to be attributable to differences in family income, which was only very weakly correlated with fiber intake.

DISCUSSION

As illustrated in **Figure 1,** most children under the age of 10 in the SNDA sample achieved the American Health Foundation age plus five grams of dietary fiber per day, however, this declined as children entered adolescence. Adolescent females were significantly less likely to achieve AHF dietary fiber recommendations than adolescent males, and the drop occurred 2 years earlier in females. Adolescents have more freedom in food selection, including going off campus to fast food and other restaurants during high school years than younger children. This increased freedom of choice coupled with a lack of awareness of dietary impact on chronic disease prevention and food sources for dietary fiber may be contributing to the lower fiber intakes in older children (Murphy 1994) . Adolescent females are perhaps most at risk for low fiber intakes due, in part, to the high prevalence of restrictive eating, dieting and meal skipping (Murphy 1994) . Burghardt and colleagues in the initial SNDA analysis found that 22% of 15-18 yr. old females skipped breakfast and 12% ate no lunch (Burghardt 1995).

The chronic pattern of low fiber intake after elementary school in youth is of concern due to the elevated risk for chronic diseases in adulthood such as coronary artery disease, some cancers, and hypertension (Williams et al. 1993, National Cancer Institute 1987). McClung and colleagues, in a study of dietary fiber intake and gastrointestinal function in children aged 2 to 12 yr., found that approximately half of their subjects consumed less than age + five g/day (McClung et al. 1995). They noted that those children with low fiber intakes were significantly more likely to experience constipation than children consuming adequate fiber and water (McClung et al. 1995). Despite physician instruction to children and parents to increase fiber intakes, McClung et al., reported that children with constipation continued to have less than half the mean fiber intakes recommended (McClung et al. 1995).

Significantly fewer participants in USDA meal programs achieved AHF fiber intake recommendations than children who did not participate. Although this could be due to gender, age, or other differences between program participants and nonparticipants, another reason for this could be an inadequate number of high fiber offerings in USDA programs. For example, Burghardt and colleagues, in the original analysis of the SNDA data, found that although high schools and middle schools were more likely to offer fresh fruits and vegetables than elementary schools (approximately 35% vs. 12% of elementary schools, $p<0.001$), they were also more likely to offer low fiber breads such as hamburger and hotdog buns and white rolls (50% vs. 25%, $p<0.001$) and more likely to offer low fiber entrees such as hamburgers, hotdogs, and cheese sandwiches than elementary schools (25% vs. 10%, $p<0.001$) (Burghardt et al. 1995). Hot chocolate and chocolate milk have been found to be popular sources of dietary fiber for children of all ages, however, these beverages were only offered on 42% of school days (Burghardt et al. 1995).

The SNDA participants' mean and median dietary fiber intakes are higher than those found in the Bogalusa Heart Study (Nicklas et al. 1995). The Bogalusa Heart Study was a prospective study of coronary artery disease risk factors in children. The dietary recalls collected from 1976-1987 were reanalyzed for dietary fiber using USDA computerized nutrient database version 4, the same database used for our analysis. The mean dietary fiber intakes of ten year olds in the SNDA sample was 15.2 g/day compared to mean intakes ranging 11.2 g/day in 1978 to 12.5 g/day in 1987 for ten year olds in the Bogalusa sample. Thirteen year olds' dietary fiber intakes in the SNDA averaged 15.8 g/day compared to Bogalusa sample intakes ranging from 11.5 g/day in 1976 to 14.0 in 1987 (Nicklas et al. 1995). There appears to be a trend toward increased dietary fiber intake over time from 1976 to 1987 values within the Bogalusa sample compared to the SNDA 1992 levels.

We found that dietary fiber intakes in SNDA adolescent females aged 12-18 were significantly lower than those of adolescent males ages 12-18. The Bogalusa study also reported similar results with females having significantly lower fiber intakes than males ($p<0.05$) (Nicklas et al. 1995) . When grams of fiber per 1000 calories was used to adjust for energy intakes, Nicklas and colleagues found the gender difference was no longer significant (Nicklas et al. 1995). However, neither the American Health Foundation fiber recommendations for children nor the USDA Food Guide Pyramid fiber recommendations for adults are adjusted for differences in energy intake or gender

(USDA 1992) , so we chose to use grams of dietary fiber consumed per day rather than grams of fiber per 1000 kcal.

Both the mean (15.6 g/d) and median (14.0 g/d) dietary fiber intakes of SNDA children aged 6-11 yr. were higher than children aged 6-11 yr. in the Nationwide Food Consumption Survey (NFCS) 1977-78 (12.1g/day) and 1987-88 (11.5 g/day) (Saldanha 1995). Similarly, for SNDA males aged 12-18 yr. mean dietary fiber intake was 21.0 g/d and median 18.3 g/d, higher than the mean of 15.2 g/d in the NFCS 1977-78 males of this age and 14.0 g/d in NFCS 1987-88 males aged 12-18 yr. Females aged 12-18 yr. in the SNDA study also had higher mean (12.6 g/d) and median (12.5 g/d) fiber intakes than NFCS 1977-78 females (mean 11.0 g/d) and NFCS 1987-88 females (10.6 g/d). The NFCS collected two day diet records and one 24 hr. recall per child, which were averaged to assess nutrient intake. However, Saldanha and colleagues used USDA Nutrient Database for Individual Food Intake Surveys version 2 released in 1985 to assess the dietary fiber intakes of these children (Saldanha 1995). Dietary fiber content of many foods was still missing in that version, and could have led to underestimation of total daily fiber intakes. Version 4 of the USDA nutrient database is more than 98% complete for dietary fiber content of foods (USDA 1990). The higher mean intakes found in the SNDA sample could also reflect a greater variety of high fiber foods available in the current food supply than earlier. For example, many new high fiber ready-to-eat breakfast cereals have been released in the past decade. High fiber cereals were found to be popular sources of dietary fiber in children's diets in our study as well as those conducted by other researchers (Saldanha 1995, Nicklas et al 1995). Other low fat food sources of dietary fiber consumed by the SNDA participants are enumerated elsewhere (Yagalla 1998).

Levine and Guthrie, in a study of nutrient intakes and eating patterns of teenagers in the Continuing Survey of Food Intakes of Individuals (CSFII) 1989-1991, found that mean fiber intake ranged from 11 to 16 grams per day in children ages 13-18 (Levine et al. 1997). Dietary fiber Intakes of females were particularly low in this analysis, with white females aged 13-18 averaging 11.2 g/day and black females averaging 11.0 g/day. Hispanic and other ethnicity children were not included in the CSFII analysis due to insufficient sample size (Levine et al. 1997) . The CSFII analysis was performed with the USDA fiber updated version 4 database.

The dietary fiber intakes of white, black and hispanic children in the SNDA study differed significantly as shown in **Table 3**. We found that black children, at most ages, consumed significantly less fiber than white children. This differs from the Bogalusa study, which found black females ages 10-17 yr., consumed significantly more fiber than white females ($p<0.01$) (Nicklas et al. 1995). Hispanic children were not included in the Bogalusa study. Hispanic adolescents in the SNDA sample consumed significantly more fiber at most ages than white adolescents. This could be due to the culturally prevalent practice of using beans and bean products in Hispanic cuisine. Family income, which has been found in earlier studies of adults to account for the variance in ethnic and racial differences in diets, was only weakly correlated to fiber intake in our study.

Our study is the only analysis of a large nationally representative sample of children ages 6-18 using the most up to date dietary fiber databases and intake recommendations, therefore, presents valuable and valid information on differences in mean dietary fiber intakes by age, gender and ethnicity. However, the SNDA study dietary information is based on a 24 hour recall, not an assessment of diet over time. Therefore, individual achievement of dietary fiber recommendations over time may vary due to day to day variability in food intake. Multiple regression analysis of factors contributing to differences in dietary fiber intake would be valuable, but only if dietary information was based on a food frequency questionnaire or other assessment of diet over time rather than a single 24 hour intake. Since the AHF recommendations themselves were only established in 1994, it is important to assess achievement with the available SNDA data. Our analysis by ethnicity (race) would have been stronger if the variable race in the SNDA data set was by determined by student self report rather than being coded by observers.

Our study examines the distribution of dietary fiber intakes in the normal diets of U.S. school children. Most studies documenting the impact of dietary fiber on promoting bowel regularity (McClung et al. 1995), weight reduction in obese children (Ryttig et al. 1989, Rigaud et al. 1990, Astrup et al 1990) and serum cholesterol reduction in children at risk for coronary artery disease (Williams et al. 1991, Dennison et al. 1993, Blumenschein 1991) have used fiber supplements such as psyllium or oat bran, rather than increasing the consumption of fiber rich foods in the daily diet. The risk of chronic disease is best reduced by incorporating healthy eating habits in daily life, rather than supplement usage. Physicians and other health professionals should educate children and their families on the benefits of regularly consuming low fat, high fiber diets to reduce risk of chronic diseases. Another key place for such nutrition education is school cafeterias, where low fat, high fiber foods can be promoted with educational graphics explaining their health benefits. Nutrition education should begin during early childhood to promote healthier eating habits in adult life, but our data clearly show the need to reemphasize these concepts during adolescence. Drewnowski and others have documented that the foods adults prefer most are those they were offered most and consumed most frequently as children (Drewnowski 1997). Therefore, health professionals should concentrate their disease preventive efforts on children and adolescents.

CONCLUSIONS

Dietary fiber intakes of children, especially adolescent and females fail to meet American Health Foundation recommendations. Achievement of AHF dietary fiber recommendations falls from over 60% in 6 year olds to less than 20% in 18 year olds. Black children have lower mean dietary fiber intakes than white children, while Hispanic adolescents have higher mean fiber intakes than white adolescents. Participants in USDA school meal programs have lower average daily fiber intakes than children who do not participate is school meal programs. Given the new AHF fiber intake recommendations and the availability of data on the dietary fiber content of foods, the USDA should incorporate dietary fiber as one of the nutrient goals for their school meal programs. School meal programs should offer low fat, high fiber food choices such as legume based entrees as meat alternates, whole grain breads and cereals, and fresh fruits and vegetables often to promote the likelihood that program participants will meet AHF dietary fiber goals.

Physicians and other health care professionals should emphasize to both parents and children the importance of consistently making high fiber food choices as a part of a healthy lifestyle. Researchers have documented that parents and children are not able to translate nutrient goals to foods in their usual diet (McClung et al. 1995). Therefore, physicians and dietitians should make food-based recommendations such Aeat more whole grains, , beans legumes, and fresh fruits and vegetables≅ rather than nutrient-based recommendations such as Aincrease your fiber intake≅. Low fat, high fiber foods voluntarily selected and consumed by children have been identified from SNDA data and can be used effectively as part of such educational efforts (Yagalla et al. 1998).

Table 1. Dietary fiber intakes (g/day) of U.S. School children by age and gender.

Age (yr.)	Females		Males	
	Mean $\pm$ SE	n	Mean $\pm$ SE	n
6	13.7 $\pm$ 0.84	52	13.9 $\pm$ 1.34	60
7	15.1 $\pm$ 0.71	134	14.4 $\pm$ 0.78	135
8	13.9 $\pm$ 0.54	158	16.2 $\pm$ 0.69	134
9	15.0 $\pm$ 0.52	186	16.7 $\pm$ 0.78	200
10	16.2 $\pm$ 0.72	176	17.1 $\pm$ 0.78	175
11	17.3 $\pm$ 0.83	155	18.6 $\pm$ 0.92	143
12	14.0 $\pm$ 0.69	123	18.1 $\pm$ 0.65*	162
13	14.8 $\pm$ 0.67	148	20.6 $\pm$ 0.89*	137
14	14.9 $\pm$ 0.89	126	22.9 $\pm$ 1.26*	137
15	14.3 $\pm$ 0.79	131	19.9 $\pm$ 1.08*	117
16	15.5 $\pm$ 1.16	120	21.6 $\pm$ 1.05*	120
17	15.1 $\pm$ 1.14	110	23.7 $\pm$ 1.74*	127
18	14.8 $\pm$ 1.99	44	20.1 $\pm$ 1.36*	50

SOURCE: weighted tabulations from USDA School Nutrition Dietary Assessment Study data, n shown are unweighted, but analyses are done on weighted means.

* statistically significant different with a two-tailed t-test, $p<0.05$.

Table 2. Mean dietary fiber intake (g/day) of U.S. school children by age and ethnicity

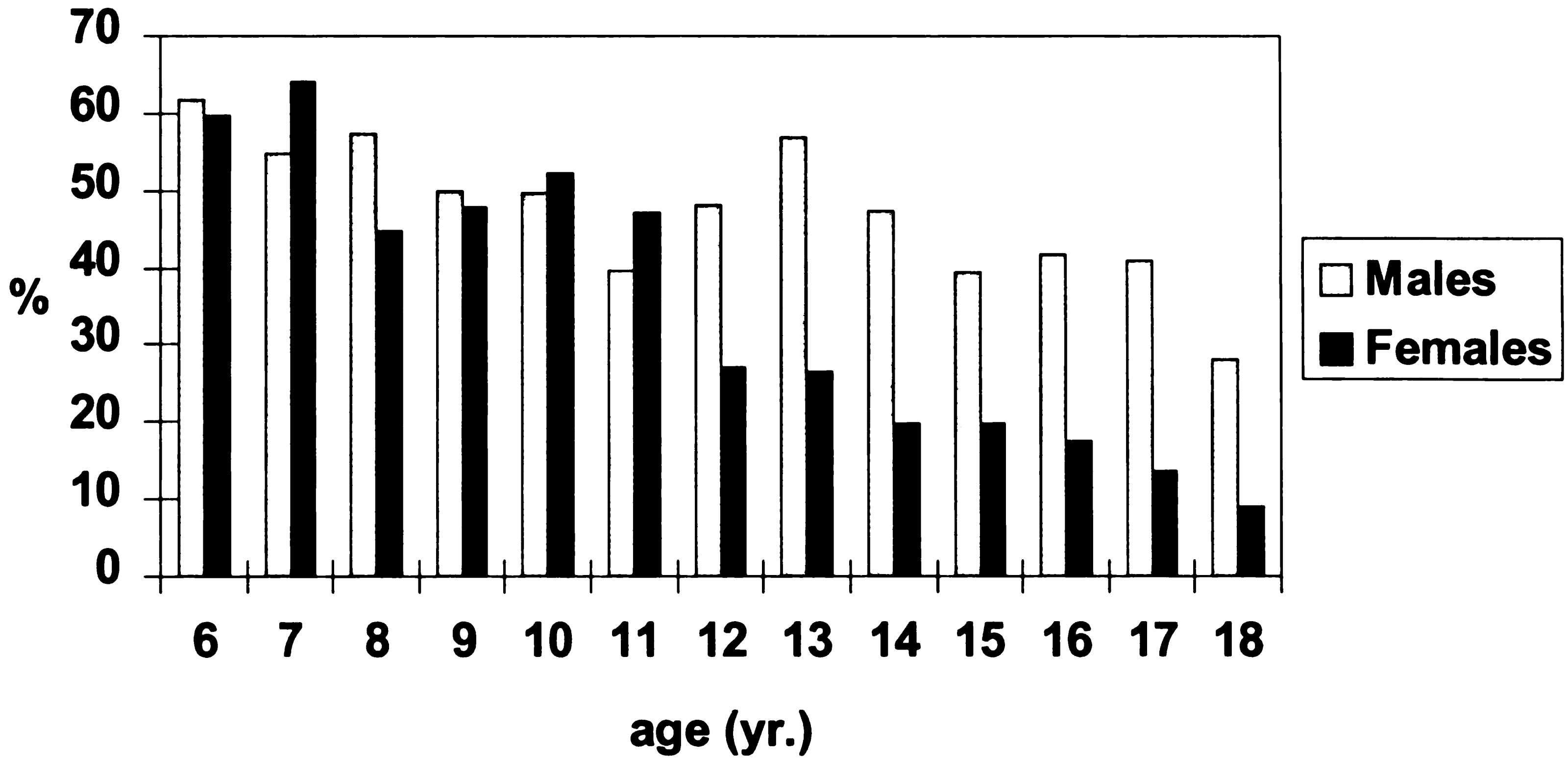
Age		White		Black		
	Hispanic					
yr.	Mean ± SE	n	Mean ± SE	n	Mean ± SE	n
6	14.7 + 1.34	62	13.1 ± 0.92*	24	11.9 ± 1.24*	22
7	15.5 ± 0.60	159	13.5 ± 0.83*	38	16.6 ± 2.11**	41
8	15.2 ± 0.52	183	15.9 ± 0.97	44	14.5 ± 1.27*	41
9	16.1 ± 0.61	259	15.2 ± 1.07*	60	15.7 ± 1.11	53
10	16.7 ± 0.67	243	15.1 ± 1.15*	48	18.5 ± 1.91**	47
11	18.5 ± 0.77	210	16.8 ± 1.29*	32	17.0 ± 1.63*	39
12	16.5 ± 0.65	194	15.5 ± 1.13*	44	16.1 ± 1.38	28
13	18.3 ± 0.85	174	15.6 ± 0.93*	53	17.0 ± 1.98*	39
14	18.6 ± 1.05	173	16.0 ± 1.45*	38	23.6 ± 2.43**	39
15	16.5 ± 0.80	160	18.6 ± 1.95**	47	16.6 ± 1.18	36
16	17.2 ± 0.93	151	21.2 ± 2.37**	47	19.5 ± 2.48**	31
17	20.1 ± 1.49	145	17.2 ± 1.24*	47	21.4 ± 3.07**	33
18	16.7 ± 1.22	65	16.5 ± 3.10	16	17.6 ± 1.43**	7

SOURCE: weighted tabulations from USDA School Nutrition Dietary Assessment Study data, n shown are unweighted, but analyses are based on weighted means; students are collapsed across gender for this analysis because gender distribution within each ethnic category did not differ significantly.

* mean is significantly ($p<0.05$, two tailed t-test) lower than mean intake in white children of same age

** mean is significantly ($p<0.05$, two tailed t-test) higher than mean intake in white children of same age

Figure 1. Percent of U.S. school children who met American Health Foundation dietary fiber recommendations (age + 5 g/d)



Chapter Five

Vended Food Consumption by U.S. School Children

ABSTRACT

Objectives: 1) to determine percent of U.S. children consuming vended foods/beverages on a typical school day by grade, race, gender, eligibility for subsidized meals, and participation in USDA meal programs, 2) to assess the nutrient contribution from vended items, 3) to determine differences in nutrient intakes and Dietary Guideline (DG) and RDA achievement between vended item consumers and nonconsumers.

Methods: The USDA School Nutrition Dietary Assessment Study data with a nationally representative sample of 3,381 children in grades 1-12 from the 48 conterminant states was examines. Food codes from the 24 hr. dietary recall data were matched to the USDA computerized nutrient database for population survey analysis version 4 to determine nutrient contribution of vended foods/beverages. The SNDA assessed DG achievement for fat (<30% energy), saturated fat (<10% energy) and cholesterol (<300 mg/d) as a categorical variable. RDA (for protein, iron, calcium, magnesium, vit A, C, B6, B12, folate, niacin, thiamin and riboflavin) achievement was also determined as a categorical variable as part of the SNDA. Descriptive analyses were performed using SAS version 6.03 and JMP statistical software. Chi square analyses and t-tests were performed to assess differences between groups.

Results: 11.4% of U.S. school children consumed vended foods/beverages and these items contributed an average of one third of the daily energy intake of those who

consumed them with energy ranging from 0 to 2170 kcal. Males and females consumed vended items equally (11.1 vs. 11.1%) and children of all ethnicities consumed vended foods equally (11.9% Hispanic, 12.5% Asian, 10.9% Caucasian and 12.2% African American). Student participation in the USDA School Breakfast Program reduced the percent of children consuming vended items compared to nonparticipants, however, no relation was observed with participation in the USDA National School Lunch Program. Fewer children who consumed vended items achieved DG than nonconsumers, but more vended food consumers achieved age-specific RDAs than nonconsumers.

Conclusions: At present no federal guidelines on vending machine use during meal hours in schools or nutritional quality of the items offered in them exist. Given the range of nutrients being derived from vended items and the percent of children consuming them, dietitians should incorporate vended foods as part of the ADA's Child Nutrition and Health Campaign. Health professionals should lobby for legislation governing vending machine use in schools and encourage local and school officials to offer healthful options in vending machines.

Vended Food Consumption by U.S. School Children

INTRODUCTION

The major sources of foods in the diets of school aged children include foods: 1) eaten at or packed from home, 2) purchased at school as part of the United States Department of Agriculture's (USDA) school meal programs or A La Carte offerings, 3) purchased from restaurants, 4) given to children by others, and 5) purchased from vending machines and school snack shops (Burghardt et al. 1995). Although the USDA and others have studied the impact of participation in USDA school meal programs on the diets of children, very little information is available in the literature concerning the impact of competitive foods such as those sold via vending machines and in school stores (Dwyer 1995).

At present there are no federal guidelines regulating what foods and beverages are offered in vending machines in schools. Rather, this is a matter regulated locally within each school and school district (Dwyer 1995). In 1970, Congress authorized the USDA to regulate the sale of foods that compete with National School Lunch Program (NSLP) lunches. Initially, USDA regulations limited the foods sold in schools to those that either contributed to one of the required meal components or that were served as an additional item with the school meal (Burghardt 1995). However, in 1972, Congress amended the USDA authority over competitive foods by exempting from restriction the sale of any food whose proceeds accrued to the school or to school organizations (Burghardt et al. 1995).

In 1977, Congress further modified this exemption by authorizing that the USDA establish regulations approving foods that could be sold in school in competition with the meal program. Such regulations were intended to restrict the sale of foods of poor nutritional quality (such as sweetened soft drinks, candy and fried chips) from being sold in school vending machines, stores and A La Carte programs. However, by the mid-1980s, lawsuit judgements forced the USDA to reconsider its regulations on competitive foods (including those available in vending machines) and to loosen the restrictions on what foods could be sold (Burghardt et al. 1995).

Due to the scarcity of information in the scientific literature on the actual contribution of vended foods to children's diets, it is difficult to say whether such foods are truly detrimental to child nutrition. Health professionals have long expressed concern about the apparent contradiction between classroom promotion of healthful diets, followed by lunch or snacks of chips and candy (Hinkle 1982). One study found that 32% of a junior high school population consumed vended foods as either an entire lunch or part of one (Ho et al. 1991). However, healthful foods and beverages (e.g. sandwiches, low-fat yogurt, and milk) could also be supplied via vending machines as a viable alternative to the foods offered in the school meals programs (Wilbur et al. 1981). A few studies have found that when popular, healthful foods were available in vending machines, they sold well (Hruban 1997, United Fresh Fruit and Vegetable Association 1978, Hoerr et al. 1993). Therefore, vended food consumption by U.S. school children deserves investigation.

The USDA School Nutrition Dietary Assessment Study (SNDA) collected data on foods purchased by children from vending machines and stores in schools but did not examine the relation of consumption of these foods and beverages on the nutrient intakes of school children (Burghardt 1995). In the publication of the SNDA results, the study authors expressed the need to examine the issue of vended food nutrient contribution more closely (Dwyer 1995). A potential scientific basis for legislation regulating foods and beverages in vending machine in schools could be obtained from examining the SNDA study vended foods data.

The objectives of our study were, therefore, 1) to examine the percentage of school children consuming vended foods by grade, race, gender, eligibility for free or reduced price school meals, participation in USDA school meal programs, and location of the vending machine in school using the SNDA data; 2) to assess the average nutrient contribution from vended foods in the diets of school children who consumed them; and 3) to determine differences in 24 hour nutrient intakes and achievement of USDA Dietary Guidelines for Americans (DG) for fat (<30% energy), saturated fat (<10% energy) and cholesterol (<300 mg/d) and National Academy of Sciences Recommended Dietary Allowances (RDA) for protein, calcium, iron and other select nutrients between vended food consumers and nonconsumers in elementary, middle and high schools (US DHHS 1989, National Research Council 1989).

METHODS

<u>Sample and Data set</u>

The SNDA data set includes information collected in the winter and spring of 1991-1992 on a nationally representative sample of 3,381 children in grades 1-12 from

545 schools across the country (Burghardt 1995). The sample was a multistage, stratified sample of districts, schools within sampled districts, and students within a subsample (329/545) of the schools. The sample of schools was designed to be representative of all schools in the 48 contiguous states plus the District of Columbia. The sample of students was designed to be representative of all students in grades 1 through 12 who were attending school on a typical school day. Students in kindergarten, pre-kindergarten, or reading readiness (pre-first grade) classes, as well as students enrolled in special education programs with self contained classrooms were excluded from the SNDA sample (Burghardt 1995).

Food recall data for a 24 hour period including a school day were collected by trained interviewers administering questionnaires. Parents of children in grades 1-3 were interviewed along with the children to obtain dietary intake data. All children in grades 4-12 reported their own intakes. All data were coded to maintain anonymity of participants (Burghardt 1995). Food composition data on all foods children consumed from the USDA NSLP and School Breakfast Programs (SBP) at each school were coded by nutritionists at the Minnesota Nutrition Coordinating Center (Burghardt 1995) . Although list of foods children consumed from A La Carte offerings, vending machines and school stores were collected, the initial SNDA study did not analyze the nutrient content of these foods. However, each food in each study participant=s diet recall was coded to identify the source from which it was obtained. The foods obtained from both vending machines and on campus stores were given the same code, so it was not possible to separate these two sources. The location of the vending machine in schools was coded as a categorical variable (either in or out of the school cafeteria) (Burghardt 1995).

Analysis

The initial analysis of the SNDA conducted by the Mathematica Policy Research, Inc. did not examine the impact of vended food consumption on the nutrient intakes of children (Burghardt 1995). SNDA data were obtained from the USDA on IBM mainframe magnetic reel tapes in Statistical Analysis for the Sciences (SAS) ASCII files with accompanying SAS programs to label data. Five relevant files (stanal.dat, stfcomp.dat, strecipe.dat, scvend.dat, stchar.dat) were downloaded to SAS version 6.03 personal computer files (SAS Institute 1998). For analysis by grade, participation in school meal programs or eligibility for free or reduced price meals all children (n=3,381) were included. Only Caucasian (n=2188), African American (n=544), Hispanic (n=459) and Asian (n=167) students' diets were included in cross cultural comparisons due to small samples with inadequate power in the mixed race and other categories (n=190 total). Food codes from the SNDA participants' diets were matched with USDA dietary fiber updated Nutrient Database for Analysis of Population Based Dietary Surveys version 4 to determine nutrient content of foods/beverages from vending machines and school stores only (not A La Carte foods), as well as to calculate 24 hour total nutrient intake of children (USDA 1990).

Variables used for analyses included grade in school, total grams per day of fat, saturated fat, and dietary fiber and total milligrams per day of cholesterol in each student's 24 hr. intake, participation in school meals programs, race, and eligibility for free (student's family income was <135% of the Poverty Index or PI) or reduced price (student's family income was >135% of PI but < 185% of PI) school meals.

A student was classified as an SBP participant if they consumed 2 out of 4 of the USDA required meal components and an NSLP participant if they consumed at least 3 out of the 5 USDA required meal components. DG (for fat, saturated fat and cholesterol) and RDA (for protein, vitamin A, vitamin C, thiamin, riboflavin, niacin, vitamin B-6, folate, vitamin B-12, calcium, iron, phosphorus, magnesium, zinc, and total energy) achievement in 24 hr. intakes was assessed as part of the original SNDA study and entered as a categorical variable (1= achieved all DGs or RDAs and 0= did not achieve all DGs or RDAs) (Burghardt et al. 1993).

Students were classified as vended foods consumers if their diet recalls included any foods or beverages from vending machines or school stores. Descriptive analyses of differences in nutrient intakes by vended food consumption were conducted using SAS version 6.03 and JMP from the SAS Institute (SAS Institute 1998, SAS Institute 1998). All student level data were weighted according to SNDA protocol to make comparisons nationally representative and adjust for selection bias (Burghardt 1995). Statistical tests employed to test significance of differences between groups included, Chi-square analyses and Student t-tests (SAS Institute 1998).

RESULTS

Approximately 668 (1.2%) of the 53,494 foods and food components consumed by the SNDA study participants were purchased from vending machines or stores in schools . The foods consumed from vending machines and stores ranged from soft drinks to refrigerated items such as sandwiches and are reported in the SNDA results (Burghardt et al. 1993). We found that foods or beverages from vending machines or school stores were consumed by 11.4% (n=387/3,381) in the unweighted sample) of U.S. school children. The percentage of children consuming vended foods/beverages by grade is represented in **Figure 1**. Note the increased consumption of vended foods during middle school years and the decline during high school years when many schools allow off-campus privileges. Hispanic (11.9%) and Asian children (12.5%) were significantly more likely to consume vended foods than Caucasian (10.9%) and African American (12.2%) children ($p<0.05$).

Interestingly, vended food consumption did not differ significantly between males and females (11.1% vs. 11.1%). Eligibility for free or reduced price school meals did not significantly affect vended food consumption, in fact the trend was toward increased consumption among those who qualified for free or reduced price meals (12.6% of those not eligible vs. 7.6% of those eligible). Students who participated in the USDA SBP were significantly less likely to consume vended foods than nonparticipants (3.5% vs. 11.6%, $p<0.001$). However, participants in the NSLP were significantly less likely to consume vended foods (15.2% of the nonparticipants vs 7.3% of the participants). Whether the vending machines were located inside the school cafeteria or elsewhere in the school also did not affect prevalence of vended food consumption by children.

Table 1 shows the list of foods and beverages consumed by U.S. school children ranked by frequency of items consumed. Soft drinks, candy, fried chips, cakes and cookies were the most popular items (n=474 total). Healthful items such as sandwiches, milk, bread, crackers, fruit and juices ranked far lower (n=104 total). Miscellaneous beverages included items such as seltzer water, tea, hot chocolate and coffee and miscellaneous foods included mostly condiments, and a few nuts, seeds, etc.

Table 2 shows the average nutrient contribution of vended foods/beverages to the diet of U.S. school children in elementary, middle and high schools (unweighted n=387) who consumed vended foods. Note that the range indicates that some children are consuming entire meals worth of food energy and macronutrients in the form of vended foods/beverages, while others seem to be using these foods/beverages as adjuncts to their diet. The lower end of the range (zero food energy and macronutrients) represents sugar-free soft drinks consumed.

The 24 hour intake of food energy from various nutrients in the diets of vended food consumers vs. nonconsumers by gender and grade category is shown in **Table 3**. Within most gender and grade categories except middle and high school males, vended food consumers had lower mean intakes of most micronutrients (e.g. vitamins A & C, calcium, and iron) while energy and macronutrient intake was often higher compared to their counterparts who did not consume vended foods or beverages. These differences in nutrient intakes among vended food consumers were statistically significant for some nutrients, although not for all.

Table 4 shows the percent of male and females achieving USDA DG for fat, saturated fat, and cholesterol in a 24 hr. period was significantly different for vended foods consumers vs. nonconsumers in each grade category except middle and high school males. Note that the trend was for a smaller percentage of those who did consume vended foods achieving fat, saturated fat and cholesterol recommendations compared to nonconsumers. However, vended foods consumers in some gender and grade categories were significantly more likely than nonconsumers to achieve age appropriate RDAs for protein, iron, calcium and other vitamins and minerals.

DISCUSSION

Given that one in ten U.S. school children consumes vended foods and beverages in a typical school day, it is imperative that dietitians and other health professionals address the nutrient content of these items as part of the American Dietetic Association=s Child Nutrition and Health Campaign (Stedronsky 1998). The age, gender, and ethnicity patterns in vended food consumption in U.S. school children is of particular interest. Specifically, the peak of vended food consumption in high school years could reflect both increased independence in food selection and access to money. Whatever the reasons, middle and high school group appear to be the most appropriate target for educational efforts encouraging healthy vending selections. Such educational messages should be part of the Child Nutrition and Health Campaign's objective to publicize the importance of healthful snacks for good nutrition for children (Stedronsky 1998).

It is important to identify the reason for vended food consumption in school children since its prevalence seems universal rather than limited to a specific gender or ethnic group. The most common reason for student nonparticipation in USDA meal programs, and perhaps use of alternative sources of food such as vending machines was dislike for the foods offered (Burghardt 1993). Interestingly, there appear to be no gender differences in the prevalence of vended food consumption in U.S. school children. Surprisingly, an individual's qualification for free or reduced price school meals did not influence their likelihood of consuming vended foods. Vended foods and beverages in schools may be priced so inexpensively that they are becoming an economic alternative to reduced price or full priced school meals. These issues warrant further research.

Burghardt and colleagues, in their technical report of the SNDA findings reported that only 16 percent of elementary schools, compared with 52 % of middle schools and 88% of high schools in the U.S. (based on weighted tabulations) have at least one vending machine in school (Burghardt et al. 1993). Vending machines are available for student use at all times including during school hours in 16% of schools. Beverages were offered in nearly all the school vending machines, but soft drinks constituted more than 2/3 of the beverages. Baked desserts (such as creme filled cakes), snack chips and candy constituted the majority of the other offerings in school vending machines while only 1% of high school machines (none of the elementary school or middle school machines) offered fresh fruit and none offered yogurt (Burghardt et al. 1993). This is alarming when considering the range of energy and macronutrients that U.S. school children are deriving from vended foods and beverages. The items most frequently purchased from vending machines and school stores identified in our study reflect the limited range of foods and beverages offered in school vending machine and stores. If healthful options are not available for e.g. sandwiches and yogurt in refrigerated vending machines, children are at risk for poor nutrition by choosing vended items over a USDA meal or a meal packed from home.

We found that the average food energy derived from vended foods and beverages in school children consuming them was about one third of the their daily intake. One study of vended snack consumption in college students found that one in ten students received 20% of their calories from vended snacks (Aljadir et al. 1981). When we examined the achievement of the age-appropriate dietary recommendations (DGs and RDAs) based on vended food consumption, we found surprising contradictions. Vended food consumers tended to be less likely to achieve the DG for fat, saturated fat and cholesterol than nonconsumers. This can be explained by the high prevalence of sweetened and fried dessert and chips consumption in vending consumers. The RDAs, which look for actual amounts of various macro and micro nutrients consumed, reflected differences in diet quality of vended food consumers compared to nonconsumers. Some individuals who consumed Another way to examine the health impact of vended foods and beverages would be to do food group analysis.

One study of unrefrigerated vended snacks at the National Institute of Health found an increase in total snack sales when low-calorie snacks were marketed in a Ahealthy snack machine placed next to a machine vending standard snacks (Wilbur et al. 1981). Hoerr and colleagues also found that sales of vended snacks increased among university students when colorful graphics identifying nutrient-dense snacks were placed on vending machines, provided the snacks available were ones popular with students, e.g. pretzels (Hoerr et al. 1993). A popular snack item was defined as one ranking among the vending industry's top 20 best-selling vended snacks nationally (Hoerr et al. 1993). Other studies using refrigerated vending machines found that if nutrient-dense snacks were offered, students bought them and vended snack sales did not decrease (Aljadir et al. 1981, French et al. 1997).

Researchers at the University of Minnesota's School of Public Health recently examined pricing strategies to promote low-fat snack choices through vending machines (French et al. 1997). They found that the sale of low-fat items (those containing 3 grams of fat or less per serving) increased from 25.7% to 45.8% of total sales when the prices of these items were reduced by 50%. This increase in low-fat snack sales did not last, however, beyond the price reduction intervention period, falling to 22% of total sales when prices returned to pre-intervention levels (French et al. 1997). The low-fat items in this study were not identified with any nutrition information, only bright yellow price labels. This suggests that environmental approaches to promoting low-fat food choices, such as competitive pricing, may promote low-fat food purchase and consumption in the population as a whole, even independent of point-of-selection nutrition education (French et al. 1997). French and colleagues suggest that small price reductions in low-fat items coupled with modest price increases for high-fat items could result in a net revenue gain and a net profit for vendors (French et al. 1997). A community-based survey of over 800 men and women in Minnesota found that requiring low-fat, healthful foods to be available in school cafeterias and eliminating high-fat foods from vending machines were the most favorably evaluated public health policies (Schmidt et al. 1989).

IMPLICATIONS

Dietitians and other health professionals should advocate with policy makers for legislation regulating the nutritional quality of foods and beverages offered in school vending machines and stores, especially during meal hours. The manner in which the nutritional quality of these items is assessed is also important. It is appropriate to restrict access to vending machines during the school meal hours if their only offerings are foods and beverages of poor nutritional quality that could place children at risk for malnutrition. However, an alternative means of ensuring the diet quality of school children is to promote the sale of healthful foods and beverages, such as fresh fruit, yogurt, low-fat milk, juice and sandwiches in school vending machines.

The research available on the sale of such healthful items from vending machines indicates that substantial market value exists among children and adolescents. Schools and local officials can gain revenue and encourage good nutrition by investing in vending machines with healthful offerings for their students' use. Dietitians and other health professionals must bring the issue of vended foods to the attention of policy makers working to improve and protect the diet quality of U.S. school children.

Figure 1. Percent of U.S. School Children Consuming Vended Foods By Grade

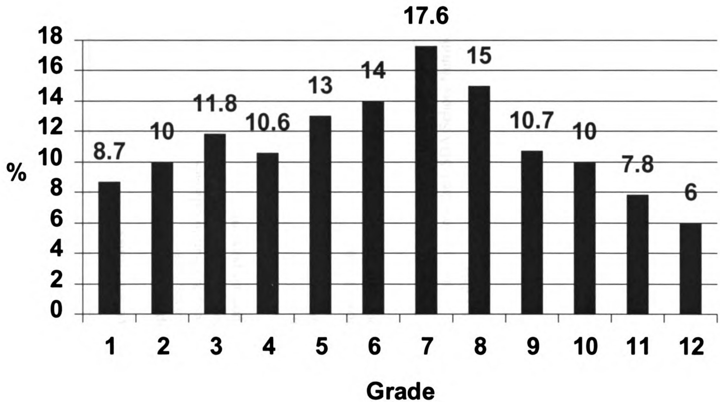


Table 1. Vended Foods and Beverages Consumed by U.S. School Children Ranked by Frequency of Consumption

Food/Beverage Consumed	Number of Items
Carbonated Soft Drinks	199
Candy	129
Fried Chips	85
Cakes, cookies, bars	61
Sandwiches/pizza/burrito/calzones	39
Fruit juice/juice drinks	38
Crackers/pretzels/popcorn	30
Milk	15
Breads	14
Ice Cream	6
Fresh Fruit	5
Yogurt	1
Miscellaneous Foods	81
Miscellaneous Beverages	12

SOURCE: tabulations from the USDA School Nutrition Dietary Assessment Study data

Table 2. Nutrient contribution of foods and beverages from vending machines or school stores to the 24 hr. intake of U.S. school children in elementary, middle and high schools consuming them (unweighted n=387/3,381)

Variable	Mean ± SE	Range
Elementary grades (1-5)	n=47	
Energy (Kcal)	199 ± 25.7	20 - 912
Carbohydrate (g)	29 ± 3.5	0 - 103
Total Fat (g)	7.8 ± 1.2	0 - 59
Saturated Fat (g)	2.7 ± 0.5	0 - 19
Protein (g)	3.8 ± 1.0	0 - 30.2
Dietary Fiber (g)	1.0 ± 0.2	0 - 8.2
Cholesterol (mg)	9.6 ± 2.9	0 - 92
Vitamin A (mcg)	21.4 ± 5.7	0 - 152
Vitamin C (mg)	7.5 ± 3.6	0 - 171
Calcium (mg)	43.4 ± 11.0	0 - 1370
Iron (mg)	0.7 ± 0.1	0 - 10.5
Middle School grades (6-8)	n=90	
Energy (Kcal)	353 ± 51.1	5 - 1551
Carbohydrate (g)	57 ± 5.6	1 - 209
Total Fat (g)	11.8 ± 2.5	0 - 86.7
Saturated Fat (g)	4.6 ± 1.0	0 - 31.7
Protein (g)	6.9 ± 2.1	0 - 68.7
Dietary Fiber (g)	1.8 ± 0.5	0 - 15.4
Cholesterol (mg)	16.8 ± 5.4	0 - 191
Vitamin A (mcg)	30.5 ± 9.1	0 - 675
Vitamin C (mg)	10.7 ± 4.1	0 - 128
Calcium (mg)	93.5 ± 26.0	0 - 1370
Iron (mg)	1.5 ± 0.3	0 - 11.6
High School grades (9-12)	n=250	
Energy (Kcal)	343 ± 23.6	0 - 2170
Carbohydrate (g)	57 ± 3.1	0 - 374
Total Fat (g)	11.4 ± 1.2	0 - 95

Saturated Fat (g)	4.1 $\pm$ 0.5	0 - 53
Protein (g)	5.5 $\pm$ 0.9	0 - 79
Dietary Fiber (g)	1.5 $\pm$ 0.1	0 - 14
Cholesterol (mg)	14.6 $\pm$ 3.0	0 - 255
Vitamin A (mcg)	29.1 $\pm$ 6.3	0 - 806
Vitamin C (mg)	12.8 $\pm$ 2.9	0 - 481
Calcium (mg)	70.7 $\pm$ 11.6	0 - 1594
Iron (mg)	1.2 $\pm$ 0.1	0 - 18.1

Table 3. Mean 24 hr. nutrient intake of U.S. school children consuming vended foods and beverages (n=387, unweighted) vs. nonconsumers (n=2994) in elementary, middle and high school grades.

Variable	Males X ± SE Nonconsumers	Males X ± SE Consumers	Females X ± SE Nonconsumers	Females X ± SE Consumers
Elementary grades (1-5)	n = 781	n = 28	n = 782	n = 19
Energy (kcal)	2352 ± 37.5	2326 ± 109.5	2092 ± 31.7	2128 ± 157.7
Carbohydrate (g)	302 ± 5.2	324 ± 21.3	275 ± 4.0	283 ± 21.5
Total Fat (g)	91 ± 1.8	84 ± 5.5	80 ± 1.6	82 ± 7.1
Saturated Fat (g)	34 ± 0.7	32 ± 2.1	30 ± 0.6	32 ± 3.1
Protein (g)	89 ± 1.8	80 ± 6.0	77 ± 1.4	74 ± 7.4
Dietary Fiber (g)	16 ± 0.3	18 ± 3.6	15 ± 0.3	14 ± 0.9
Cholesterol (mg)	299 ± 9.7	259 ± 24.2	243 ± 5.9	231 ± 35.2
Vitamin A (mcg)	1031 ± 33.8	1103 ± 353.1	882 ± 27.0	749 ± 91.5
Vitamin C (mg)	130 ± 4.3	131 ± 31.7	132 ± 4.6	102 ± 19.2
Calcium (mg)	1155 ± 23.3	1058 ± 72.1	997 ± 16.7	865 ± 82.9
Iron (mg)	16 ± 0.4	16 ± 1.9	14 ± 0.3	13 ± 1.0
Middle School grades (6-8)	n = 379	n = 48	n = 353	n = 42
Energy (kcal)	2909 ± 63.6	3275 ± 232.0	2252 ± 57.8	2419 ± 142.8
Carbohydrate (g)	377 ± 8.6	411 ± 30.1	301 ± 7.9	326 ± 18.7
Total Fat (g)	112 ± 2.9	130 ± 11.1	86 ± 2.6	91 ± 6.8
Saturated Fat (g)	42 ± 1.1	52 ± 4.9	32 ± 1.1	34 ± 2.9

Protein (g)	108 ± 2.6	121 ± 8.9	79 ± 2.3	84 ± 7.0
Dietary Fiber (g)	19 ± 0.5	20 ± 1.7	15 ± 0.5	15 ± 1.2
Cholesterol (mg)	352 ± 13.2	336 ± 39.0	523 ± 10.4	250 ± 27.2
Vitamin A (mcg)	1291 ± 76.7	1256 ± 165.4	875 ± 49.7	790 ± 98.6
Vitamin C (mg)	152 ± 6.5	161 ± 20.5	130 ± 7.5	131 ± 17.3
Calcium (mg)	1339 ± 7.9	1472 ± 140.2	1060 ± 39.9	978 ± 103.6
Iron (mg)	20 ± 0.7	21 ± 2.4	15 ± 0.5	15 ± 1.2
High School grades (9-12)	n = 353	n = 119	n = 345	n = 131
Energy (kcal)	3309 ± 103.9	3230 ± 191.7	2164 ± 60.6	2556 ± 151.7
Carbohydrate (g)	414 ± 12.0	527 ± 25.3	282 ± 7.5	344 ± 20.5
Total Fat (g)	131 ± 5.3	157 ± 8.0	83 ± 3.1	97 ± 6.4
Saturated Fat (g)	49 ± 2.1	59 ± 3.1	31 ± 1.2	36 ± 2.2
Protein (g)	128 ± 4.6	139 ± 7.8	81 ± 2.7	87 ± 5.7
Dietary Fiber (g)	21 ± 0.8	25 ± 1.6	14 ± 0.6	16 ± 1.0
Cholesterol (mg)	397 ± 17.6	466 ± 36.6	250 ± 10.5	272 ± 26.2
Vitamin A (mcg)	1385 ± 92.8	1409 ± 232.0	861 ± 72.3	908 ± 101.3
Vitamin C (mg)	182 ± 11.9	208 ± 23.0	133 ± 9.0	136 ± 14.1
Calcium (mg)	1519 ± 61.0	1630 ± 97.1	948 ± 33.5	982 ± 59.7
Iron (mg)	24 ± 1.2	24 ± 1.5	14 ± 0.5	15 ± 1.1

SOURCE: weighted tabulations from the School Nutrition Dietary Assessment Study data

* means within gender and grade category significantly different by Tukey-Kramer t-test, $p<0.05$.

Table 4. Achievement of Dietary Guidelines and Recommended Dietary Allowances* in Elementary, Middle and High School Male and Female Vended Food Nonconsumers (n=2994) vs. Consumers (n=387, unweighted).

Variable	Males (%) Nonconsumers	vs. Consumers	Females (%) Nonconsumers	vs. Consumers
Elementary grades (1-5)	n=781	n=28	n=782	n=19
Dietary Guideline Achievement	14.0	14.2	16.5	16.7
RDA Achievement**	39.0	35.2	27.2	16.9
Middle School grades (6-8)	n=379	n=48	n=353	n=42
Dietary Guideline Achievement	12.2	6.7	14.5	17.1
RDA Achievement**	31.6	40.7	13.8	12.1
High School grades (9-12)	n=353	n=119	n=345	n=131
Dietary Guideline Achievement	7.8	6.8	18.7	15.7
RDA Achievement**	27.1	35.5	11.4	11.8

SOURCE: weighted tabulations from the USDA School Nutrition Dietary Assessment Study data

* Dietary Guidelines used were total fat (<30% energy), saturated fat (<10% energy) and cholesterol (<300 mg/d); RDAs were age-appropriate values for protein, calcium, iron, etc.

** RDA achievement for both male and female vended food consumers was significantly lower than nonconsumers in all grade categories by Chi-square analysis, p<0.05.

Table 5. Mean 24 hr. nutrient intake of U.S. school children consuming vended foods and beverages(n=387, unweighted) vs. nonconsumers (n=2994) in elementary, middle and high school grades.

Variable	Nonconsumers	. Consumers
Elementary grades (1-5)	n = 1522	n = 47
Energy (kcal)	2223 ± 27.9	2246 ± 91.2
Carbohydrate (g)	288 ± 3.7	308 ± 16.0
Total Fat (g)	86 ± 1.3	84 ± 4.5
Saturated Fat (g)	32 ± 0.5	32 ± 1.8
Protein (g)	83 ± 1.2	78 ± 4.2
Dietary Fiber (g)	16 ± 0.3	17 ± 2.2
Cholesterol (mg)	271 ± 6.4	248 ± 20.4
Vitamin A (mcg)	957 ± 24.3	961 ±215.3
Vitamin C (mg)	131 ± 3.4	119 ± 20.3
Calcium (mg)	1076 ± 16.0	980 ± 59.5
Iron (mg)	15 ± 0.3	15 ± 1.2
Middle School grades (6-8)	n = 732	n = 90
Energy (kcal)	2595 ± 45.9	2856 ± 153.2
Carbohydrate (g)	341 ± 6.5	370 ± 19.3
Total Fat (g)	99 ± 2.1	112± 7.2
Saturated Fat (g)	37 ± 0.9	43 ± 3.1
Protein (g)	94 ± 1.7	103 ± 6.6
Dietary Fiber (g)	17 ± 0.4	17 ± 1.1
Cholesterol (mg)	304 ± 8.6	340 ± 26.2
Vitamin A (mcg)	1092± 47.8	1033 ± 105.1
Vitamin C (mg)	141 ± 5.0	146 ± 13.8
Calcium (mg)	1206 ± 29.3	1236 ± 97.6
Iron (mg)	17 ± 0.4	18 ± 1.6
High School grades (9-12)	n = 698	n = 250
Energy (kcal)	2731 ± 66.8	3263 ± 120.9
Carbohydrate (g)	347 ± 7.7	432 ± 15.9
Total Fat (g)	106 ± 3.4	126 ± 5.1
Saturated Fat (g)	40 ± 1.3	47 ± 1.9
Protein (g)	104 ± 3.0	112 ± 4.9

Dietary Fiber (g)	18 ± 0.5	20 ± 1.0
Cholesterol (mg)	323 ± 11.1	366 ± 22.4
Vitamin A (mcg)	1120± 62.7	1149 ± 125.2
Vitamin C (mg)	157 ± 7.0	170 ± 14.5
Calcium (mg)	1231 ± 38.4	1295 ± 61.1
Iron (mg)	19 ± 0.7	20 ± 1.0

SOURCE: weighted tabulations from the School Nutrition Dietary Assessment Study data

* means within gender and grade category significantly different by Tukey-Kramer t-test, p<0.05.

Chapter Six

Conclusions

1. Over 1,800 low fat and saturated fat and high dietary fiber foods being voluntarily selected and consumed by children were identified from existing USDA meal program offerings. One of the ways in which school food service personnel can meet USDA=s Recommended Dietary Allowance and Dietary Guideline goals for school meals is to offer such foods more frequently. At present, popular low fat sources of dietary fiber such as low fat hot chocolate or chocolate milk and fresh fruits and vegetables are being offered less than 50% of school days.
2. Dietary fiber intakes of U.S. school children do not meet American Health Foundation (age + 5 g/day) recommendations. Adolescent females are at particular risk for inadequate dietary fiber intakes (only 10% of 18 year females achieved AHF recommendations). Black children had significantly lower mean dietary fiber than white children at most ages, while Hispanic adolescents had significantly higher mean dietary fiber intakes than whites of the same age.
3. Dietary fiber content of foods is now available in computerized nutrient database and the American Health Foundation has set pediatric intake recommendations. However, U.S. school children, even those participating in USDA school meal programs have inadequate dietary fiber intakes as shown with the SNDA data. Therefore, the USDA should incorporate dietary fiber into the nutrient goals for school meal programs to encourage increased dietary fiber intakes in meal program participants. Pediatricians and other health professionals should educate

parents and children on consistently making high dietary fiber food choices using food based recommendations such as Aeat more whole grain bread, fresh fruits and vegetables and legumes.

4. One in ten U.S. school children consume vended foods and beverages in a typical school day. More Asian and Hispanic children consumed vended items than children of other ethnicities. Children participating in USDA school breakfast program consumed vended foods less frequently than those who did not participate. However, no relation was observed with the USDA National School Lunch Program. Children who qualified for free or reduced price school meals were equally likely to consume vended foods as children who did not qualify for subsidized meals. Equal proportions of males and females consumed vended foods.

5. Vended foods contributed an average of one third of the daily intake of energy in the diets of children who consumed them. A smaller percent of children who consumed vended foods achieved age-appropriate RDAs compared to children who did not consume vended foods in all grade categories.

6. Dietary Guideline achievement often gave misleading results for analysis of the impact of vended foods to children=s diet quality. Some children who consumed sweetened soft drinks, which contributed energy but no other nutrients were found to have achieved DGs, because DG examine the nutrient density from fat (<30% energy from fat) and saturated fat (<10% energy) in the diet. Therefore, RDA assessment or food group analysis would be a more appropriate method of assessing the relation of vended items to diet quality.

Chapter Seven

Recommendations for Future Studies

1) Dietary fiber recommendations are for average intake not intake on a given day. Therefore, assessment of dietary fiber intake of U.S. school children using food diaries or other multiple day records, rather than 24 hr. recalls would help assess the achievement of the American Health Foundation intake recommendations. This information would provide additional rationale for including dietary fiber in the USDA=s nutrient goals for the school meal programs.
2) Dietary fiber analysis by meal comparing school meals with those brought from home or other sources would be helpful in determining how the USDA school meals are doing in providing dietary fiber to children.
3) Surveys examining local and district level policy regarding vending machine use and contents of vending machines in schools would help frame future legislation regulating vended foods.
4) Vended food consumption should also be assessed using food diaries or other multiple day intakes rather than 24 hr. recalls to determine the average impact of such items on diet quality of children. Factors associated with vended food use by children should be further examined. Reasons for greater vended food consumption by middle school children and Asian and Hispanic children should be explored further in order to develop appropriately targeted educational programs for healthful snacking.

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