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RESEARCH PAPER

Dietary patterns of Akwesasne Mohawk adolescents

Julia Ravenscroft[1], Lawrence M. Schell[1,2], and Akwesasne Task Force on the Environment[3]

[1]*Department of Anthropology, University at Albany, 1400 Washington Avenue, Albany, NY 12222, USA,* [2]*Center for the Elimination of Minority Health Disparities, University at Albany, 1400 Washington Avenue, Albany, NY 12222, USA, and* [3]*Akwesasne Mohawk Nation, PO Box 992, via Hogansburg, NY 13655, USA*

Abstract

Background: Native American youth have greater rates of overweight/obesity than same-aged youth from the general population. Even though dietary shifts are suspected, surprisingly little information exists concerning the dietary patterns of contemporary Native American adolescents.

Aim: This study examines the dietary composition of Native American adolescents residing in upstate New York at the Akwesasne Mohawk Nation. The goal of this investigation is to assess the food patterns of Akwesasne adolescents via a total diet approach.

Participants/setting and methods: The sample is comprised of 246 Mohawk adolescents between the ages of 10–16.9 years of age residing at the Akwesasne Mohawk Nation. Food frequency data was collected from adolescents via interview during a cross-sectional study investigating their exposure to environmental pollutants.

Results and conclusion: Nutrient-dilute but energy-dense foods characterize most of the top 10 dietary sources of energy, carbohydrates, and fat. Although micronutrient intakes are by and large adequate in the sample, micronutrients are most often derived from highly fortified food sources. Adolescent diets contain few naturally-occurring sources of many micronutrients, especially folate and iron. A narrow variety of foods dominate the top dietary sources across both macronutrient and micronutrients, strongly suggesting the need for increased dietary diversity within this age group.

Keywords

Adolescents, diet composition, environmental contamination, Native Americans

History

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Introduction

Nutrition-related health issues have occupied a fundamental role in the health status of Native communities since contact with Europeans. Colonization, the continued loss of aboriginal territories, forced relocation to reservations, and decreases in local agriculture and farming produced substantial shifts in subsistence practices as well as available local food sources (Rhoades, 2000; Young, 1994). With these disruptions, the diet and lifestyle of many Native American communities has radically changed and, during the 20th century, escalating levels of obesity in combination with some of the highest rates of diabetes worldwide (Broussard et al., 1991; Burrows et al., 2000; Centers for Disease Control Prevention, 2011; Eisenmann et al., 2003; Gohdes, 1991; Liao et al., 2004; Welty, 1991) have become primary public health concerns for Native people (Gohdes, 1991; Rhoades, 2000; Young, 1994).

Information and data about Native dietary patterns around the time of contact and shortly after comes from a variety of sources, including accounts from early travellers, descriptions from missionaries and medical personnel, archaeological studies, as well as Native oral traditions. Before contact, Native Americans in the Northeastern woodlands cultivated corn, beans, squash and other crops as well as gathered a large variety of wild animal and plant foods (Parker, 1910). Native groups in the Northeast such as the Iroquois, Micmac and Objibway depended on a diversity of mammals such as caribou, deer, muskrat and beaver, fish from lakes and streams and wild fowl, and also collected berries, wild rice, maple sugar, as well as a variety of fruits, roots, bark, nuts and lichen (Driver & Massey, 1957; Gonzalez, 1969). Ethnographic accounts of early contact between Native Americans and Europeans such as Jacques Cartier and Henry Hudson remark on the vastness of corn cultivation along the banks of the Hudson and St. Lawrence Rivers and the presence of thriving villages (Hakluyt, 1889). Observations of dietary patterns immediately post-contact suggest sources of essential micronutrients and basic protein-calorie requirements were adequate and that dietary patterns across Native North America were diverse, reflecting opportunistic and effective utilization of varied ecological zones (Driver & Massey, 1957). High-fibre, nutrient-dense foods needing a measurable expenditure of physical activity to hunt, gather and then prepare characterized the diet of many Native groups during this time period.

By the early 20th century, instead of an adequate and diverse diet, many Native communities faced food shortages, chronic deficiencies in the quality of available foods, and health issues related to under-nutrition (Carlile et al., 1972;

Correspondence: Julia Ravenscroft, MA, Department of Anthropology, University at Albany, 1400 Washington Avenue, Albany, NY 12222, USA. Tel: (518) 442-7769. E-mail: jravenscroft@albany.edu

Moore, 1969; New Mexico College of Agriculture and Mechanic Arts, 1954; Van Duzen et al., 1969). In a 1926–1927 survey, the Bureau of Indian Affairs identified insufficient quantity and quality of food as the primary factor affecting the health of Native Americans in the US (Merian, 1928). As Teufel (1996) suggests, the dynamics of diet and activity change are unique to Native communities because the often abrupt curtailment of traditional subsistence activities attributable to forced relocation or containment policies dramatically alter where Native peoples find food, how they procure food, what is perceived as food, and how food is distributed. A handful of surveys from the 1950s through the 1960s also documented similar findings of food scarcity and observed growth rates of Native children much lower than national reference values (Carlile et al., 1972; Moore, 1969; New Mexico College of Agriculture and Mechanic Arts, 1954; Van Duzen et al., 1969).

In a few generations since the mid-20th century, the nutritional status of Native Americans has shifted, with a transition from chronic under-nutrition in most communities to some of the most elevated rates for both overweight/obesity and diabetes worldwide (Broussard et al., 1991; Burrows et al., 2000; Centers for Disease Control Prevention, 2011; Dillinger et al., 1999; Eisenmann et al., 2003; Gohdes, 1991; Liao et al., 2004; Welty, 1991). Currently, concern over rapidly increasing rates of overweight/obesity in children as well as adults has become a focal health and research initiative in Native communities (Broussard et al., 1991; Caballero et al., 2003; Eisenmann et al., 2000, 2003; Lohman et al., 1999; Story et al., 1999; Sugarman et al., 1990; Zephier et al., 2006). Even though growth studies indicate that rates of paediatric obesity have increased in all children across the US over the last 50 years (Ogden et al., 2002; Troiano & Flegal, 1998), Native youth now have greater rates of overweight/obesity than same-aged youth from the general population (Anderson & Whitaker, 2009; Broussard et al., 1991, 1995; Gallo et al., 2005; Gruber et al., 1995; Hanley et al., 2000; Hearst et al., 2011; Jackson, 1993; Zephier et al., 2006).

While dietary shifts are suspected primary contributors to the changing patterns of disease currently experienced by Native American communities, surprisingly little information exists concerning the dietary patterns of contemporary Native American children and adolescents (Cole et al., 2001; Khalil et al., 2010; LaRowe et al., 2010; Lytle et al., 2002; Story et al., 1998, 1999). National surveys of health and nutrition such as the NHANES series of studies have not included Native Americans in their samples, and there are still relatively few published investigations of nutrient intake levels among Native children, and especially Native adolescents. Understanding the dietary patterns of adolescents is important as food preferences emerge at this time and propensity for overweight as well as obesity-related diseases may find their antecedents during critical periods within the childhood and adolescent life stages (Cameron & Demerath, 2001; Lanigan & Singhal, 2009; Rolland-Cachera et al., 2006).

Overweight and obesity at a rudimentary level is related to an imbalance between dietary intake and energy expenditure. However, recent research suggests that aspects of diet composition may play an essential function regarding the aetiology of overweight and obesity, rather than a model with an overall increase in dietary energy intake as the primary causative factor (Abete et al., 2010; Gazzaniga & Burns, 1993; Hollis & Mattes, 2005; Nguyen et al., 1996; Schoeller & Buchholz, 2005; Wells & Siervo, 2011).

This study examines the dietary composition of Native American adolescents residing in upstate New York at the Akwesasne Mohawk Nation. We have previously observed in this sample of adolescents that the mean BMI of the youths (10–16 years of age) significantly exceeds the 50th percentile of the CDC reference population (Gallo et al., 2005; Schell & Gallo, 2012). In fact, the mean BMI lies between the 85th and 90th percentile across all ages and both sexes. In light of their current nutritional status, the goal of this analysis is to assess the food patterns of Akwesasne adolescents via a total diet approach. As overall dietary quality is the sum of collective dietary choices over time, such an approach may allow for the identification of emerging dietary trends within a population group, food choices that are inconsistent with current dietary recommendations and dietary patterns associated with health outcomes of interest.

Materials and methods

Background and sample characteristics

The sample is comprised of 271 Mohawk adolescents between the ages of 10–16.9 years of age who participated in the community-based study ''PCBs (polychlorinated biphenyls) and the wellbeing of Mohawk youth'' (MAWBS) funded by NIEHS between 1995–2000 as part of the Superfund Basic Research Program. Detailed descriptions of recruitment and sampling are reported in previously published work (Schell et al., 2003). At the time of recruitment, general informed consent information and the aims of the project were explained to potential participants by Mohawk data collection staff. All data collection staff and research staff signed a confidentiality agreement in which they guaranteed to protect the identity and confidentiality of all participants. One youth per household was eligible to participate in the project. If more than one youth within the age range of interest resided in the household, data collectors approached the oldest first. As the youths were less than 17 years of age, informed consent was gained from the mothers of each youth and written assent to participate was gained from the youths themselves. Youths were not eligible to participate in the project if they had been hospitalized due to serious brain injury or had a diagnosis of serious organic psychological pathology or Foetal Alcohol Syndrome/Foetal Alcohol Effects. These exclusion criteria were primarily intended to control for confounding in the investigation of PCB exposure and cognitive development, one of the larger research aims of the overall project.

The MAWBS project engaged with the Akwesasne Mohawk Nation using the principles of community-based participatory research to guide the development of the research partnership. In a collaborative research model, the community directly participates in the formulation of research questions and goals, provides input as to appropriate research methodologies and instruments, helps to conduct the research through the hiring of local data collectors, and actively provides feedback regarding the analysis and publication of results. A full description of our research partnership is available in previously published work (Schell et al., 2005, 2007). Each participant was compensated for their time and all study protocols were reviewed and approved by the Institutional Review Board at the University at Albany, S.U.N.Y. and the Research Advisory Committee of the Akwesasne Task Force on the Environment.

The data collection staff catalogued all households within the reserve and then generated a random sample from a master list of households. The randomized households were then approached in order, however, because Akwesasne is a fairly small community and the project's age range of interest quite narrow, recruitment was expanded after the first year to include all of the households originally surveyed.

This resulted in the recruitment of 294 mother/youth pairs (156 females and 138 males), of which 19 chose to later discontinue their participation in the project. The primary reason participants declined further participation was a refusal to complete the blood draw necessary for PCB level testing that was a component of the larger project. Three additional participants were later excluded from the study as their blood samples were unfortunately broken during transportation to the laboratory and it was not possible to obtain a second sample. Additionally, one participant was identified as not meeting eligibility requirements (9 years of age) and was later withdrawn from the sample. Thus, the complete sample is comprised of 271 youth: 140 females and 131 males.

Dietary assessment

To assess dietary intakes, Mohawk data collectors conducted the National Cancer Institute (NCI) and Block Dietary Data Systems Block 95 (Block et al., 1990, 1992; National Cancer Institute, 1999) semi-quantitative food frequency interview with individual participating youths if they were 13 years of age or older. Those participants between 10–12.9 years of age completed the food frequency jointly with their mother or primary guardian. The Block 95 food frequency has been found a valid instrument in a variety of samples, including young adults (Block et al., 1990, 1992; Caan et al., 1998; Subar et al., 2001). The food groups itemized on the Block 95 and the reference portion sizes were derived from an analysis of NHANES II 24-hour dietary recall data (Block et al., 1994). The NCI food frequency invites participants to recall the frequency they consumed a specific food item or food group over a period of time (never, less than once a month, per month, per week, or per day) as well as their usual portion or serving size. To aid the recall of portion sizes more precisely, each data collector used food models reflecting various portion sizes in addition to a set of measuring spoons and a set of measuring cups as the interview progressed to help the participant judge their portion size. To capture consumption of food items not listed on the food frequency, interviewers queried participants regarding foods eaten more than once a week in an open-ended fashion. Those foods eaten one or more times a week but not specified on the food frequency are included in the subsequent nutrient analysis. Participants were also asked how frequently they consumed restaurant foods or fast food items (fried chicken, burgers, pizza, Chinese food, Mexican food, fried fish). Supplementary descriptive information regarding typical dietary practices like removing fat from meat and the skin on chicken, adding table salt or pepper and adding additional butter/margarine was also collected from participants.

Dietary data analysis

The semi-quantitative food frequency data gained from interview was entered into DietSys 4.0; DietSys is a DOS program developed to analyse the NCI semi-quantitative food frequency questionnaire (National Cancer Institute, 1999). Using the frequency data, DietSys estimates intakes of specific foods and food groups, estimates nutrient intakes for 33 major nutrients, in addition to determining the primary food sources of both macro- and micronutrients. The population intake frequencies generated by DietSys are derived from the participant's reported frequency of consumption, portion size, as well as the nutrient content of each individual food. The database from which DietSys derives the nutrient content of foods is based on USDA Food Consumption Survey data and the NHANES II nutrient content database.

After calculating nutrient levels and intake frequencies in DietSys, data values were transferred to the Statistical Package for the Social Sciences (SPSS–18) for data analysis (SPSS Inc, 2010). The distributions of all the nutrient estimates and grouped foods calculated by DietSys were evaluated, as recommended by Block (National Cancer Institute et al., 1997) and extreme low or high values for any estimated nutrient were examined and the original data for individual outliers reviewed. All participants with food frequencies that estimated energy consumption as less than 800 kcal and greater than 4500 kcal were dropped from the analysis ($n = 246$).

The mean, median, standard deviation and inter-quartile range for the macronutrients (total energy intake, total fat, total protein, and total carbohydrate) were calculated for the whole sample and for males and females. Macronutrient density levels (percentage energy from protein, carbohydrate, total fat and saturated fat) are reported for the sample as a whole and compared across sex via Student's t-tests. The mean, median, standard deviation and inter-quartile range for each micronutrient (calcium, phosphorus, magnesium, zinc, iron, vitamin A, vitamin b1, vitamin b2, vitamin b6, vitamin C, vitamin E, niacin and folate) were also calculated separately for males and females as well as the sample as a whole.

To describe the adolescent diets in more practical terms and provide information to the community that could be readily applied in educational and healthcare settings, the top 10 food sources of each macronutrient, as well as selected micronutrients (calcium, iron, folate, vitamin C and zinc) were determined. This type of data provides useful information concerning potential points of intervention, especially if macronutrient estimates reveal areas of concern in relation to recommended intake guidelines. DietSys is able to calculate the percentage a food item or food group contributes to intake of a specific nutrient via the Sources-Sort function. The top 10 sources of macronutrients represent food sources that contribute ~2% or more to the total intake of macronutrients. Food sources of macronutrients and selected micronutrients were assessed separately for males and females, allowing for identification of potential differences between male and female adolescents in relation

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to food choices that are major contributors to their nutritional intakes.

Results

As expected, the total caloric consumption of the adolescent males is significantly different to that of the females, as is their protein and carbohydrate intakes ($p \leq 0.05$). Total fat intake does not differ significantly between the sexes, although the total fat intake of males is higher (Table 1). When compared to the National Research Council recommendations for daily caloric intakes, the adolescent girls consume significantly more than the recommended 2200 kcal per day ($p \leq 0.05$), while for the boys there are no significant differences between the guidelines (11–14 years = 2500 kcal; 15–17 years = 3000 kcal) and their actual intakes.

Top contributing food sources of macronutrients and dietary fibre are shown in Tables 2 and 3. Top sources were ranked for males and females separately. For both males and females, top 10 sources of the macronutrients energy, protein and fat include the food items milk and beef, as well as the food group biscuits/muffins/doughnuts/cookies, reflecting their ubiquitous consumption and presence in the adolescents' diets. Nutrient-dilute but energy-dense foods characterize most of the top 10 energy sources and include salty snacks, biscuits/muffins/doughnuts/cookies, french-fries, sweetened fruit drinks, ice cream/frozen yogurt, and soda. When these nutrient-dilute food sources are combined, they account for 25% of the energy intake of males and 22% of the energy intake for females.

Breakfast cereals and yeast-based breads are top three sources of carbohydrates for both males and females. Sugar-added beverages such as Kool-Aid and soda are also top sources of carbohydrates and, when combined, contribute 13% and 15% of total carbohydrate intake for males and females, respectively. Other top 10 sources of carbohydrates are primarily energy-dense and nutrient-dilute foods including biscuits/muffins/doughnuts/cookies, french-fries, salty snacks, ice cream/frozen yogurt, and pizza. Protein sources are similar for both males and females, with beef dishes/hamburger, milk, and poultry comprising the top three food sources for both sexes. Poultry and pork, energy-dilute but nutrient-dense lean meats, comprise a smaller component of total protein intake, contributing 9.5% for males and 13% for females.

Sources of dietary fat for the adolescents are generally foods high in saturated fats, but nutrient-dilute. Salty snacks, biscuits/muffins/doughnuts/cookies, butter, mayonnaise/salad dressings, hot dogs, french-fries, and processed lunch meats are all top 10 food sources for dietary fat and possess high levels of saturated fats. When combined, these seven food sources contribute 37% of the fat intake of both males and females. The highest ranked sources of dietary fibre are ready-to-eat cereals, yeast breads and rolls, and the food group apples, applesauce and pears. Notably french-fries and other white potatoes are the fourth highest source of fibre for both boys and girls, demonstrating the high prevalence of convenience foods in the diets of the youth. Fresh whole fruit is a rich source of fibre for Akwesasne youth, as whole fruit top 10 sources contribute 15.1% and 18.5% of fibre intake for males and females, respectively, even though overall levels of whole fruit consumption are low.

The most frequent sources of energy and macronutrients for Akwesasne boys and girls are very similar to those of the nationally representative US sample of youth assessed by the Continuing Study of Food Intake by Individuals (CSFII) (Subar et al., 1998). Among boys, with the exception of fibre, ~6.7 of the top 10 contributors to each macronutrient in the CSFII sample are also top 10 contributors to the respective macronutrients in our Akwesasne sample (Table 2). For the girls, 7.5 of the top 10 food sources for each macronutrient in the CSFII sample are also top 10 contributors at Akwesasne (Table 3).

Tables 4 and 5 show mean usual micronutrient intakes and their range for both males and females, as well as the Estimated Average Requirement (EAR) for the appropriate age category and the percentages below the EAR for each micronutrient. Percentages below the cut-point for the EAR were calculated individually for each age group and then proportionally summed for each sex. For the males, one micronutrient, calcium, likely has individuals within this group of Akwesasne adolescents who are not meeting their requirements as 77% were below the EAR for calcium. In contrast, the micronutrients, calcium, phosphorous, and folate all likely have individuals not meeting their requirements among Akwesasne adolescent females, as 81% were below the EAR for calcium, 29% for phosphorous, and 35% for folate.

Table 1. Estimated energy and macronutrient intakes ($n = 246$).

	All			Girls			Boys		
	Mean	Median	Range	Mean	Median	Range	Mean	Median	Range
Total calories (kcal)	2510	2432	1911–3072	2386**	2211	1834–2951	2647*	2580	2108–3263
Total fat (g)	110	102	84–137	108	100	79–128	113	106	85–139
Protein (g)	88	84	68–104	83	78	61–99	93*	91	73–109
Carbohydrate (g)	295	286	215–361	274	261	203–323	319*	309	242–388
% kcal fat	39.3	39.0	34.5–43.5	40.4	40.8	36.7–44.5	38.1	37.5	33.2–42.1
% kcal protein	14.1	14.0	12.8–15.4	14.1	13.8	12.6–15.0	14.2	14.1	13.0–15.5
% kcal carbohydrate	47.2	46.4	42.7–52.1	46.1	45.4	41.3–51.1	48.4	48.0	44.3–53.7

Diets with total kcal <800 and >4500 were excluded.
Range = 25th to 75th percentile.
117 males and 129 females.
$*p \leq 0.05$; $**p \leq 0.05$ (compared to National Research Council guidelines).

Table 2. Food sources of energy and macronutrients for Akwesasne boys aged 10–16.9 years ($n = 117$) compared to boys of 12–18 years in the 1989–1991 continuing surveys of food intakes by individuals ($n = 710$).

	Akwesasne boys		CSFII boys	
	Rank	%	Rank	%
Food sources of Energy				
Milk (2%, Whole, Low-fat)	(1)	7.4	(2)	9.5
Yeast Bread, Rolls	(2)	6.8	(1)	9.8
Beef dishes, Hamburger	(3)	6.7	(3)	7.0
Biscuits, Muffins, Doughnuts, Cookies, Cake	(4)	5.8	(4)	6.3
Salty Snacks (Chips, Popcorn)	(5)	5.1	(8)	3.3
Ready-to-eat Cereals	(6)	4.6	(6)	4.1
French Fries and other White Potatoes	(7)	4.5	(NA)[a]	***
Pasta and Spaghetti	(8)	3.3	(14)	2.1
Kool-Aid and Fruit Drinks	(9)	3.2	(19)	1.7
Orange Juice, Grapefruit Juice	(10)	3.2	(20)	1.7
Food sources of Carbohydrate				
Yeast Bread, Rolls	(1)	10.4	(1)	14
Ready-to-eat Cereals	(2)	8.3	(4)	6.9
Kool-Aid and Fruit Drinks	(3)	6.7	(8)	3.5
Orange Juice, Grapefruit Juice	(4)	6.2	(11)	3.1
Soft Drinks, Soda	(5)	6.1	(2)	12.3
Milk (2%, Whole, Low-fat)	(6)	6.0	(5)	6.6
Biscuits, Muffins, Doughnuts, Cookies, Cake	(7)	5.9	(3)	7.4
French Fries and other White Potatoes	(8)	5.8	(NA)[a]	***
Pasta and Spaghetti	(9)	4.1	(10)	3.2
Salty Snacks (Chips, Popcorn)	(10)	3.7	(13)	2.9
Food sources of Protein				
Beef dishes, Hamburger	(1)	15.4	(1)	17.9
Milk (2%, Whole, Low-fat)	(2)	14.2	(2)	15.8
Poultry	(3)	6.3	(3)	9.5
Yeast Bread, Rolls	(4)	6.1	(4)	7.7
Pasta and Spaghetti	(5)	5.8	(13)	1.9
Cheese, dishes with cheese	(6)	4.7	(5)	7.2
Ready-to-eat Cereals	(7)	4.7	(7)	2.6
Pizza	(8)	3.9	(NA)[b]	***
Pork (fresh)	(9)	3.3	(11)	2.0
Eggs	(10)	2.9	(9)	2.2
Food sources of Fat				
Salty Snacks (Chips, Popcorn)	(1)	8.3	(7)	5.1
Beef dishes, Hamburger	(2)	8.1	(1)	11.7
Biscuits, Muffins, Doughnuts, Cookies, Cake	(3)	7.0	(5)	6.7
Milk (2%, Whole, Low-fat)	(4)	6.5	(2)	10.7
Butter	(5)	5.3	(22)	1.1
Margarine	(6)	4.9	(4)	7.0
Mayonnaise and Salad Dressings	(7)	4.5	(6)	5.3
Hot Dogs	(8)	4.4	(15)	2.3
Cheese, Dishes with Cheese	(9)	4	(3)	7.4
French Fries and other White Potatoes	(10)	3.6	(NA)[a]	***
Food sources of Fibre				
Ready-to-eat Cereals	(1)	11.7	(2)	10.8
Yeast Bread, Rolls	(2)	7.2	(1)	14.2
Apples, Apple Sauce, Pears	(3)	6.6	(11)	2.3
French Fries and other White Potatoes	(4)	5.8	(NA)[a]	***
Oranges, Tangerines	(5)	5.1	(21)	1.0
Corn	(6)	3.9	(8)	4.0
Orange Juice, Grapefruit Juice	(7)	3.8	(16)	1.2
Peanuts, Peanut Butter	(8)	3.5	(12)	2.1
Bananas	(9)	3.4	(14)	1.3
Beans (Dried Type)	(10)	3.4	(3)	9.5

[a]French Fries not available as single food item from CSFII.
[b]Pizza not available as single food item from CSFII.

Many essential nutrients are likely adequate in these adolescent's diets, as habitual intake of a nutrient above the EAR is associated with a very low probability of inadequacy. Vitamin A, thiamine (B1), riboflavin (B2), pyridoxine (B6), niacin, zinc, iron, and vitamin C are all likely adequate because of the very low proportion of individuals who fall

Table 3. Food sources of energy and macronutrients for Akwesasne girls aged 10–16.9 years ($n = 129$) compared to girls of 12–18 years in the 1989–1991 continuing surveys of food intakes by individuals ($n = 716$).

	Akwesasne girls		CSFII girls	
	Rank	%	Rank	%
Food sources of Energy				
Milk (2%, Whole, Low-fat)	(1)	7.5	(2)	8.8
Beef dishes, Hamburger	(2)	6.5	(3)	6.4
Biscuits, Muffins, Doughnuts, Cookies, Cake	(3)	5.8	(5)	6.0
Yeast Bread, Rolls	(4)	5.3	(1)	9.7
French Fries and other White Potatoes	(5)	4.5	(NA)[a]	***
Salty Snacks (Chips, Popcorn)	(6)	4.4	(6)	4.6
Kool-Aid and Fruit Drinks	(7)	4.3	(15)	2.0
Pasta and Spaghetti	(8)	4.0	(11)	2.7
Ready-to-eat Cereals	(9)	3.4	(8)	3.3
Cheese, dishes with cheese	(10)	3.2	(7)	4.4
Food sources of Carbohydrate				
Kool-Aid and Fruit Drinks	(1)	9.4	(9)	3.9
Yeast Bread, Rolls	(2)	8.6	(1)	13.7
Ready-to-eat Cereals	(3)	6.4	(6)	5.5
Milk (2%, Whole, Low-fat)	(4)	6.4	(4)	6.1
Orange Juice, Grapefruit Juice	(5)	6.4	(11)	3.5
Biscuits, Muffins, Doughnuts, Cookies, Cake	(6)	6.0	(3)	7.1
French Fries and other White Potatoes	(7)	6.0	(NA)[a]	***
Soft Drinks, Soda	(8)	5.5	(2)	12.3
Pasta and Spaghetti	(9)	4.4	(7)	4.1
Salty Snacks (Chips, Popcorn)	(10)	3.4	(10)	3.8
Food sources of Orotein				
Beef dishes, Hamburger	(1)	14.8	(1)	16.8
Milk (2%, Whole, Low-fat)	(2)	14.6	(2)	14.5
Poultry	(3)	8.8	(3)	11.8
Pasta and Spaghetti	(4)	6.1	(7)	2.4
Cheese, dishes with cheese	(5)	5.4	(4)	8.1
Yeast Bread, Rolls	(6)	4.8	(5)	7.8
Pizza	(7)	4.0	(NA)[b]	***
Pork (fresh)	(8)	3.7	(8)	2.4
Ham and Lunch Meats[c]	(9)	2.9	(6)	3.7
Ready-to-eat Cereals	(10)	2.9	(11)	1.9
Food sources of Fat				
Milk (2%, Whole, Low-fat)	(1)	9.9	(2)	10.3
Butter	(2)	7.9	(19)	1.2
Beef dishes, Hamburger	(3)	7.3	(1)	10.6
Salty Snacks (Chips, Popcorn)	(4)	6.9	(4)	7.3
Biscuits, Muffins, Doughnuts, Cookies, Cake	(5)	6.7	(5)	6.2
Margarine	(6)	6.1	(7)	6.0
Mayonnaise and Salad Dressings	(7)	4.8	(6)	6.1
Cheese, Dishes with Cheese	(8)	4.3	(3)	8.8
Hot Dogs	(9)	3.9	(15)	1.8
Ham and Lunch Meats[d]	(10)	3.6	(18)	1.5
Food sources of Fibre				
Ready-to-eat Cereals	(1)	10.5	(5)	6.9
Apples, Apple Sauce, Pears	(2)	9.1	(12)	1.9
Yeast Bread, Rolls	(3)	5.9	(1)	15.3
French Fries and other White Potatoes	(4)	5.9	(NA)[a]	***
Oranges, Tangerines	(5)	5.7	(14)	1.5
Kool-Aid and Fruit Drinks	(6)	3.8	(NA)[e]	***
Corn	(7)	3.8	(10)	3.6
Bananas	(8)	3.6	(21)	1.0
Pasta and Spaghetti	(9)	3.3	(7)	5.1
Biscuits, Muffins, Doughnuts, Cookies, Cake	(10)	3.0	(8)	4.1

[a]French Fries not available as single food item from CSFII.
[b]Pizza not available as single food item from CSFII.
[c]Ham food group and Cold Cuts food group from the CSFII are combined.
[d]The Cold Cut food group from the CSFII does not contain Ham. Ham as a source of fat is not reported by Subar et al. (1998) as it contributes <1% of fat.
[e]Fruit drinks as a source of fibre are not reported by Subar et al. (1998) as they contribute <1% of fibre.

Table 4. Micronutrient levels and percentage below EAR: Boys ($n = 117$).

	Mean	Min	Max	SD	EAR (age range and value)	Percentage < EAR	AI	Percentage < AI
Phosphorous (mg/day)	1712.8	709.3	5480.9	734.84	1055	12.0		
Zinc (mg/day)	16.8	6.3	50.3	8.14	9–13 = 7; 14–18 = 8.5	3.4		
Iron (mg/day)	19.1	6.4	72.8	8.95	9–13 = 5.9; 14–18 = 7.7	0.9		
Vit A (μg/day)	1508.8	400.3	6075.2	764.04	9–13 = 445; 14–18 = 630	0.9		
Vit b1 (mg/day)	2.3	0.9	5.4	0.95	9–13 = 0.7; 14–18 = 1	0.9		
Vit b2 (mg/day)	2.9	1.1	7.8	1.31	9–13 = 0.8; 14–18 = 1.1	1.7		
Vit b6 (mg/day)	2.7	1.0	11.5	1.41	9–13 = 0.8; 14–18 = 1.1	1.7		
Vit C (mg/day)	250.0	33.8	1019.0	156.25	9–13 = 39; 14–18 = 63	1.7		
Niacin (mg/day)	29.7	9.0	85.3	12.98	9–13 = 9; 14–18 = 12	0.9		
Folate (μg/day)	486.1	167.9	1819.0	255.74	9–13 = 250; 14–18 = 330	17.1		
Calcium (mg/day)	1141.9	371.1	4433.9	564.53			1300	77.0

EAR, Estimated Average Requirement; AI, Adequate Intake.

Table 5. Micronutrient levels and percentage below EAR: Girls ($n = 129$).

	Mean	Min	Max	SD	EAR (age range and value)	Percentage < EAR	AI	Percentage < AI
Phosphorous (mg/day)	1470.9	304.7	4391.1	707.63	1055	28.7		
Zinc (mg/day)	14.8	3.2	50.9	8.36	9–13 = 7; 14–18 = 7.3	7.8		
Iron (mg/day)	16.4	3.4	55.0	8.03	9–13 = 5.7; 14–18 = 7.9	1.6		
Vit A (μg/day)	1431.6	352.9	5523.3	877.74	9–13 = 420; 14–18 = 485	1.6		
Vit b1 (mg/day)	2.0	0.4	6.5	1.05	9–13 = 0.7; 14–18 = 0.9	1.6		
Vit b2 (mg/day)	2.5	0.6	8.0	1.37	9–13 = 0.8; 14–18 = 0.9	2.3		
Vit b6 (mg/day)	2.3	0.5	7.8	1.21	9–13 = 0.8; 14–18 = 1	0.0		
Vit C (mg/day)	229.8	36.5	975.8	160.15	9–13 = 39; 14–18 = 56	2.3		
Niacin (mg/day)	25.2	5.6	78.4	12.43	9–13 = 9; 14–18 = 11	1.6		
Folate (μg/day)	413.4	90.3	1628.4	252.91	9–13 = 250; 14–18 = 330	34.9		
Calcium (mg/day)	996.0	198.2	3975.6	609.90			1300	80.6

EAR, Estimated Average Requirement; AI, Adequate Intake.

below the EAR for each of these nutrients. The ample availability of the B vitamins within the adolescents' diet is undoubtedly reflective of the high consumption rates of fortified ready-to-eat cereals and other enriched foods such as pasta and breads.

Overall, the food sources of selected micronutrients, calcium, iron, folate, zinc, and vitamin C are similar for both adolescent males and females (Tables 6 and 7). Milk and cheese account for ~55% of the adolescents' intake of calcium. Dietary sources of iron are largely provided by breakfast cereals and yeast-based breads. These fortified food sources contribute 33% of the iron intake for males and 30% of the iron intake for females, ~3-times as much as the top source of naturally occurring iron, beef. Biscuits/muffins/doughnuts/cookies and pasta are also top sources of iron, demonstrating the contribution of fortified grain products in relation to iron intakes in the adolescents' diets.

Ready-to-eat cereals are the prime contributors to both zinc and folate intake for both males and females. In terms of folate intake, fortified ready-to-eat cereals contribute 32–33% of total folate intake, which is more than double the top source of naturally occurring folate, orange juice and grapefruit juice. Whole fruits such as oranges and tangerines as well as folate-rich dried beans are in the top 10 sources, but only make modest contributions of 2% or less. Several naturally folate-rich foods such as dark leafy greens are not top sources due to infrequent consumption. Other top sources of zinc include milk, pasta and cheese, but processed and non-lean meats are also major contributors to zinc intake, constituting 11% for both males and females.

Citrus juices such as orange juice and grapefruit juice are the primary contributor to dietary vitamin C intake, providing more than a third of daily vitamin C intake. Solid fruits do contribute to vitamin C intake, with oranges and tangerines making a moderate contribution of 10% of intake and other fruits like grapefruit and bananas accounting for 2% or less of intake. Sugar-added, energy-dense fruit drinks as the second highest source of vitamin C are sizeable contributors to intake, even though these beverages typically contain very little fruit juice.

Macronutrient intakes of the adolescents, specifically measures of macronutrient dietary composition, were compared to national level data from the series of NHANES studies (Table 8). As 24-hour recalls are used to assess dietary intake, it is not possible to compare absolute nutrient intakes between adolescents participating in the NHANES studies and the current investigation because of methodological differences between the food frequency and 24-hour recall approaches. None the less, it is possible to compare overall measures of macronutrient dietary composition. Table 8 shows that both males and females from Akwesasne gain significantly more of their energy from fat compared to values reported for NHANES adolescents and significantly less of their energy from carbohydrates than reported for NHANES adolescents ($p \leq 0.05$).

Discussion

The current analysis of food source contribution to various nutrients reveals a limited collection of foods that dominate

Table 6. Food sources of micronutrients for Akwesasne boys aged 10–16.9 years ($n = 117$).

	Akwesasne boys	
	Rank	%
Food sources of Calcium		
Milk (2%, Whole, Low-fat)	(1)	43.8
Cheese, Dishes with Cheese	(2)	10.4
Ice Cream, Frozen Yogurt, Milkshake	(3)	8.2
Yeast Bread, Rolls	(4)	5.6
Pasta and Spaghetti	(5)	3.3
Biscuits, Muffins, Doughnuts, Cookies, Cake	(6)	2.7
Pizza	(7)	2.4
Beef dishes, Hamburger	(8)	2.1
Oranges, Tangerines	(9)	1.8
Orange Juice, Grapefruit Juice	(10)	1.6
Food sources of Iron		
Ready-to-eat Cereals	(1)	22.4
Beef dishes, Hamburger	(2)	10.9
Yeast Bread, Rolls	(3)	9.7
Pasta and Spaghetti	(4)	6.3
French Fries and other White Potatoes	(5)	4.9
Biscuits, Muffins, Doughnuts, Cookies, Cake	(6)	3.6
Eggs	(7)	2.8
Salty Snacks (Chips, Popcorn)	(8)	2.5
Ham and Lunch Meats	(9)	1.7
Chinese food from Restaurant	(10)	1.6
Food sources of Vitamin C		
Orange Juice, Grapefruit Juice	(1)	35.8
Kool-Aid and Fruit Drinks	(2)	11.1
Oranges, Tangerines	(3)	9.9
Ready-to-eat Cereals	(4)	8.0
Tang and Start	(5)	3.4
HI-C	(6)	3.3
French Fries and other White Potatoes	(7)	5.7
Pasta and Spaghetti	(8)	2.6
Broccoli	(9)	2.4
Salty Snacks (Chips, Popcorn)	(10)	1.6
Food sources of Zinc		
Ready-to-eat Cereals	(1)	21.8
Beef dishes, Hamburger	(2)	20.9
Milk (2%, Whole, Low-fat)	(3)	8.7
Pasta and Spaghetti	(4)	5.0
Cheese, Dishes with Cheese	(5)	3.9
Yeast Bread, Rolls	(6)	3.4
Ice Cream, Frozen Yogurt, Milkshake	(7)	3.3
Hot dogs	(8)	2.2
Ham and Lunch Meats	(9)	2.1
Salty Snacks (Chips, Popcorn)	(10)	1.6
Food sources of Folate		
Ready-to-eat Cereals	(1)	33.5
Orange Juice, Grapefruit Juice	(2)	16.7
Yeast Bread, Rolls	(3)	5.6
Salty Snacks (Chips, Popcorn)	(4)	4.3
Milk (2%, Whole, Low-fat)	(5)	3.8
Pizza	(6)	3.3
Corn	(7)	2.6
Pasta and Spaghetti	(8)	2.5
Eggs	(9)	2.2
Green Salad	(10)	2.1

Table 7. Food sources of micronutrients for Akwesasne girls aged 10–16.9 years ($n = 129$).

	Akwesasne girls	
	Rank	%
Food sources of Calcium		
Milk (2%, Whole, Low-fat)	(1)	45.2
Cheese, Dishes with Cheese	(2)	11.7
Ice Cream, Frozen Yogurt, Milkshake	(3)	5.8
Yeast Bread, Rolls	(4)	4.4
Pasta and Spaghetti	(5)	3.5
Biscuits, Muffins, Doughnuts, Cookies, Cake	(6)	3.2
Pizza	(7)	2.4
Beef dishes, Hamburger	(8)	2.2
Oranges, Tangerines	(9)	1.9
Orange Juice, Grapefruit Juice	(10)	1.6
Food sources of Iron		
Ready-to-eat Cereals	(1)	21.22
Beef dishes, Hamburger	(2)	10.8
Yeast Bread, Rolls	(3)	7.9
Pasta and Spaghetti	(4)	6.8
French Fries and other White Potatoes	(5)	5.1
Eggs	(6)	2.8
Pizza	(7)	2.3
Salty Snacks (Chips, Popcorn)	(8)	2.2
Cheese, Dishes with Cheese	(9)	2.2
Kool-Aid and Fruit Drinks	(10)	2.1
Food sources of Vitamin C		
Orange Juice, Grapefruit Juice	(1)	33.6
Kool-Aid and Fruit Drinks	(2)	14.4
Oranges, Tangerines	(3)	10.2
French Fries and other White Potatoes	(4)	5.4
HI-C	(5)	4.1
Ready-to-eat Cereals	(6)	6.6
Tang and Start	(7)	2.8
Pasta and Spaghetti	(8)	2.6
Broccoli	(9)	2.6
Grapefruit	(10)	1.6
Food sources of Zinc		
Ready-to-eat Cereals	(1)	22.3
Beef dishes, Hamburger	(2)	19.7
Milk (2%, Whole, Low-fat)	(3)	9.0
Pasta and Spaghetti	(4)	5.4
Cheese, Dishes with Cheese	(5)	4.5
Ham and Lunch Meats	(6)	2.3
Hot dogs	(7)	2.1
Yeast Bread, Rolls	(8)	2.7
Pork	(9)	2.0
Fried Chicken	(10)	2.0
Food sources of Folate		
Ready-to-eat Cereals	(1)	31.6
Orange Juice, Grapefruit Juice	(2)	17.6
Yeast Bread, Rolls	(3)	4.7
Milk (2%, Whole, Low-fat)	(4)	4.2
Salty Snacks (Chips, Popcorn)	(5)	4.0
Pizza	(6)	4.0
Pasta and Spaghetti	(7)	2.8
Corn	(8)	2.6
Oranges, Tangerines	(9)	2.4
Eggs	(10)	2.3

the top sources across both macronutrients and micronutrients. Food groups and food items that are the top contributors to energy and, thus, important components of the adolescents' diets are not necessarily food items or food groups that are rich in macro- or micronutrients.

At the time these data were collected (1996–2000) the USDA food guide pyramid (1992) recommended 2–3 servings per day from the ''milk, yogurt, cheese'' group, 2–3 servings per day from the ''meat, poultry, fish, beans, eggs, and nuts'' group, and foods from the ''fats, oils, and sweets'' group be used ''sparingly'' (USDA, 1992). The adolescents meet and don't exceed the recommendations for the dairy and meats groups, but far exceed the ''use sparingly'' recommendation for fats and oils, with almost five servings per day (USDA, 1992). The USDA also recommended 6–8 servings of bread/cereal/rice/pasta, 2–4 servings of fruit per day and 3–5 servings of vegetables at the time of data collection (1996–2000) (USDA, 1992). For all of these food groups,

Table 8. Dietary composition of Akwesasne youth: Comparison to NHANES.

	Akwesasne Mohawk	NHANES III		NHANES 1988–1994	
Boys, *n*	117	338	368	750	751
Age range (years)	10–16.9	12–15	16–19	12–15	16–19
% kcal from fat	38.1*	33.1	34.6	33.1	34
% kcal from protein	14.2	14.2	14.4	14.3	14.6
% kcal from carbohydrates	48.4*	54	49.6	53.8	50.7
Girls, *n*	129	373	397	848	810
Age range (years)	10–16.9	12–15	16–19	12–15	16–19
% kcal from fat	40.4*	33.7	34.4	33.8	33.8
% kcal from protein	14.1	13.5	14.1	13.2	13.9
% kcal from carbohydrates	46.1*	54.4	52.4	54.6	53.2

*$p \leq 0.05$ compared to age-specific mean for NHANES III and NHANES 1988–1994.

adolescents at Akwesasne did not meet the USDA guidelines (data not presented). The inconsistency of actual food group intakes with USDA recommendations is reflected in the food source data generated in this analysis, as energy-dense, fat-dense foods dominate the top 10 food sources for each macronutrient. Food sources in general demonstrate little diversity and few fruits and vegetables are top sources for micronutrients and, in tandem, Akwesasne adolescents do not meet the USDA guidelines for these food groups. Similarly, although the consumption of a few selected foods from the bread/cereal/rice/pasta group is high (e.g. ready-to-eat cereal), there is not a broad range of foods consumed from this food group and the adolescents fall short of the suggested servings per day guidelines.

Ready-to-eat cereals are top contributors to vitamin and mineral intakes which in part demonstrate the high rate of cereal consumption among adolescents in addition to the high levels of enrichment and fortification of current breakfast cereals. Consequently, ready-to-eat cereal has a significant impact on overall intake levels and almost serves as a surrogate vitamin/mineral supplement for many of the adolescents. Although high consumption of cereal is beneficial to increasing levels of key nutrients like folate or iron, it is problematic that the adolescents' diets contain so few foods naturally-rich in these essential nutrients. Reliance on cereal as a food source can potentially reduce dietary diversity and conceivably lead to substantial added sugar as well as excessive energy intake. One possible benefit of the high consumption rates of ready-to-eat cereal is that cereal is routinely consumed with milk. As calcium levels are likely inadequate in this group of adolescents cereal may provide a vehicle for the consumption of milk, an important calcium source.

Fresh fruits and vegetables are only minor contributors to the adolescents' micronutrient intakes, with vitamin C the only micronutrient with a whole fruit or vegetable that contributes more than 2% to total intake. In fact, the only vegetable consumed in high enough amounts to be included as a top 10 source of the selected micronutrients examined here is broccoli. The low consumption of fresh fruit and vegetables is notable in the context of concerns about overweight and obesity in the community, as fruit and vegetables are rich in micronutrients and fibre, energy-dilute and also linked to decreases in chronic diseases related to obesity.

Dietary guidelines suggest children and adolescents restrict their intake of dietary fat to ≤30% of energy intake. Adolescents at Akwesasne currently have fat intakes that significantly exceed this guideline. Within the diets of the adolescents is a strong presence of fat-dense, energy-dense, and nutrient-dilute foods including biscuits/muffins/doughnuts/cookies, french-fries, salty snacks, and ice cream/frozen yogurt as well as sugar-added beverages. High intakes of these energy-dense foods potentially compromise and displace the consumption of more energy-dilute, but nutrient rich foods.

Other studies of dietary intake among Native American adolescents

It is also of interest to compare the nutrient intake profiles of Akwesasne adolescents to adolescents residing in other Native communities. From 1980 and onward the number of surveys assessing the dietary patterns of Native youth increased (e.g. Cole et al., 2001; Gilbert et al., 1992; Gray & Smith, 2003; Smith & Rinderknecht, 2003; Story et al., 1986), although a comprehensive understanding of contemporary dietary and physical activity patterns in Native adolescents is still lacking (Cole et al., 2001; Lytle et al., 2002; Story et al., 1998, 1999).

In general, the investigations of dietary intakes among Native American adolescents reveal Native youth typically met or exceeded US daily recommended intake levels (US DRI's) for most micronutrients, with the frequent exception of iron, calcium, and zinc. The findings of the present study of adolescents from Akwesasne very much mirror these results in relationship to micronutrient adequacy. Apart from communities in the Southwest, levels of folate and other B-complex vitamins met and usually far exceeded recommended intake levels, probably due to fortification of many foods including breakfast cereals and bread. This trend is also found in the present sample from Akwesasne. Low consumption levels of ready-to-eat cold cereals are reported in the Southwest by those studies that did examine dietary constituents and is probably related to their observed low B-complex vitamin levels (Ballew et al., 1997). Overall, diets of Native adolescents across the US are characterized by high intakes of protein and total fat in combination with little consumption of high-fibre grains and fresh fruit as well as few nutrient-dense vegetables. Every one of the studies found that dietary fat intakes exceeded recommended levels of 30% of energy from fat (US Department of Agriculture & US Department of Health and Human Services, 2000), with levels that ranged from 33% to almost 40%. The dietary composition profile of the Akwesasne adolescents from our current study is similar; the Akwesasne adolescents have low consumption of nutrient dense, energy-dilute fruits and vegetables and these food sources are found rarely as top contributors to overall nutrient intakes. Additionally, the percentage of dietary energy from fat is 38% for males and 40% for females, amongst the highest reported so far for adolescents from any Native community within the US.

Strengths and limitations

A strength of this study is that it investigates dietary composition in a population group for which there is little data regarding dietary food sources: Native American adolescents in the Northeast. Of the few studies of dietary intakes in Native American youth, most have focused on school-aged children or pre-schoolers, rather than adolescents. The present study of adolescents from Akwesasne is the only known investigation of dietary intakes within this age group of a community located in the Northeastern US; most other studies of adolescent dietary patterns have focused on communities west of the Mississippi, particularly communities in the Southwest.

Although various methodologies are available to assess dietary intake, we chose a semi-quantitative food frequency to characterize usual food and nutrient intakes over a longer period of time. There are limitations to the food frequency method, one in particular is that it does not assess all possible foods consumed and is constrained by those foods and food groups included on the questionnaire. To address this concern, interviewers asked open-ended questions regarding food items consumed more than once a week, which we included in our analysis. At the time this study took place, there were very few existing validated semi-quantitative food frequencies available and no semi-quantitative food frequencies specifically validated in Native American populations; we chose the NCI food frequency because it was found valid for assessing customary dietary intake in a variety of populations, was widely used in epidemiological investigations, and provided the best possibility of gaining comparative data (Block et al., 1990, 1992; Caan et al., 1998; Subar et al., 2001). Participants of 13 years of age and younger (age range in the study 10–16.9 years) completed the food frequency interview in tandem with their mother or guardian, likely greatly improving the validity of the instrument with this age group. All interviewers were Mohawk community members highly familiar with local food preparation styles and local dishes. As many food sources and dietary staples for the Akwesasne adolescents are pre-packaged and ready-to-eat (cereal, salty snacks, sugared beverages, etc.), detailed knowledge on the part of the adolescents concerning food preparation techniques may be less fundamental to attaining a global picture of overall dietary patterns. For the older adolescents, although they may lack some knowledge of food preparation, it is possible that we gained a more accurate portrayal of their overall dietary patterns regarding consumption of snack foods, candy, etc., as adolescents may be more willing to share this information if their parent/guardian is not a direct participant during the interview.

There are very little data that report dietary sources of energy and micronutrients available for comparison to the Akwesasne youth. We used data from the CSFII which is the only detailed analyses of national data on food sources of energy and other macro- and micronutrients in a sample of comparable age to the Akwesasne youth (Subar et al., 1998). Unfortunately the most recent published analysis of dietary composition from a national sample (NHANES 2003–2006) combines all children between 2–18 years and does not provide a separate analysis by sex so is not possible to make direct comparisons with our data (Keast et al., 2013). We interpret the comparison to the CSFII with caution, as the CSFII dietary source values are based on one 24-hour recall then aggregated to food groups, somewhat limiting the comparability of the food source results to our semi-quantitative food frequency data. However, our study, like both the Subar et al. (1998) CSFII analysis and the more recent study by Keast et al. (2013), finds that the foods that predominate the diets of the youth, while important because they are primary contributors, are not necessarily the same foods that are rich in specific nutrients.

The food landscape at Akwesasne—factors related to food choice

Perhaps the most pervasive factor shaping the dietary profiles of Native adolescents in the US, including those adolescents from Akwesasne, is the lack of social and economic power Native individuals and communities possess and, thus, the little opportunity they have to change the conditions that promote poor nutrition (Story et al., 1998). This diverse population group, which comprises over 500 federally recognized tribes, has the highest poverty rate of any ethnic group in the nation. According to US Census data, 27% of Native Americans live below the poverty level compared to 14.3% of the total US population (Macartney et al., 2013) and, in addition, Native Americans experience the greatest unemployment levels of any ethnic group, as 16.2% of men and 13.4% of women are unemployed (Henchy et al., 2000). This is over twice the national unemployment rate for all ethnicities which stands at 6.4% for men and 6.2% for women (Henchy et al., 2000). The consequence of such poor economic circumstances results in 43% of Native children under the age of five living in poverty. Poverty is probably the principle factor related to food insecurity or a constraint on resources to the point where families cannot afford to purchase enough food to provide a balanced and varied diet or trade out higher cost, nutrient-dense foods for lower cost, nutrient-dilute foods (Drewnowski & Specter, 2004). Several studies have documented a direct association between food insecurity, participation in supplemental food programmes and obesity within the general population of children and adolescents in the US (Dietz, 1995; Olson, 1999; Townsend et al., 2001). Low socioeconomic status and the general homogenizing effect of the ''mainstream American diet'' has reduced dietary variability, consolidating usual dietary patterns around a handful of core foods that are inexpensive, energy-dense, and easily accessible. A generalized dietary pattern of low-fibre with little fresh fruit and vegetable consumption, high fat, especially from pre-packaged snack foods, and high caloric intake, with increases in simple carbohydrates such as sugared beverages, has emerged and is prevalent among the youth of Akwesasne.

One of the goals of this paper is to quantify in detail the food choices made by adolescents and their families at Akwesasne. We consider these choices a direct reflection of the local food landscape, as they represent foods that are available, accessible, and affordable to community members. During the timespan of our project there were no grocery stores or supermarkets located within the Akwesasne Nation territory. The only commercial sources of food were convenience stores, gas stations, restaurants, and fast-food outlets. There were no commercial outlets from which to purchase fresh fruits, vegetables or meats within the boundaries of Akwesasne.

The delocalization of the food supply in this rural community began many years before, perhaps when food commodities such as flour, sugar, and tea were first introduced to Iroquoia through the fur trade (Delâge, 1993), but, more recently, the detection of environmental contamination within the boundaries of Akwesasne has further hastened this trend as locally grown, produced, and hunted foods are no longer considered safe by residents. The Mohawk Nation at Akwesasne, in response to the contamination of their local environment by persistent organic pollutants (such as polychlorinated biphenyls) originating from nearby industries, issued a fish advisory in 1985 warning women of childbearing age and children to avoid locally caught fish. This was followed by advisories by New York State Department of Environmental Conservation in 1989 and New York State Department of Health in 1991, recommending all persons to avoid consumption of any fish or riverine species (beaver, muskrat, duck) from local waters. Until recently, the consumption of local fish and riverine species was a way of life and an economic necessity at the Akwesasne community for years. Families harvested many types of fish from local waters including bass, catfish, walleye, bullhead, and sturgeon, supplying a significant source of protein as well as calcium and vitamin D to the community. As employment opportunities at Akwesasne, like many Native communities, have been limited and wages generally low, fish served not only to provide a component of the diet but also as an important addition to household economies. Along with fishing, many households also cultivated small gardens and grew fruit trees. The territory was home to many dairy and other small farmers. Concern over environmental contamination has greatly curtailed the local farming economy and few individuals currently maintain their gardens and orchards because of concern over potential contamination of soil and ground water. The Mohawk community thus faces a complex situation involving the potential of direct exposure to toxicants through consumption of contaminated foods and the subsequent health effects of limited food choices due to lack of socioeconomic leverage and pollution of local resources.

Conclusions

Analysis of the dietary composition of Akwesasne adolescents yields food intake patterns that are dependent on energy-dense and fat-dense food sources with low consumption levels of high-fibre grains and nutrient-dense fruits and vegetables. Of particular note is the narrow variety of foods that dominate the top sources across both macronutrients and micronutrients, strongly suggesting the need for increased dietary diversity within this age group. Using a total diet approach that provides a detailed analysis of dietary components, an understanding of the food sources of nutrient levels rather than just absolute nutrient intake amounts has the potential to afford new understanding regarding the increasing levels of overweight and obesity adolescents in this community are experiencing. However, it is imperative to place our results regarding the food sources of nutrient intakes within the context of the local food landscape at Akwesasne. The loss of low-cost food sources such as fresh produce from gardens and locally caught fish due to environmental contamination has the potential to greatly impact food choice in this community; a community where food choices are already constrained by socioeconomic inequalities. At Akwesasne, environmental contamination is part of the backdrop in which dietary and physical activity decisions are made, so future recommendations for public health policy that make sense and are acceptable to the community must consider this context.

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Declaration of interest

The authors report no conflicts of interest. The authors alone are responsible for the content and writing of the paper.

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