Findings and Implications of the Navajo Health and Nutrition Survey

Intake of Nutrients and Food Sources of Nutrients among the Navajo: Findings from the Navajo Health and Nutrition Survey[1,2]

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ABSTRACT Diet has been implicated in the etiology of chronic diseases in many populations, including the Navajo and other American Indian tribes. This report describes the current nutrient intake of the Navajo and identifies the primary food sources of key nutrients. In the Navajo Health and Nutrition Survey, interviewers obtained single 24-h diet recalls from 946 nonpregnant participants age 12–91 between October 1991 and December 1992. Among various sex and age groups, total fat contributed 33–35% of energy and saturated fat contributed 10–11% of energy in the diets. Median fiber intake was 11–14 g/d. Median intakes of vitamin A, vitamin E, vitamin B-6, folate, calcium and magnesium were below sex- and age-specific recommended dietary allowances (RDA) for men and women of all age groups. Intake of vitamin C was below the RDA for men and women age 20 and older. Median iron intake was below the RDA for women under age 60. Fruits and vegetables were each consumed less than once per day per person, as were dairy products. Fry bread and Navajo tortillas, home-fried potatoes, mutton, bacon and sausage, soft drinks, coffee and tea provided 41% of the energy and 15–46% of the macronutrients consumed. Recommendations to increase the intake of essential micronutrients in the Navajo diet are presented. J. Nutr. 127: 2085S–2093S, 1997.

KEY WORDS: • *Navajo* • *American Indian* • *diet survey* • *nutrition*

Diet has been implicated in the etiology of diabetes, cardiovascular disease and cancer in many populations including the Navajo and other American Indian tribes (National Research Council 1989a, Rhoades et al. 1987). Before European contact, the Navajo cultivated corn and other crops but also ate a wide variety of wild animal and plant foods (Kluckhohn and Leighton 1974). After the Spanish introduced sheep and goats in the 17th century, the Navajo adopted mutton as a dietary staple but continued to grow and gather many plant foods. By the 1930s, a trend toward increased reliance on mutton and purchased staples (sugar, flour, coffee, bacon) was observed, but the Navajo's nutritional status was reported to be adequate and the absence of obesity was noted (Carpenter and Steggerda 1939, Steggerda and Eckhardt 1941).

In 1955, a survey of 1246 individuals in two regions of the Reservation found that the Navajo diet was good and that there appeared to be no nutritional problems, with the possible exception of inadequate vitamin C intake (Darby et al. 1956, Sandstead et al. 1956, Stockell et al. 1956). In 1968, a large survey of a single community on the Navajo Reservation found a high risk of inadequacy of iron, protein and vitamin C intakes (University of Pittsburgh 1969). Three small surveys between 1969 and 1981 found evidence of widespread nutritional inadequacy among both children and pregnant or lactating women, including low intakes of vitamin A, folate, calcium and iron. These studies led to the initiation of several nutritional support programs on the Navajo Reservation (Butte et al. 1981, Van Duzen et al. 1969 and 1976).

There has never been a comprehensive survey of the nutritional status of a representative sample of the Navajo people living on or near the Reservation. This report presents the dietary findings of the 1991–1992 Navajo Health and Nutrition Survey, including nutrient intakes and the primary food sources of nutrients.

MATERIALS AND METHODS

The 985 participants in the Navajo Health and Nutrition Survey were drawn from the total population of Navajo living on the Navajo

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[2] Preliminary results from the Navajo Health and Nutrition Survey were presented to the Navajo Nation and Navajo Area Indian Health Service Staff at Flagstaff, AZ, on 29 August 1995 and at Farmington, NM, on 13 December 1996.

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Reservation and in nearby communities. Households were selected by a three-stage cluster design based on census enumeration districts, segments within districts and clusters of 10 households within segments. All individuals 12 y of age and older within selected households were eligible to participate. The sampling strategy and sex-age distribution of the sample are described in detail elsewhere (White et al. 1997).

Interviewers administered a single 24-h diet recall to all participants. Thirty-five pregnant women and three individuals who were unable to respond to the dietary interview were excluded from this analysis. Interviews were conducted Monday through Friday and were distributed approximately evenly during the months from October 1991 through December 1992.

Interviewers were members of the Navajo community who were fluent in both Navajo and English. Staff of the National Center for Health Statistics trained both the interviewers and the Indian Health Service (IHS)[4] public health nutritionists who supervised them in the interview techniques used in the Third National Health and Nutrition Examination Survey (NHANES III, National Center for Health Statistics 1994). Training for the dietary recall included instruction in standardized probes for completeness, portion size estimation, preparation techniques, brand names, recipes and the use of nutritional supplements. The interviewers assisted participants in estimating portion sizes by referring to two- and three-dimensional models and standard measuring and serving utensils. They also examined the household's measuring and serving utensils and food packages.

Twenty-four hour recall data were recorded on interview forms for later entry into the Food Intake Analysis System (FIAS version 2.3) software (University of Texas Health Science Center at Houston, Houston, TX). FIAS uses a subset of the USDA Nutrient Data Base for Food Consumption Surveys, release 6 (U.S. Department of Agriculture, Human Nutrition Information Service 1991). To code all foods reported in the 24-h recalls, the data base was supplemented with six Navajo food ingredients: blue corn meal, juniper ash water, Mormon tea, two varieties of Navajo tea [*Ephedra* sp. and *Thelasperma* spp. (Wolfe et al. 1985)], and North American pine nuts (ESHA II nutrient database, 1987, ESHA Research, Salem, OR). Navajo recipes were incorporated into the database by modifying existing FIAS recipes. Representative recipes for fry bread, Navajo tortillas, blue corn mush with and without ash, kneeldown bread, Navajo cake and sumac pudding were obtained from informants who prepared them frequently; these recipes were used for all individuals who reported those foods. Other added recipes included a variety of soups, stews and mixed dishes that were coded separately for each household that reported them.

The 24-h diet recalls were coded by two of the interviewers who were trained by one of the supervising nutritionists. All computerized diet records were then reviewed against the original data recording forms by the supervising nutritionist, a Navajo coder, and a coding and software consultant. Any data entry errors that could not be unambiguously corrected from the original record were coded according to default definitions (e.g., the diameter of a fry bread, the composition of a Navajo taco) that were based on the expertise of the supervising nutritionist and the Navajo coder. Error and outlier reports from the FIAS software were reconciled with the original record.

The FIAS software nutrient data output was converted to a SAS data set (SAS Institute, Cary, NC) for analyses. We present weighted means, standard errors and 15th, 50th and 85th percentiles for energy and 22 nutrients. Sample weights were assigned according to the sampling design described by White et al. (1997), and weighted analyses were performed with SUDAAN software (Shah 1991). Because of the highly skewed distributions of many nutrients, sex and age-group comparisions were based on nonparametric Wilcoxon statistical tests (Siegal 1956).

We compared the median intake of nutrients to sex- and age-specific recommended dietary allowances (RDA, National Research Council 1989b). Because our age strata differed slightly from those of the RDA, we used the RDA for 15- to 18-y-olds for participants age 12–19 in our study, the RDA for 25- to 50-y-olds for participants age 20–59, and the RDA for ≥51 y for participants age 60 and older. To the extent that the RDA for some nutrients differ by age group, application of these RDA values to evaluate intake of our participants <15 y and between 50 and 59 y may result in some misclassification. We assessed this by comparing the median value for the affected age strata against the lower RDA value as well.

Calculation of food sources of nutrients. The contribution of individual foods to the intake of selected nutrients for the population as a whole was calculated using the method described by Block et al. (1985a and 1985b) and Pennington (1992). Foods were grouped into discrete categories. With some exceptions, the categories are those of the Food Guide Pyramid (U.S. Department of Agriculture 1995). We created the exceptions to examine the contributions of specific foods or categories of food (e.g., eggs; legumes; restaurant and fast foods; pastries and desserts such as pies, cakes, and cookies; and snacks such as chips and popcorn) to nutrient intake. The categories also reflect Navajo food classifications and eating patterns.

The software we used did not permit us to disaggregate mixed dishes into components; thus some foods could not be counted separately in food group analysis. Mixed dishes coded as recipes, such as soups, stews or meatloaf, were classified according to the constituent food contributing the largest proportion of energy and of most other nutrients. For example, mutton stew as prepared by most Navajos derives most of its energy and nutrients from mutton; thus it was classified with meats. Some other foods are coded as single items in the data base. For example, the calcium in cheese on fast-food cheeseburgers was included in estimates of calcium intake, but because a fast-food cheeseburger is coded as a single item in the software, it was attributed to the cheeseburger rather than to the dairy product category in the food group analysis. Pizza is also coded as a single item in the data base. Similarly, small amounts of fruits and vegetables used in mixed dishes were included in the calculation of nutrient intakes but were not tabulated separately as fruits and vegetables in the food group analysis. However, the mixed dishes represent categories of food or food groups as defined and consumed by the Navajo.

The only exceptions to this were the Navajo taco and the mutton sandwich. A Navajo taco is a piece of fry bread covered with chili beans, usually prepared with ground beef, then topped with shredded lettuce, grated cheese, salsa, tomatoes, green chili and sometimes chopped onions. A mutton sandwich is a Navajo tortilla wrapped around grilled mutton, sometimes served with slices of hot pepper and condiments. Because the composition of Navajo tacos and mutton sandwiches may vary, the interviewers attempted to elicit detailed descriptions of each one reported; these were coded as individual ingredients. Default codes for Navajo tacos and mutton sandwiches, based on those served in restaurants or by market vendors on the Reservation, were used if necessary.

The software permitted us to count the number of times participants reported eating specific foods, but we were not able to express these counts in terms of the standard servings of the Food Guide Pyramid (U.S. Department of Agriculture 1995). Each food reported therefore represents a serving as consumed by the participant, but this may be different than a standard serving.

To describe the food sources of nutrients, we present the percentage contribution of each food group to the total consumption of macronutrients and to the total consumption of five micronutrients that have consistently been found to be low in Navajo diets in the past, i.e., vitamin A, vitamin C, folate, calcium and iron.

RESULTS

Nutrient intakes. Very few participants used vitamin supplements; these were almost exclusively the 35 pregnant women excluded from this analysis. The contribution of supplements to the intakes of the 17 other participants (<2%) who reported them could not be coded accurately because the participants could not identify the supplements by brand and dose. The intakes reported here therefore include only nutrients derived from foods.

[4] Abbreviations used: FIAS, food intake analysis system; IHS, Indian Health Service; NHANES II, Second National Health and Nutrition Examination Survey; NHANES III, Third National Health and Nutrition Examination Survey; RDA, recommended dietary allowance.

Intakes of energy, carbohydrate and saturated fat varied significantly by age group among both men and women (**Table 1**). Among men, intakes of protein, vitamin E, vitamin C, calcium and phosphorous varied significantly with age group. Among women, intakes of total fat, vitamin A, β-carotene, vitamin C, folate, calcium and phosphorous decreased significantly with increasing age group (**Table 2**). Participants age 60 and older consumed diets that were denser in protein, total fat, fiber, niacin, thiamin, iron and magnesium per 1000 kcal than younger participants ($P < 0.01$ for all comparisons, data not shown), but consumed diets less dense in carbohydrate, vitamin C and calcium ($P < 0.001$ for all comparisons). There were no statistically significant differences in nutrient intake by sex within age groups, except among participants age 40–59. Men age 40–59 consumed more energy, carbohydrate and protein than women (Table 1) and more phosphorous and zinc (Table 2) ($P < 0.01$).

Among both men and women, the median intakes of vitamin A, vitamin E, vitamin B-6, folate, calcium and magnesium were below the RDA in all age groups (Table 2). The median vitamin C intake was below the RDA for men and women age 20 and older. Median thiamin intake was below the RDA for men age 60 and older and women under age 60. Median riboflavin intake was below the RDA for men under age 20 and men age 60 and older, and for women over age 20. Median iron intake was below the RDA for all women under age 60.

Intakes relative to the RDA for five nutrients consistently found to be low among the Navajo in the past (vitamin A, vitamin C, folate, calcium and iron) are shown in **Figure 1**. Median intakes of vitamin A among men and among women >20 y were particularly low relative to the RDA, as were intakes of calcium for both sexes and all age groups. The median intake of vitamin C decreased significantly with age among both men and women. Median iron intake was below the RDA for women <60 y.

Food sources of nutrients. Forty-one percent of the energy and 15–46% of the macronutrients in the diets were derived from the following few foods: Navajo tortillas and fry bread, home-fried potatoes, soft drinks, coffee and tea, mutton and mixed dishes containing mutton, and processed meats (bacon, sausage, lunch meats and canned meat products) (**Table 3**). These core foods also accounted for 17% of the Vitamin A, 32% of the vitamin C, 22% of the folate, 24% of the calcium and 30% of the iron consumed (**Table 4**).

Meats, excluding mutton, and grain products, excluding Navajo grains, desserts and snacks, each contributed 15% to the energy intake (Table 3). Meats, excluding mutton, also contributed 29% of protein, 20% of total fat, 20% of saturated fat and 21% of iron intake (Tables 3 and 4). Grains, excluding Navajo grains, desserts and snacks, contributed 15% of carbohydrate, 11% of vitamin A, 19% of folate, 15% of calcium and 23% of iron (Tables 3 and 4). Restaurant and fast-food meals accounted for only 3% of the foods mentioned by participants, but contributed 8% of the energy, 11% of the total fat, 13% of the saturated fat and 11% of the calcium (Tables 3 and 4). Foods of low nutritional value such as soft drinks, desserts and snacks, sugars and candy, and fats and oils counted separately (e.g., spread on bread, dressing on salad) together contributed 15% of energy intake and 11% of total fat intake. Because the category of soft drinks included fortified fruit-flavored beverages, they contributed 19% of the vitamin C and 9% of the calcium consumed.

Fruits and vegetables were each consumed less than once per person per day. Although fruits and vegetables contributed 25% of the fiber in the diets, 34% of the vitamin A, 57% of the vitamin C and 31% of the folate (Tables 3 and 4), their infrequent consumption resulted in low overall intakes of these nutrients (Table 2). Dairy products, rich in calcium, were consumed less than once per person per day. Only 19% of the dairy prodcuts mentioned were identified as lower fat items (skim, 1% or 2% milk, ice milk). Dairy products contributed 26% of the calcium in the diets (Table 4), but infrequent consumption led to low overall intake of calcium. Although juniper or other plant ash used in the preparation of blue corn dishes is a traditional source of calcium in the Navajo diet, it contributed only 1% of the calcium reported on a population basis. For 10 individuals who consumed blue corn dishes with ash, however, ash was a major source of calcium (average 475 mg per person, range 266–1127 mg).

DISCUSSION

Our analysis has several limitations. The first is that saturated fat and cholesterol are likely to be underestimated in this analysis. The FIAS software uses default assumptions if the type of fat is not specified in a food record. In some cases, the interviewers did not record the type of fat used in food preparation. Although many Navajo families use vegetable oils or shortenings consistent with the default assumptions of the software, many others use bacon fat, lard or mutton fat. However, the estimate of the total fat content of the diets should not be affected by this limitation.

Another limitation is that we were not able to separate the components of some mixed dishes and prepared foods to assess their individual contributions to the diet. The nutrient contents of component foods of a recipe were captured in the nutrient intake analysis, but could not be separated in the analysis of food sources of nutrients. This applied chiefly to dairy products and fruits and vegetables that were components of mixed dishes. However, the misclassifications that resulted are likely to be of small magnitude because this happened relatively infrequently, most often with restaurant and fast-food entrees that are coded as a unit rather than as component foods and that accounted for only 3% of the items coded.

Because interviews were conducted primarily on Monday through Friday, very few diet recalls were available for Fridays and Saturdays. Dietary intakes may vary substantially on weekdays compared with weekends in many segments of the U.S. population (Gibson 1990). We found no differences between Sundays and the other days of the week among our participants, but cannot assess possible differences on Fridays or Saturdays. However, many Navajo, particularly those in rural areas, make their living as farmers, herders or artisans and are less likely to be affected by weekday/weekend distinctions in lifestyle than are some other groups. Future dietary surveys among the Navajo should collect data on weekend days as well as weekdays to explore this possible source of dietary variability.

The potential for inaccurate estimates of median intakes of nutrients below the RDA occurred among participants age 12–14 and among those age 51–59 for whom the RDAs are slightly lower than the reference values applied to our age strata. However, if the lower RDA values had been applied to these age strata, median intakes would still be below the RDA, with the exception of niacin among men age 11–14, folate among men and women age 11–14 and iron among women age 40–59.

Our survey indicates that the current diet of the Navajo exceeded the recommended fat content of 30% of energy and saturated fat content of 10% of energy, even with the likely

TABLE 1

Intake of energy and macronutrients by sex and age group among participants in the Navajo Health and Nutrition Survey, 1991–1992

	Men															
	12–19 y $n = 89$				20–39 y $n = 157$				40–59 y $n = 77$				60+ y $n = 67$			
	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th
Energy, *kcal*[1] *	2262 (119)	1213	2172	3056	2127 (65)	1169	1910	3044	2066 (105)	1298	1896†	3112	1650 (135)	775	1572	2566
Carbohydrate, *g***	296 (12)	165	276	399	267 (10)	127	238	416	242 (13)	127	224†	351	205 (16)	102	188	289
% Energy from carbohydrate	52 (1.0)	41	51	63	50 (0.9)	39	48	60	49 (1.1)	33	49	58	51 (1.6)	38	49	63
Protein, *g**	86 (5)	45	85	120	83 (3)	40	71	130	90 (4)	45	87†	137	70 (7)	28	56	115
% Energy from protein*	15 (0.4)	11	14	19	16 (0.4)	11	15	20	18 (0.6)	12	16	23	17 (0.7)	11	16	20
Total fat, *g*	84 (7)	38	73	128	81 (3)	37	72	128	82 (6)	40	77	124	62 (6)	22	54	102
% Energy from total fat	33 (1.0)	24	33	41	34 (0.7)	25	35	44	35 (1.0)	24	35	43	33 (1.2)	22	33	42
Saturated fat, *g**	30 (2)	12	28	45	26 (1)	11	23	43	27 (2)	11	25	42	20 (2)	5	17	36
% Energy from saturated fat	11 (0.4)	7	11	15	11 (0.5)	7	10	15	12 (0.4)	8	11	15	11 (0.7)	6	11	16
Cholesterol, *mg*	388 (38)	109	302	696	388 (20)	86	330	691	403 (31)	107	314	731	298 (32)	37	256	493
Fiber, *g*	14 (1)	6	14	22	15 (1)	4	11	22	14 (1)	6	11	23	14 (1)	4	11	24
	Women															
	12–19 y $n = 73$				20–39 y $n = 225$				40–59 y $n = 163$				60+ y $n = 95$			
	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th
Energy, *kcal*[1] ***	2031 (191)	940	1977	3017	1958 (60)	1330	1825	2749	1708 (90)	964	1556†	2448	1618 (74)	974	1446	2401
Carbohydrate, *g****	274 (28)	118	237	436	236 (8)	151	221	322	206 (9)	112	194†	311	196 (9)	106	189	277
% Energy from carbohydrate**	54 (1.2)	44	55	63	49 (0.6)	39	48	58	49 (0.8)	37	48	60	49 (1.4)	35	49	61
Protein, *g*	75 (7)	35	68	111	78 (3)	46	71	107	73 (4)	32	65†	108	70 (3)	36	67	99
% Energy from protein	15 (0.9)	10	15	21	16 (0.4)	11	16	21	17 (0.4)	11	16	22	18 (0.6)	12	17	24
Total fat, *g**	73 (7)	30	65	115	79 (3)	41	71	112	67 (5)	31	61	101	62 (4)	27	56	97
% Energy from total fat*	31 (1.2)	20	31	41	35 (0.6)	26	35	44	34 (0.8)	24	34	42	33 (1.1)	22	34	42
Saturated fat, *g***	25 (3)	8	21	43	26 (1)	13	24	39	22 (2)	9	19	41	21 (2)	8	17	34
% Energy from saturated fat	11 (0.5)	5	10	15	11 (0.2)	8	12	16	12 (0.3)	7	11	14	11 (0.5)	7	10	14
Cholesterol, *mg*	316 (52)	99	233	605	334 (15)	107	265	582	320 (27)	79	266	507	291 (29)	72	203	535
Fiber, *g*	17 (2)	6	14	30	14 (1)	6	12	21	13 (1)	5	11	21	14 (1)	5	11	21

[1] 1 kcal = 4.18 kJ.
* Age group differences $P \leq 0.01$.
** Age group differences $P \leq 0.001$.
*** Age group differences $P \leq 0.0001$.
† Sex difference $P \leq 0.01$.

TABLE 2

Intake of micronutrients by sex and age group among participants in the Navajo Health and Nutrition Survey, 1991–1992

	Men															
	12–19 y *n* = 89				20–39 y *n* = 157				40–59 y *n* = 77				60+ y *n* = 67			
	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th
Vitamin A, *μg RE*[1]	650 (80)	134	436§	1179	763 (84)	68	405§	1288	707 (243)	46	254§	762§	525 (81)	29	292§	995§
β-Carotene, *μg RE*	271 (64)	16	94	442	383 (65)	12	77	548	266 (67)	6	41	456	283 (70)	1	43	733
Vitamin E, *μg α*-TE[2]*	6.5 (0.6)	2.4	5.7§	9.0§	8.7 (1.2)	2.1	5.2§	11.3	6.1 (0.5)	1.3	5.0§	10.0	6.0 (1.2)	0.1	4.0§	7.2§
Vitamin C, *mg**	174 (33)	20	71	306	113 (14)	13	47§	194	98 (18)	10	34§	186	67 (11)	7	29§	137
Thiamin, *mg*	1.8 (0.1)	0.9	1.5	2.6	1.9 (0.1)	0.7	1.8	2.9	1.8 (0.1)	0.9	1.9	2.7	1.6 (0.1)	0.2	0.9§	2.0
Riboflavin, *mg*	1.9 (0.1)	0.8	1.6§	2.9	1.9 (0.1)	0.8	1.8	2.6	1.7 (0.1)	0.3	1.9	2.0	1.5 (0.1)	0.2	1.0§	2.0
Niacin, *mg NE*[3]	22 (2)	11	19§	33	25 (1)	11	21	38	27 (1)	16	24	36	23 (2)	10	19	34
Vitamin B-6, *mg*	1.5 (0.1)	0.9	1.0§	1.9	1.6 (0.1)	0.8	1.0§	2.0	1.5 (0.1)	0.8	1.0§	1.9	1.4 (0.2)	—	0.8§	2.0
Folate, *μg*	231 (28)	99	174§	393	250 (18)	75	172§	434	192 (19)	77	137§	326	169 (17)	51	125§	258
Vitamin B-12, *μg*	4.4 (0.4)	0.7	3.5	6.9	4.7 (0.6)	0.9	3.0	7.1	6.6 (2.3)	1.0	3.0	7.9	3.7 (0.4)	0.2	2.4	6.6
Calcium, *mg**	876 (157)	201	587§	1301	560 (33)	194	438§	918§	447 (37)	174	345§	713§	402 (33)	119	311§	655§
Magnesium, *mg*	241 (13)	133	227§	323§	258 (10)	113	228§	385	255 (12)	151	235§	356	228 (20)	94	200§	373
Phosphorous, *mg*	1369 (92)	666	1317	1875	1174 (39)	588	1070§	1787	1123 (54)	606	1100†	1562	908 (75)	352	822	1507
Iron, *mg*	15 (1)	6	14	21	16 (1)	6	13	22	16 (1)	9	15	21	14 (1)	6	13	19
Sodium, *mg*	2673 (241)	1527	3298	6057	3544 (135)	1555	3151	5577	3542 (234)	1804	3396	5282	2945 (285)	1244	2529	4685
Zinc, *mg*	12 (1)	6	11§	18	12 (1)	5	10§	20	13 (1)	6	11§†	19	11 (1)	3	9§	16
	Women															
	12–19 y *n* = 73				20–39 y *n* = 225				40–59 y *n* = 163				60+ y *n* = 95			
	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th	Mean (SEM)	15th	50th	85th
Vitamin A, *μg RE**	751 (87)	155	588§	1379	661 (64)	139	406§	1122	686 (102)	114	330§	1055	437 (60)	43	280§	888
β Carotene, *μgRE**	460 (56)	23	245	864	341 (52)	19	109	585	452 (92)	11	94	837	237 (43)	5	55	538
Vitamin E, *μg α-TE**	6.1 (0.8)	1.8	4.3§	10.0	7.1 (0.8)	2.5	5.0§	8.9	5.2 (0.4)	2.2	3.8§	7.8§	4.6 (0.4)	1.2	3.4§	6.9§
Vitamin C, *mg****	166 (38)	20	88	259	95 (10)	14	56§	176	85 (8)	12	40§	173	65 (8)	10	29§	158
Thiamin, *mg*	1.6 (0.1)	0.9	1.0§	2.2	1.6 (0.3)	0.9	1.0§	2.0	1.5 (0.1)	0.9	1.0§	2.0	1.6 (0.1)	0.9	1.8	2.0
Riboflavin, *mg*	1.7 (0.2)	0.7	1.8	2.4	1.6 (0.1)	0.8	1.0§	2.0	1.5 (0.1)	0.9	1.0§	2.0	1.5 (0.1)	0.9	1.0§	2.0
Niacin, *mg NE*	21 (1)	9	19	30	22 (1)	12	21	30	22 (1)	11	20	31	21 (1)	11	19	32
Vitamin B-6, *mg*	1.5 (0.1)	0.7	1.0§	2.0	1.4 (0.1)	0.8	1.0§	1.9	1.3 (0.1)	0.6	0.9§	2.0	1.2 (0.1)	0.8	1.0§	1.5§
Folate, *μg**	251 (47)	69	174§	392	220 (15)	91	165§	358	183 (15)	72	136§	284	171 (14)	68	136§	280
Vitamin B-12, *μg*	3.7 (0.5)	0.4	2.9	6.5	4.5 (0.4)	2.0	3.2	6.5	4.3 (0.6)	1.0	2.8	5.6	3.7 (0.3)	0.5	2.9	6.7
Calcium, *mg**	637 (71)	229	544§	1091§	483 (19)	194	372§	774§	378 (22)	167	310§	589§	386 (37)	152	315§	606§
Magnesium, *mg*	239 (27)	98	214§	388	231 (9)	133	208§	316	224 (16)	111	195§	309	219 (9)	131	200§	319
Phosphorous, *mg**	1141 (110)	542	1127§	1801	1084 (32)	664	969§	1503	916 (44)	479	842†	1342	910 (36)	501	844	1282
Iron, *mg*	13 (1)	6	11§	20	14 (1)	8	12§	20	14 (1)	7	12§	19	14 (1)	7	13	20
Sodium, *mg*	3449 (449)	1346	2826	5162	3268 (113)	1854	2831	4638	3072 (211)	1370	2725	4614	2938 (155)	1538	2546	4449
Zinc, *mg*	10 (1)	4	9§	16	12 (1)	6	10§	15	10 (1)	4	9§†	15	10 (1)	4	8§	15

* Age group differences $P \leq 0.01$.
** Age group differences $P \leq 0.001$.
*** Age group differences $P \leq 0.0001$.
† Sex difference $P \leq 0.01$.
§ Below sex- and age-specific Dietary Allowances. RDA 15–18 y used for participants 12–19 y old; RDA 25–50 y used for participants 20–59 y old; RDA for 51+ y used for participants 60+ y old (NRC 1989b).
[1] RE, retinol equivalent.
[2] *α*-TE, *α*-tocopherol equivalent.
[3] NE, niacin equivalent.

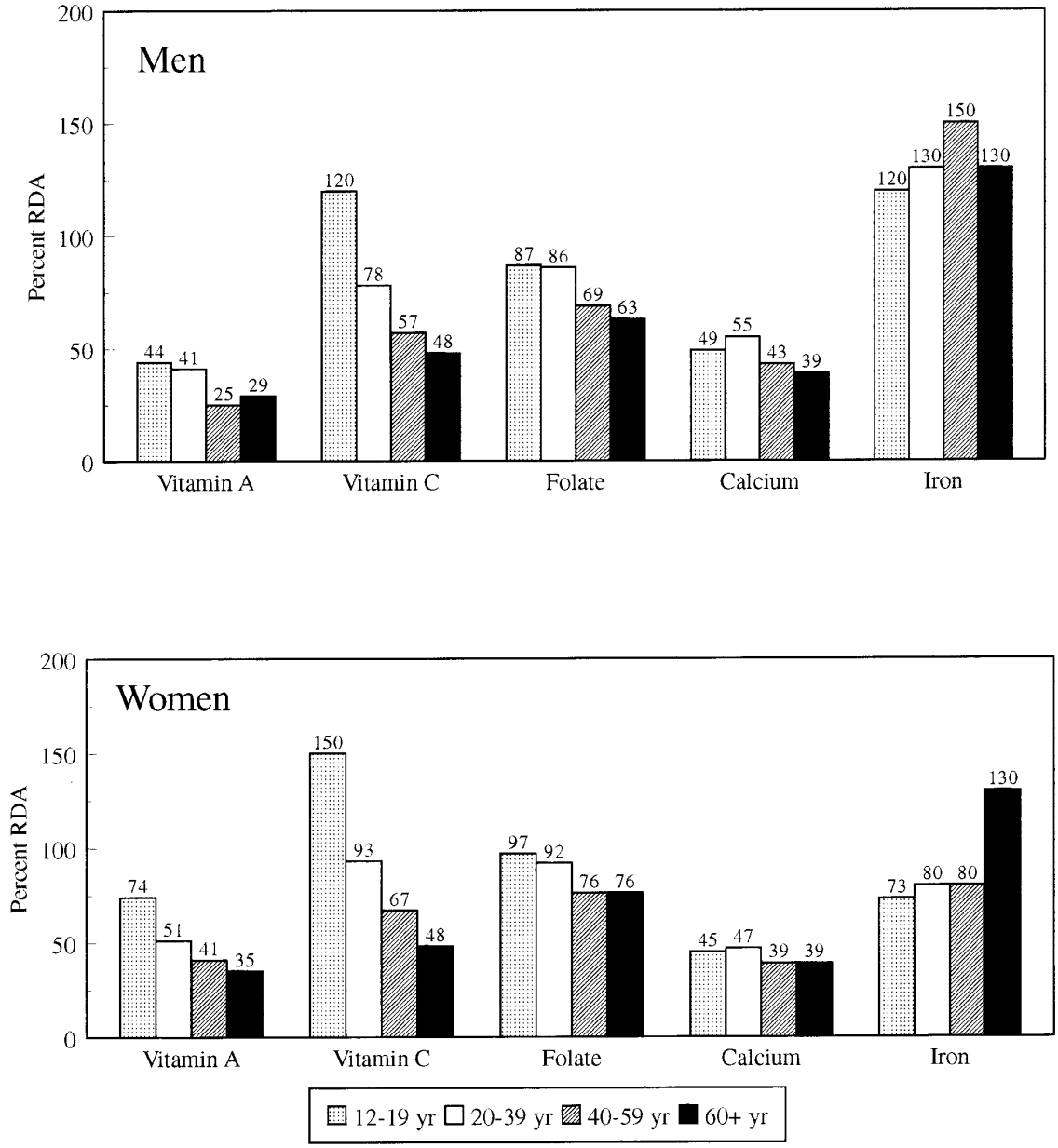

FIGURE 1 Median Intake of selected micronutrients by participants in the Navajo Health and Nutrition Survey, 1991–1992, expressed as percentage of sex- and age-specific recommended dietary allowance (RDA) (National Research Council 1989b).

underestimate of saturated fat (National Research Council 1989a). Although median cholesterol intakes were consistently less than the recommended 300 mg/d, cholesterol intakes may have been underestimated in this analysis, as was saturated fat.

Some segments of the Navajo population continue to be at risk of inadequate intakes of several key nutrients, including those that have been found to be inadequate among the Navajo in the recent past, namely, vitamin A, vitamin C, folate, calcium and iron (Butte et al. 1981, Sandstead et al. 1956, Stockell et al. 1956, University of Pittsburgh 1969). Although intakes of vitamin C among teenagers and of iron among women of reproductive age appear to be higher than they once were (Butte et al. 1981, University of Pittsburgh 1969), intake of vitamin C is still inadequate among most Navajo and intake of iron is inadequate among women under age 60. Participants age 60 and older in our sample had diets particularly low in vitamin A, vitamin C, folate and calcium. The elderly may eat different foods than younger adults because they consume less total energy, but their diets are denser in protein, fat, iron and some other nutrients, although less dense in vitamin C and calcium. This is consistent with the observations of IHS dietitians that many elderly Navajo report diets of limited variety.

There are many ways to enhance the intakes of key nutrients, but dietary interventions must be feasible and consistent with existing food preferences. Three major limitations affect dietary choice among the Navajo: cost, availability and shelf life. Most Navajo families have limited cash resources and purchase food on the Reservation where selection is limited (Ford and Harris 1988). Many families shop infrequently and do not have refrigeration; thus perishable items must be consumed quickly. Because

TABLE 3

Food sources of macronutrients among participants in the Navajo Health and Nutrition Survey, 1991–1992

	% Contribution						
	Energy	Carbohydrate	Protein	Total fat	Saturated fat	Cholesterol	Fiber
Navajo tortillas	8	13	7	1	0	0	7
Navajo fry bread	6	7	2	8	6	0	7
Fried potatoes	9	8	3	9	8	2	14
Soft drinks[1]	7	15	0	0	0	0	0
Coffee, tea and herb tea[2]	2	1	0	0	0	0	0
Mutton[3]	2	0	3	4	5	4	0
Mixed dishes with mutton	4	2	7	6	8	5	6
Processed meat[4]	3	0	5	7	9	4	0
Subtotal	41	46	27	35	36	15	34
Other meat, poultry, and fish[3]							
Beef, pork and venison[3]	6	0	14	10	11	11	0
Mixed meat dishes	3	1	5	3	3	4	2
Chicken and turkey[3]	4	0	8	6	5	5	0
Mixed poultry dishes	1	1	1	1	1	2	1
Fish and seafood	1	0	1	0	0	1	0
Subtotal	15	2	29	20	20	23	3
Other grains[5]	15	17	15	7	7	2	16
Restaurant and fast-food entrees	8	6	10	11	13	6	6
Fruits and vegetables[6]	6	13	4	2	0	0	25
Desserts and snacks[7]	5	6	1	7	2	1	7
Dairy	4	3	5	5	12	4	0
Eggs	3	0	6	7	6	44	0
Legumes	2	2	3	2	2	1	9
Total	99†	95‡	100	96†	98†	96†	100

[1] Includes fortified, fruit-flavored drinks <100% juice.
[2] Includes milk and sugar in coffee and tea.
[3] Includes organ meats.
[4] Includes canned and processed meat, sausage and bacon.
[5] Excludes Navajo grain dishes and grain-based desserts and snacks.
[6] Excludes home-fried potatoes.
[7] Includes pies, cakes, cookies, chips and popcorn; excludes dairy desserts and candy.
† Fats, oils, spreads and dressings accounted for the remainder.
‡ Sugar, syrup and candy accounted for the remainder.

fortified ready-to-eat cereals supply many nutrients, require no refrigeration, and have a long shelf-life, they could be a valuable addition to Navajo diets. Cereals were reported very infrequently in this survey, perhaps because they are relatively expensive. Fruits and vegetables are also dense sources of many micronutrients but they were consumed, on the average, less than twice a day. Although some kinds of fresh fruits and vegetables are available and affordable on the Reservation, many fresh produce items may be unavailable, very expensive or too perishable for families who shop infrequently and lack refrigerators. Canned fruits and vegetables are available and adaptable to Reservation shopping and storage patterns.

Dairy products are not widely consumed among the Navajo, in part because lactose intolerance is common and in part because dairy products are perishable. The survey participants reported using canned and powdered milk more frequently than fresh milk. A few participants reported preparing Navajo tortillas and fry bread with nonfat dry milk, thus increasing the calcium content from 40 to 144 mg per tortilla, but even this use of milk may be problematic for those who are lactose intolerant. Traditional blue corn meal foods with ash provided substantial amounts of calcium for the few participants who ate them. In spite of the low reported calcium intakes of the participants, IHS diagnoses of hip fracture and other sequelae of osteoporosis are rare (Indian Health Service unpublished data for Navajo Area, 1992–1994).

The median folate intake among Navajo women was consistently below the current RDA, and the median folate intake of Navajo women under age 40 was less than half of the most recent recommendation by the U.S. Public Health Service (1992) that women of reproductive age who are capable of becoming pregnant consume 400 μg folic acid/d to reduce the risk of neural tube birth defects. The low folate intake among Navajo women of reproductive age is of special concern because of the Navajo's high average fertility (Navajo Nation 1993) and the relatively high prevalence of neural tube defects among Native American populations (Wilcox and Marks 1994). Folate intake could be increased by greater consumption of fortified ready-to-eat cereals, oranges and orange juice. Canned and boxed juices with extended shelf-life could be adaptable to the shopping and consumption patterns of the Reservation. These beverages contain more nutrients than soft drinks, which contribute calories but few nutrients to the diet.

Until about the middle of the twentieth century, the Navajo lived an active lifestyle and ate a wide variety of gathered and cultivated foods in addition to the staple mutton. An increasingly sedentary lifestyle and erosion of

TABLE 4

Food sources of selected micronutrients among participants in the Navajo Health and Nutrition Survey, 1991–1992

	% Contribution				
	Vitamin A	Vitamin C	Folate	Calcium	Iron
Navajo tortillas	0	0	4	4	13
Navajo fry bread	0	0	2	4	7
Fried potatoes	1	10	5	4	3
Soft drinks[1]	3	19	4	9	0
Coffee, tea and herb tea[2]	0	0	2	1	0
Mutton[3]	8	0	2	1	2
Mixed dishes with mutton	3	1	3	1	4
Processed meat[4]	2	2	0	0	1
Subtotal	17	32	22	24	30
Other meat, poultry and fish[3]					
Beef, pork and venison[3]	4	0	2	2	8
Mixed dishes with beef, pork, or venison	4	2	2	1	7
Chicken and turkey[3]	2	0	1	1	5
Mixed dishes with chicken or turkey	1	0	0	0	1
Fish and seafood	0	0	0	0	0
Subtotal	11	2	5	4	21
Other grains[5]	11	3	19	15	23
Restaurant and fast-food entrees	4	3	7	11	8
Fruits and vegetables[6]	34	57	31	8	7
Desserts and snacks[7]	1	1	1	5	3
Dairy	8	2	2	26	0
Eggs	11	0	6	4	4
Legumes	0	0	7	3	4
Total	97†	100	100	100	100

[1] Includes fortified, fruit-flavored drinks <100% juice.
[2] Includes milk and sugar in coffee and tea.
[3] Includes organ meats.
[4] Includes canned and processed meat, sausage and bacon.
[5] Excludes Navajo grain dishes and grain-based desserts and snacks.
[6] Excludes home-fried potatoes.
[7] Includes pies, cakes, cookies, chips and popcorn; excludes dairy desserts and candy.
† Fats, oils, spreads and dressings accounted for the remainder.

traditional dietary patterns, with increasing dependence on relatively few refined, processed and nutrient-poor foods may be major factors in the increases in obesity and chronic diseases documented among the Navajo in the past half century. Diet is an important behavioral risk factor for all chronic diseases and is susceptible to intervention within the limits of the resources available to a population.

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