VALIDATION OF A DIETARY HISTORY QUESTIONNAIRE FOR AMERICAN INDIAN AND ALASKA NATIVE PEOPLE

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Objective: We assessed reliability and relative validity of a self-administered computer-assisted dietary history questionnaire (DHQ) for use in a prospective study of diet, lifestyle, and chronic disease in American Indians in the Dakotas and Southwestern US and Alaska Native people.

Design: Reliability was assessed by one-month test-retest of the dietary history questionnaire. Validity was assessed by comparison of the weighted average of up to 12 monthly 24-hour recalls collected prospectively and a dietary history questionnaire completed in the 13th month.

Participants: Participants were recruited at the baseline visit of the Education and Research Toward Health Study in Alaska, the Northern Plains and the Dakotas.

Results: Reliability (Pearson correlation) of the DHQ ranged from $r = 0.43$ for vitamin A density to $r=0.90$ for energy intake. The association of nutrient and food estimates assessed by 24-hour recalls and the DHQ completed at the end of the year reflected no bias towards recent intake. Macronutrients expressed as density (nutrients per 1000 calories) did appear to be valid (r 0.50-0.71) as did several micronutrients (range $r=.22$ to 0.59), fiber ($r=0.51$), and servings of red meat (r=0.67). However, the DHQ overestimated intake and gross amounts of nutrients were not strongly associated with the weighted average of the 24-hour recalls.

Conclusions: The DHQ developed for estimation of dietary intake in American Indians and Native people in Alaska is reliable. Estimates of nutrient density appeared to have acceptable relative validity for use in epidemiologic studies. (*Ethn Dis.*2010;20:429–436)

Key Words: Dietary Intake, American Indians, Alaska Natives, Diet Measurement

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INTRODUCTION

Rates of chronic diseases vary substantially among American Indian and Native people in Alaskan (AIAN) communities and between AIAN and other ethnic groups for reasons that are largely unknown.[1] While some of the variation in disease rates may have a genetic basis, it is likely that variations in dietary intake, physical activity patterns, and other lifestyle characteristics contribute to these differences. More than a dozen studies have collected some dietary intake information in AIAN with most using one or more 24-hour recalls to estimate intake.[2–9] These studies consistently report dietary intakes that are likely to be associated with the development of chronic disease. High intake of dietary and saturated fat has been consistently reported in studies of AIAN since the 1960s.[2–6,10] Additionally, these studies show low intakes of fiber,[8,9] vitamin C,[8,11] calcium,[9] folate,[9,11] vitamin A,[11] and iron.[8] On the other hand, one of these studies suggested that the reported dietary intake of American Indians was similar to the median reported from National Health and Examination Survey III (NHANES III) and therefore not consistent with the higher prevalence of coronary vascular disease documented in their population compared to the United States population in general.[11] Further understanding of the association of dietary intake with chronic disease in AIAN is warranted. Although 24-hour recalls are the gold standard for small studies, their use is cost and time prohibitive in large epidemiologic studies. Therefore, development of an appropriate questionnaire to examine dietary intake in epidemiologic studies of AIAN was needed.

The Education and Research Towards Health (EARTH) Study was funded by the National Cancer Institute to determine how diet, physical activity, and other lifestyle and cultural factors relate to the development and progression of chronic diseases. We developed regionally appropriate versions of an audio computer-assisted self-interviewing (A-CASI) diet history questionnaire (DHQ) to assess dietary intake over the past year for AIAN populations.[12] In order to assess how well the DHQ estimates dietary intake for AIAN populations, we compared prospective intake measured monthly with a 24-hour recall over a one-year period with intake recalled on the DHQ administered at the end of the year. In this article, we discuss the validity and reliability of the DHQ compared to monthly 24-hour diet recalls over a year in a subset of EARTH study participants.

METHODS

Study Design and Participants.

A prospective study was designed to validate the EARTH DHQ used to

Table 1. Validation study design and schedule of study measures

	Month												
Measure	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Baseline EARTH study visit	x*												
Computer-assisted Diet History Questionnaire	x	x											x
24-hour recall		x	x	x	x	x	x	x	x	x	x	x	x

* Indicates a measure at this time point.

measure dietary intake recalled over the past year (Table 1). Participants for the dietary intake validation study were recruited from each field center as they presented for their EARTH study visit.[13] Individuals were eligible if they: were between aged 25 and 60 years; had a telephone or were reachable at a single telephone number on most days; spoke and understood English; were able to complete the A-CASI form of the DHQ; and were not planning to make major changes to their diet or move in the next year. One hundred twenty-four participants from Alaska, the southwest United States, and the Plains States completed at least one component (reliability or validity) of the study. Eighty-three participants who completed any 24-hour recall also completed and returned at least eight 24-hour recall interviews; three participants returned fewer than eight recalls. Eighty-seven participated in the test-retest reliability component of the study.

EARTH DHQ

The development of the EARTH DHQ has been previously described.[12] Briefly, the A-CASI DHQ included traditional foods and other foods typically consumed by AIAN. Participants first responded to whether they consumed foods in a broad food category (eg, cheese). When the response indicated 12 or more times per year, the individual chose specific types of cheeses (regular cheese, processed cheese, and cottage cheese) they consumed and answered further questions regarding the typical frequency and portion (3 sizes shown in pictures) consumed. If the answer was no or less than 12 or more times per year, the skip pattern went directly to the next food category. The questionnaires for Alaska and Plains/Navajo were customized to query regionally consumed foods including, but not limited to: agutaq, bird eggs, caribou, moose, musk ox, and reindeer for Alaska, and wojapi, chil'chin, Indian or Navajo Tacos, and blue corn breads and cereals for Plains/Navajo.

The A-CASI EARTH DHQ was administered up to three times. A subset of participants repeated the EARTH DHQ after one month of initial EARTH study enrollment to establish reliability. Another subset of participants completed 24-hour diet recalls for 12 months, prospectively, for comparison with a DHQ completed at the end of the 12 months to establish validity.

Repeated Telephoned 24-Hour Recalls

Twenty-four hour diet recalls were collected from participants monthly for 12 months. The 24-hour recalls were conducted by a trained interviewer who recorded the information using the multiple pass technique.[14,15] The recall process took 20–40 minutes to complete.

The first 24-hour recall was administered in person with two-dimensional portion size aids provided to each participant for use during the interview. Subsequent recalls were conducted by telephone. If the participant was not home a brief message was left with a number for the participant to return the call. If the individual was unavailable or unwilling to participate that day, the interviewer called again based on established protocol. At the end of the 12 months of 24-hour diet recall collection, the A-CASI DHQ was repeated.

Dietary recalls were conducted on randomly selected days so that participants would not change their intake on scheduled days. Random day selection for the 24-hour recall for each month was based on blocks of possible combinations of the days of the week. They were permuted to 12 days so that they corresponded to month and included both week day and weekend days. Blocks with three weekend days within three months in succession were rejected and new blocks selected to achieve a balance of weekday and weekend days.

Interviewer Training

Centralized training was conducted with all interviewers to standardize probes used for food. After the interviewers were trained, they submitted practice interviews on audiotape. These were reviewed for quality control. Once the accuracy was 95% or better, the interviewer was certified to conduct 24-hour recalls with participants. Dietary interviews were audiotaped with permission of the participants and sent to the coordinating center.

Data Entry

Data were collected in the three field centers. Data were copied at the field center and mailed to the coordinating center on a weekly basis. Two coders at the coordinating center coded the data using the Nutrition Data System for

Research (NDS-R Database ©, Regents of the University of Minnesota). Both coders were trained by the principal investigator. Local dietitians assisted in determining recipes or food codes to be utilized for ethnic foods. Duplicate entry of recalls was compared until the macronutrients were within 90% of each other. Questions regarding coding were clarified using the audiotapes or directed to the interviewer.

Quality Assurance

Ongoing quality assurance of the 24-hour dietary recalls was conducted by reviewing audiotapes of the recorded 24-hour recalls. The 24-hour recalls were assessed for missing foods, missed probes for brand, preparation method or additions to foods, and whether the interviewer continued reviewing foods listed until the participant had no further corrections. Results of quality assurance checks were reviewed with the interviewer on a monthly basis.

Statistics

Statistical analyses were conducted using SAS®, version 9.13 (SAS Institute Inc, Cary, NC). A subset of macronutrient, micronutrient and food intake variables were chosen for presentation based on relevance to cancer because the initial grant objective was to be able to assess long-term cancer risk. Descriptive statistics (eg, mean, frequency) were used to characterize the study participants. Tertiles were used for categorical analysis. Pearson and Spearman correlations statistic were used to assess reliability (test-retest) of the DHQ.

Generalized estimating equations[16] were used to evaluate the probability of missing 24-hour dietary recalls within a calendar month or season. There were more missing data between April and September than October through March. Therefore, to assure that approximately equal weight was given to each season, we constructed the averaged food and nutrient intakes over the year by first computing separate averages of the 24-hour recalls for the longer-daylight (April through September) and shorter daylight (October through March) periods. We then averaged the results between these 2 periods. The resulting weighted average was used as the reference standard for evaluating validity of the DHQ.

We assessed the influence of day of the week, season, time in study, sex, age, marital status, education and BMI on the dietary intake reported on the 24-hour recalls using a mixed effects model under the assumption of a compound symmetry error structure to account for repeated measurements in the same individuals. The validity of the EARTH DHQ relative to the 24-hour recalls was assessed using adjusted and unadjusted Pearson *r* relating the DHQ variables to corresponding variables based on the one-year weighted averages from the 24-hr recalls. Finally, multiple linear regression analysis was used to determine if bias in the DHQ relative to the averaged 24-hour recalls was related to day of the month or season of administration of the DHQ.

The following summary statistics were used to characterize associations of the DHQ estimates at different time points: 1) Pearson's *r* to assess the association of the linear associations of continuous estimates of food (servings/day) and nutrient density (grams/1000 kcal) variables; and 2) Spearman correlation to assess the nonparametric association using the continuous measurements. The Pearson's *r* was used to assess the agreement between the estimates from the EARTH DHQ and the repeated 24-hour recalls. Additionally, a corrected Pearson *r*[17] was computed to take into account the attenuation in the Pearson *r* that would be expected to occur because the 24-hour recall intake was based on 12 daily assessments rather than all 365 days of the year evaluated by the EARTH DHQ food and nutrient intakes. Systematic bias between DHQ and weighted averages of the diet recalls was evaluated by performing paired *t* tests.

Table 2. Participant characteristics

	Total		Alaska		Plains/Navajo		
	N=124	%	*N*=54	%	*N*=70	%	*P**
Age (years)							
<35	35	28.2	17	31.5	18	25.7	
35–49	61	49.2	31	57.4	30	42.9	
>49	28	22.6	6	11.1	22	31.4	.03
Sex							
Male	30	24.2	9	16.7	21	30.0	
Female	94	75.8	45	83.3	49	70.0	.09
Marital status							
Single	45	36.3	22	40.7	23	32.9	
Married	79	63.7	32	59.3	47	67.1	.37
Education							
< High school	12	9.7	3	5.6	9	12.9	
High school only	31	25.0	17	31.5	14	20.0	
College or above	81	65.3	34	63.0	47	67.1	.19
BMI							
<25	17	13.7	9	16.7	8	11.4	
25–29.9	37	29.8	16	29.6	21	30.00	
30+	70	56. 5	29	53.7	41	58.6	.69

* *P* value for difference between Alaska and Plains/Navajo.

RESULTS

The majority of participants in this study were female, between 35 and

49 years of age, married, and had at least some post high school education (Table 2). Approximately one third were overweight (BMI 25–29.9) and more than half were obese (BMI $\geq$ 30). Participants from Alaska tended to be younger than the Plains/Navajo participants; other characteristics were similar across these geographical regions. There were no significant differences in these characteristics between Alaska and Plains/Navajo participants.

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In general, agreement (reliability) of the DHQ after repeated administration was greater when assessing the linear association using (Pearson correlation) than nonparametric (Spearman correlation, Table 3). The association was greatest for calories and carbohydrates, and lowest for vitamin A density. Agreement was also high for daily servings of foods from selected food groups (red meat, fruits and vegetables). Although comparison of the means of the gross intake of nutrients indicated a significant difference (eg, mean $\pm$ SE difference 51.2 $\pm$ 18.4, P=.007), there was no difference in the estimates of the macronutrient density variables (eg, protein/1000 kcal, mean difference $\pm$ SE $-.31 \pm 0.77$ g/1000 kcal, P=.69; -1.94 ± 2.22 g carbohydrate/1000 kcal, P=.38; 1.57 $\pm$ 0.83 g fat/1000 kcal P=.06). Results for other nutrients (vitamin A, vitamin D, fiber, and calcium) followed the same pattern, eg, differences for gross daily intake, but no significant difference in energy adjusted intakes.

We examined the association of dietary recalls in three month quarters with the A-CASI DHQ to assess whether the questionnaire was more strongly associated with more recent intake than with long-term intake (Table 4). Correlations were not systematically different in the most recent months compared to other three month quarters. We assessed difference by season and found no differences in macronutrient, micronutrient or food intake across season when season was defined as winter, spring, summer and fall or as two seasons, October through March and April through September (data not shown).

The validity of the DHQ administered at the end of the year-long prospective data collection was assessed against the weighted mean of the 24-hour dietary recalls using Pearson's correlation with and without adjustment. Although the validity of the gross levels of energy and other macronutrients was poor, macronutrient density variables were valid, particularly carbohydrate and fat density. The adjusted correlation of micronutrients ranged from 0.22 for vitamin E density to 0.59 for calcium density. Correlations for servings per day of red meat was r =0.67, for fruits was r = 0.32 and for vegetables r = 0.22.

DISCUSSION

Dietary intake is a difficult exposure to measure accurately regardless of whether the period of intake is one day, a few days, a week or a year.

Table 3. Test-retest reliability of the EARTH dietary history questionnaire at the EARTH baseline visit and one month later (*N*=87)

	Baseline		One month		Pearson correlation	Spearman correlation
	Mean	SD*	Mean	SD		
Energy intake	3891.5	3788.5	2896.7	2240.7	0.90	0.78
Carbohydrate g/d†	451.5	392.8	342.4	305.9	0.92	0.76
Carbohydrate density‡	120.7	28.1	118.1	24.3	0.72	0.71
Protein g/d	159.9	168.0	116.4	77.9	0.87	0.78
Protein density‡	40.9	8.8	41.9	8.0	0.66	0.59
Fat g/d	157.4	182.4	113.6	87.0	0.82	0.78
Fat density*	38.6	9.6	38.9	8.7	0.71	0.70
Sucrose density‡	17.2	8.6	16.5	7.7	0.54	0.54
Vitamin A density‡	3882.1	3763.5	3676.2	2021.7	0.43	0.53
Vitamin E density‡	4.4	1.4	4.3	1.3	0.75	0.70
Vitamin D density‡	3.8	3.3	3.7	3.1	0.73	0.63
Calcium density‡	389.1	152.9	401.2	159.3	0.66	0.65
Fiber density‡	9.4	3.4	9.2	3.2	0.69	0.77
Red meat (servings/d)	1.6	2.0	1.3	1.1	0.86	0.82
Fruits (servings/day)	1.8	2.1	1.4	2.3	0.75	0.66
Vegetables (servings/day)	4.9	6.8	3.2	2.9	0.85	0.44

* SD= standard deviation.
† g/d= grams per day.
‡ Density variables are nutrient per 1000 kcal.

Table 4. Association of EARTH Diet History Questionnaire with the 24-hour dietary recalls in each quarter of the year (*N*=83)

	1st quarter Pearson *r*	2nd quarter Pearson *r*	3rd quarter Pearson *r*	last quarter Pearson *r*
Calories	0.09	0.06	−0.02	0.10
Carbohydrate (g/d) *	0.09	−0.02	−0.04	0.08
Carbohydrate density†	0.49	0.39	0.49	0.44
Protein (g/d)	0.23	0.18	0.18	0.16
Protein density†	0.44	0.38	0.29	0.17
Fat (g/d)	0.15	0.13	0.05	0.22
Fat density†	0.38	0.32	0.40	0.49
Sucrose density†	0.45	0.12	0.29	0.11
Vitamin A density†	0.12	0.32	0.27	0.04
Vitamin E density†	0.20	0.14	0.09	0.18
Vitamin D density†	0.24	0.32	0.02	0.13
Calcium density†	0.43	0.51	0.27	0.56
Fiber density†	0.24	0.30	0.26	0.32
Red Meat (servings/d)	0.60	0.31	0.55	0.30
Fruits (servings/d)	0.43	0.17	0.25	0.01
Vegetables (servings/d)	0.11	0.10	0.20	0.07

* grams per day.
† Density variables are nutrient per 1000 kcal.

Estimates of gross intake and energy adjusted intakes of micro- and macronutrient intakes using the EARTH DHQ were reliable after one month. The questionnaire appeared to capture intake over the year with no apparent bias toward recent intake. However, the EARTH DHQ overestimated daily intake as compared to the estimates from repeated 24-hour recalls. Assessment of nutrients expressed per 1000 calories eliminated differences between the estimates from the two methods suggesting that the EARTH DHQ should be used for measuring energy density rather than gross intake for most

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Table 5. Association of the weighted average of 24-hour recalls with the EARTH Dietary History Questionnaire (*N*=83)

	EARTH DHQ*		24-Hour Recalls*		Pearson Correlation‡	Adjusted Pearson Correlation
	Mean	SD†	Mean	SD		
Calories	2853.0	1682.2	2125.5	676.9	0.08	0.09
Carbohydrate (g/d)	351.5	236.3	247.2	79.7	0.03	0.03
Carbohydrate density§	123.0	26.4	119.2	15.7	0.60	0.71
Protein (g/d)	113.9	73.8	80.3	27.5	0.27	0.30
Protein density	40.4	9.3	38.7	7.7	0.43	0.50
Fat (g/d)	107.8	70.4	90.9	36.4	0.18	0.21
Fat density	37.8	9.0	41.3	5.2	0.57	0.74
Sucrose density	18.8	9.3	22.8	8.0	0.35	0.41
Vitamin A density	3620.7	2408.2	3311.6	1848.0	0.30	0.41
Vitamin E density	4.2	1.2	5.5	3.1	0.20	0.22
Vitamin D density	3.1	2.3	3.9	3.5	0.24	0.28
Calcium density	378.4	133.6	354.7	123.8	0.53	0.59
Fiber density	9.9	3.8	7.7	1.9	0.40	0.51
Red meat (servings/d)	1.4	2.0	1.1	0.8	0.61	0.67
Fruits (servings/d)	1.9	2.7	0.6	0.5	0.30	0.32
Vegetables (servings/d)	3.4	3.3	2.6	1.0	0.17	0.22

* 24-hour recalls were collected prospectively for 12 months and the DHQ was administered at the end of the 12 months.
† SD = Standard deviation.
‡ Pearson correlation corrected for attenuation resulting from day-to-day variation in 24-hour diet recalls.
§ Density variables are nutrient per 1000 kcal.

nutrients. The range of relative validity (correlations) of macro- and micronutrient density was similar to that reported for dietary nutrient intakes from questionnaires used in epidemiologic studies of other populations.[18–22]

The finding that the DHQ was reliable when repeated after four weeks is reassuring. Others have reported that dietary questionnaires such as the Health Habits and History Questionnaire are reliable for usual past-year nutrient intakes,[23] but several with longer intervals between repeated administration had lower correlation coefficients than the EARTH DHQ.[24,25] The reliability of the Health Habits and History Questionnaire was better than its relative validity.[25] However, reliability and validity of the food frequency questionnaire used in the Shanghai Men's Health Study was similar.[20] Higher reliability than validity could be interpreted as a systematic error in estimating intake using the EARTH DHQ. Our assessment of the A-CASI questionnaires suggests that they were well-accepted and usable by AIAN population surveyed.[26] Although people often know what kinds of foods they eat, estimation of how much and how often may be more difficult to quantify on a self-administered computerized food frequency questionnaire than recall of intake on the previous day as described to an interviewer.

The EARTH DHQ overestimated food and nutrient intakes when compared to the weighted average of repeated 24-hour dietary recalls. Use of the energy density approach is common and it appeared to compensate for the over-reporting. A previous comparison of dietary intake of Pima Indians using only one 24-hour recall and a food frequency questionnaire also reported overestimates of intake with a food frequency questionnaire.[27] Other DHQ and food frequency questionnaires administered to minority populations also demonstrate over-reporting by the respondents[28] and suggest that improvement in frequency of report was most responsible for the poor rank agreement between methods.[29] In our study, the relative extent that the estimated intake using the weighted 24-hour recalls may have underestimated dietary intake and the EARTH DHQ overestimated intake is unclear.

Although the DHQ appeared to overestimate gross intake, estimates were similar for most nutrients when expressed as energy density (per 1000 kilocalories) and rank agreement in intake was acceptable when using nutrient density. The adjusted Pearson correlations using the density approach for most nutrients were within the same range as the de-attenuated correlations observed between diet records and several food frequency questionnaires[18,30–32] or DHQs[33] despite differences in number of 24-hour recalls or records for comparison and different referent periods. Others have reported lower validity for DHQ or food frequency questionnaires among Blacks than Whites.[33] The adjusted Pearson correlations for calorie-adjusted nutrients in that study ranged from 0.10 for total fat to 0.83 for potassium for Black men and −0.22 for protein and 0.59 for calcium for Black women. Calorie-adjusted nutrient intake often differed between the DHQ and the average of seven 24-hour dietary recalls,[33] though it was not clear why.

Retrospective recall bias is always a concern in study design. We were initially interested in seasonal differences and their potential impact on a year-long estimate of dietary intake in addition to the challenge of recalling intake over the prior year. However, we did not detect differences in the association of dietary intake across the two seasons. Others report that the seasonal differences are generally small[34] and /or did not influence categorical classification enough to affect interpretation of most large studies.[35]

Validation of the EARTH DHQ as compared to the reference method of 24-hour dietary recalls is subject to several limitations. The smaller proportion of men who participated in the study does not allow comparison of reliability or validity for men and women separately. The number of participants in each segment of the study was fewer than planned, particularly at the Plains/Navajo site. Men were less likely to participate, which may have been related to the burden of monthly data collection. The educational level of the participants in this sub-study reflects greater educational attainment than in the EARTH study and might, therefore, be a source of bias. However, we did not detect any difference in association based on educational status. All other sub-study participant characteristics including age and BMI were similar to the parent study.[36] Gross intakes were generally not valid. However, the level of validity for nutrient density was similar to the validity demonstrated for other diet questionnaires,[18,33] but low (<.30) for some nutrients such as vitamin E and vitamin D and for servings of vegetables. Therefore, energy density variables will need to be utilized for analysis using many of the dietary variables for the main EARTH study data. In addition, questionnaires from the overall EARTH study participants with improbably low and high reported intakes will need to be carefully considered (eg, omitted or included in sensitivity analysis).

The EARTH DHQ is reliable and valid for use in epidemiologic studies of AIAN people that look at nutrient density but not gross intake. We recommend careful choice of dietary variables used in examining associations of dietary intake and health outcomes or other characteristics in this population. These data provide evidence that an A-CASI DHQ can provide useful information on dietary intake over an extended period without undue influence of seasonal variation. Further inquiry into the dietary patterns of these populations may lead to greater understanding of the diet-related underpinnings of health and health disparities.

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REFERENCES

1. Denny CH, Holtzman D, Cobb N. Surveillance for health behaviors of American Indians and Alaska Natives. Findings from the Behavioral Risk Factor Surveillance System, 1997–2000. *MMWR Surveill Summ*. 2003;52:1–13.
2. Bell RA, Shaw HA, Dignan MB. Dietary intake of Lumbee Indian women in Robeson County, North Carolina. *J Am Diet Assoc*. 1995;95:1426–8.
3. Mayberry RH, Lindeman RD. A survey of chronic disease and diet in Seminole Indians in Oklahoma. *Am J Clini Nutr*. 1963;13:127–34.
4. Nobmann ED, Byers T, Lanier AP, et al. The diet of Alaska Native adults: 1987–1988. *Am J Clin Nutr*. 1992;55:1024–32.
5. Reid JM, Fullmer SD, Pettigrew KD, et al. Nutrient intake of Pima Indian women: relationships to diabetes mellitus and gallbladder disease. *Am J Clin Nutr*. 1971;24:1281–9.
6. Teufel NI, Dufour DL. Patterns of food use and nutrient intake of obese and non-obese Hualapai Indian women of Arizona. *J Am Diet Assoc*. 1990;90:1229–35.
7. Bell RA, Mayer-Davis EJ, Jackson Y, et al. An epidemiologic review of dietary intake studies among American Indians and Alaska Natives: implications for heart disease and cancer risk. *Ann Epidemiol*. 1997;7:229–40.
8. Ballew C, White LL, Strauss KF, et al. Intake of nutrients and food sources of nutrients among the Navajo: findings from the Navajo Health and Nutrition Survey. *J Nutr*. 1997;127:2085S–93S.
9. Nobmann ED, Lanier AP. Dietary intake among Alaska Native women resident of Anchorage, Alaska. *Int J Circumpolar Health*. 2001;60:123–37.
10. Nobmann ED, Ponce R, Mattil C, et al. Dietary intakes vary with age among Eskimo adults of Northwest Alaska in the GOCADAN study, 2000–2003. *J Nutr*. 2005;135:856–62.
11. Stang J, Zephier EM, Story M, et al. Dietary intakes of nutrients thought to modify cardiovascular risk from three groups of American Indians: The Strong Heart Dietary Study, Phase II. *J Am Diet Assoc*. 2005;105:1895–903.
12. Slattery ML, Murtaugh MA, Schumacher MC, et al. Development, implementation, and evaluation of a computerized self-administered diet history questionnaire for use in studies of American Indian and Alaskan native people. *J Am Diet Assoc*. 2008;108:101–9.
13. Slattery M, Schumacher M, Lanier A, et al. A prospective cohort of American Indian and Alaska native people: study design, methods, and implementation. *Am J Epidemiol*. 2007;166:606–15.
14. Feskanich D, Buzzard IM, Welch BT, et al. Comparison of a computerized and a manual method of food coding for nutrient intake studies. *J Am Diet Assoc*. 1988;88:1263–7.
15. Feskanich D, Sielaff BH, Chong K, et al. Computerized collection and analysis of dietary intake information. *Comput Methods Programs Biomed*. 1989;30:47–57.
16. Liang K, Zeger S. Regression analysis for correlated data. *Annual Review of Public Health*. 1993;14:43–68.
17. Levin S, Jacobs DR, Jr., Ainsworth BE, et al. Intra-individual variation and estimates of usual physical activity. *Ann Epidemiol*. 1999;9:481–8.
18. Willett WC. *Nutritional Epidemiology*. New York: Oxford University Press; 1998.
19. Relative validity and reproducibility of a diet history questionnaire in Spain. II. Nutrients. EPIC Group of Spain. European Prospective Investigation into Cancer and Nutrition. *Int J Epidemiol*. 1997;26 Suppl 1:S100–9.
20. Villegas R, Yang G, Liu D, et al. Validity and reproducibility of the food-frequency questionnaire used in the Shanghai men's health study. *Br J Nutr*. 2007;97:993–1000.
21. Hjartaker A, Andersen LF, Lund E. Comparison of diet measures from a food-frequency questionnaire with measures from repeated 24-hour dietary recalls. The Norwegian Women and Cancer Study. *Public Health Nutr*. 2007; 10:1094–103.
22. Murphy NJ, Schraer CD, Thiele MC, et al. Dietary change and obesity associated with glucose intolerance in Alaska Natives. *J Am Diet Assoc*. 1995;95:676–82.
23. Hartman AM, Block G, Chan W, et al. Reproducibility of a self-administered diet history questionnaire administered three times over three different seasons. *Nutr Cancer*. 1996;25:305–15.
24. Parr CL, Veierod MB, Laake P, et al. Test-retest reproducibility of a food frequency questionnaire (FFQ) and estimated effects on disease risk in the Norwegian Women and Cancer Study (NOWAC). *Nutr J*. 2006;5:4.
25. Katsouyanni K, Rimm EB, Gnardellis C, et al. Reproducibility and relative validity of an extensive semi-quantitative food frequency questionnaire using dietary records and biochemical markers among Greek schoolteachers. *Int J Epidemiol*. 1997;26 Suppl 1:S118–27.
26. Edwards SL, Slattery ML, Murtaugh MA, et al. Development and use of touch-screen audio computer-assisted self-interviewing in a study of American Indians. *Am J Epidemiol*. 2007;165:1336–42.
27. Smith CJ, Nelson RG, Hardy SA, et al. Survey of the diet of Pima Indians using quantitative food frequency assessment and 24-hour recall. Diabetic Renal Disease Study. *J Am Diet Assoc*. 1996;96:778–84.
28. Larkin FA, Metzner HL, Thompson FE, et al. Comparison of estimated nutrient intakes by food frequency and dietary records in adults. *J Am Diet Assoc*. 1989;89:215–23.
29. Flegal KM, Larkin FA, Metzner HL, et al. Counting calories: partitioning energy intake estimates from a food frequency questionnaire. *Am J Epidemiol*. 1988;128:749–60.
30. Schroder H, Covas MI, Marrugat J, et al. Use of a three-day estimated food record, a 72-hour recall and a food-frequency questionnaire for dietary assessment in a Mediterranean Spanish population. *Clin Nutr*. 2001;20:429–37.
31. Thompson FE, Kipnis V, Midthune D, et al. Performance of a food-frequency questionnaire in the US NIH-AARP (National Institutes of Health-American Association of Retired Persons) Diet and Health Study. *Public Health Nutr*. 2008;11:183–95.
32. Toft U, Kristoffersen L, Ladelund S, et al. Relative validity of a food frequency questionnaire used in the Inter99 study. *Eur J Clin Nutr*. 2007.

33. Liu K, Slattery M, Jacobs D, Jr., et al. A study of the reliability and comparative validity of the cardia dietary history. *Ethn Dis*. 1994;4:15–27.
34. Ma Y, Olendzki BC, Li W, et al. Seasonal variation in food intake, physical activity, and body weight in a predominantly overweight population. *Eur J Clin Nutr*. 2006;60:519–28.
35. Fowke JH, Schlundt D, Gong Y, et al. Impact of season of food frequency questionnaire administration on dietary reporting. *Ann Epidemiol*. 2004;14:778–85.
36. Slattery ML, Schumacher MC, Lanier AP, et al. A prospective cohort of American Indian and Alaska Native people: study design, methods, and implementation. *Am J Epidemiol*. 2007;166:606–15.

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