Current Research

Poverty and Food Intake in Rural America: Diet Quality Is Lower in Food Insecure Adults in the Mississippi Delta

CATHERINE M. CHAMPAGNE, PhD, RD, FADA; PATRICK H. CASEY, MD; CAROL L. CONNELL, PhD, RD; JANICE E. STUFF, PhD, RD; JEFFREY M. GOSSETT, MS; DAVID W. HARSHA, PhD; BEVERLY McCABE-SELLERS, PhD, RD; JAMES M. ROBBINS, PhD; PIPPA M. SIMPSON, PhD; JUDITH L. WEBER, PhD, RD; MARGARET L. BOGLE, PhD, RD; for the Lower Mississippi Delta Nutrition Intervention Research Initiative

ABSTRACT

Objective To determine if measures of diet quality differ between food insecure and food secure adults in a rural high-risk population.

Design Random digit dialing telephone survey of a cross-section of the population designed to collect data on food intake, household demographics, and food security status.

Setting A representative sample of adults who live in 36 counties in the Lower Mississippi Delta region of Arkansas, Louisiana, and Mississippi.

Subjects One thousand six hundred seven adults, both white and African American.

Main outcome measures Food security status and diet quality, as defined by adherence to the Healthy Eating Index and Dietary Reference Intakes by determinations from self-reported food intake (1 day intake).

Statistical analyses Regression analysis, *t* tests, Wald statistic, and beta tests were employed.

Results Food secure adults scored higher on Healthy Eating Index than food insecure adults (P=0.0001), but the regression model showed no differences when multiple factors were included. Food secure individuals consistently achieved higher percentages of the Dietary Reference Intakes (specifically Estimated Average Requirements and Adequate Intakes) than food insecure individuals, with the greatest differences seen for vitamin A (P<0.0001), copper (P=0.0009), and zinc (P=0.0022) and very little difference for vitamins C (P=0.68) and E (P=0.32). Both populations consumed diets extremely low in fiber.

Conclusions Food insecurity is associated with lower quality diets in this population. It is acknowledged that serious limitations are associated with the use of one 24-hour recall and for comparison between food intake and assessment of food security. These findings still suggest a pressing need for nutrition interventions to improve dietary intake in these at-risk impoverished individuals.

J Am Diet Assoc. 2007;107:1886-1894.

C. M. Champagne is a professor-research and D. W. Harsha is an assistant professor-research, Pennington Biomedical Research Center, Baton Rouge, LA. P. H. Casey is a professor, Department of Pediatrics, J. M. Gossett is a research associate, J. L. Weber is an associate professor, and J. M. Robbins and P. M. Simpson are professors, Arkansas Children's Hospital Research Institute, University of Arkansas for Medical Sciences, Little Rock. C. L. Connell is an assistant professor, Nutrition and Food Systems, College of Health, University of Southern Mississippi, Hattiesburg. J. E. Stuff is an assistant professor, Department of Agriculture/ARS Children's Nutrition Research Center, Department of Pediatrics, Baylor College of Medicine, Houston. B. McCabe-Sellers is a research coordinator and M. L. Bogle is executive director, Delta Nutrition Intervention Research Initiative, US Department of Agriculture, Agricultural Research Service, Little Rock, AR.

Address correspondence to: Catherine M. Champagne, PhD, RD, FADA, Professor-Research, Pennington Biomedical Research Center, 6400 Perkins Rd, Baton Rouge, LA 70808-4124. E-mail: Champacm@pbrc.edu

0002-8223/07/10711-0013$32.00/0
doi: 10.1016/j.jada.2007.08.003

Previous studies have described such immediate consequences of household food insecurity as irregular household food supply, disturbed eating patterns, and poor diet quality (1-5). Other studies have identified consequences such as decreased nutrient intake and diet factors (6-9) that play key roles in the prevention and control of chronic disease. Collectively, several studies report an association of food insecurity and food insufficiency with decreased dietary intake in adults (1,5-7), increased body weight (10), hypoglycemia in people with diabetes (11), compromised health status in elderly people (2), and socio-familial problems (3).

With increasing recognition of the multidimensional nature of diets consumed by free-living individuals, dietary patterns have emerged as an alternative or an adjuvant to the traditional approach of using single nutrients or food groups as exposures for examining diet and health associations. The US Department of Agriculture (USDA) Healthy Eating Index (HEI) is a summary measure of overall diet quality, providing a picture of type and quantity of foods people eat and whether or not their diets comply with the Dietary Guidelines and the Food Guide Pyramid (12). There is typically a need to compare intakes of individuals with recommendations for appropriate nutrient intakes suggested by health professionals, as well as to evaluate the diet and certain dietary components in relation to other demographic variables of interest.

The expectation was that in the Lower Mississippi Delta region, with high prevalence of poverty and chronic disease, diet quality as measured by HEI would be negatively associated with food insecurity and other demographic factors. Only two previous studies we know of have examined the association between food insufficiency and the HEI. In the study by Basiotis and colleagues (13), women's overall diet quality as gauged by the HEI (12,14) and its components were examined. Data were from the 1988-1994 National Health and Nutrition Examination Survey (NHANES) and used the self-reported household food sufficiency status, body mass index based on measured height and weight, and self-reported individual food intake for a 1-day period. In a second study by Bhattacharya and colleagues (15) that involved the analysis of NHANES III data, individual component questions of food security were negatively correlated with HEI scores in adults aged 18 to 64 years and elders aged 65+ years controlling for poverty and other factors.

The objective of this research was to determine if measures of diet quality differ between food insecure and food secure adults in a rural high-risk population. It was also necessary to determine whether or not nutrient intake and dietary energy density differ between food insecure and food secure adults.

RESEARCH METHODS AND PROCEDURES

Residents of the Lower Mississippi Delta region comprise a unique and largely unstudied high-risk population with respect to nutritional health. This predominantly rural, minority, and traditionally agricultural region bordering the Mississippi River in Arkansas, Louisiana, and Mississippi has a high prevalence of poverty (16,17) and diet-related chronic diseases relative to their peers in the rest of the United States (18,19). The Lower Mississippi Delta Nutrition Intervention Research Initiative was established to collect baseline data on the nutritional health of Delta residents to develop and evaluate sustainable nutrition interventions (17). The Delta Nutrition Intervention Research Initiative validated dietary methodology in Lower Mississippi Delta residents (20), and applied the methodology to describe their nutrient intakes (21). Household food insecurity status is double the national rates (22) and is associated with poorer self-reported physical and mental health in adults (23) in the Lower Mississippi Delta Region.

Foods Of Our Delta Study (conducted in the year 2000) was a baseline cross-sectional telephone survey of a representative sample of the population aged 3 years and older, and was conducted between January and June 2000. A stratified cluster sampling plan was used to assign 36 Delta Nutrition Intervention Research Initiative counties to nine strata according to percent urban (16), percent African American, and percent living below the federal poverty level. Eighteen counties (two from each stratum) were selected with probability proportional to size to represent the stratum in the telephone sample. List-assisted random digit dialing methodology (24) was used to select a random sample of telephone numbers from the eligible blocks of numbers in these 18 counties; nonresidential and nonworking numbers were identified and removed. This protocol was approved by the Institutional Review Boards of the partner institutions of the Delta Nutrition Intervention Research Initiative.

Of the 3,455 eligible households, 1,293 or 37.4% refused to participate. A total of 1,751 adults completed the first interview (dietary intake and health data, including self-reported weight and height) and 1,662 completed the next interview (food security survey). Three of the 1,662 were later excluded for being younger than age 18 years, yielding a final sample size of 1,659. This analysis includes the 1,607 Lower Mississippi Delta adults who reported race as either African American or white. Fourteen hundred seventy-seven households who had complete data for outcome and predictor variables were used in the regression analyses.

HEI scores were calculated using programs and databases from the USDA HEI Working Group, which consisted of USDA staff from the Center for Nutrition Policy and Promotion and the Office of Evaluation and Analysis in the Food and Nutrition Service. It is extremely difficult to accurately assess sodium, and it appears that standard USDA recipes used to calculate sodium content of food may potentially underestimate the amount of sodium used in the Lower Mississippi Delta. Thus, two types of HEI scores were calculated, those with sodium as well as scores that exclude the sodium component.

Data Collection

A computer-assisted telephone interview was conducted to determine the eligibility of the households. Characteristics of an eligible household were one that had at least one member 18 years of age or older, the telephone number was not for business use only, and the household was located in one of the 18 Delta Nutrition Intervention Research Initiative sample counties. During this initial interview, information on age, sex, ethnicity, and the presence of children in the household was determined. All members of the household were enumerated and one adult proband per household was selected randomly (25). A second nonscheduled telephone call was made to collect information using a two-part questionnaire that included a multiple-pass 24-hour dietary recall, and a series of trailer questions about the usual intake, water consumption, height, weight, the presence of selected chronic health conditions, and general self-reported health for adults. This methodology has been described elsewhere (21). Approximately 1 to 2 weeks later, the adult in the household who had completed the dietary interview was interviewed again with questions including the food security status of the household (26).

In this survey food security status was evaluated using the 18-item Household Food Security Module (26) to construct the 12-month food security scale that classifies households as food secure or food insecure with or without hunger. Classifications include food secure, household shows no or minimal evidence of food insecurity; food insecure without hunger, food insecurity is evident in the household concerns and in adjustments to household food management, including reduced quality of diets (little or no reduction in household members' food intake was reported); and food insecure with hunger, the food intake for adults and children in the household has been reduced to the extent that they have repeatedly experienced the physical sensations of hunger.

For out analysis, food security status was collapsed to a dichotomous variable (food secure and food insecure) because the three-level variable when cross-tabulated with levels of other variables resulted in few responses in some cells.

Nutrition Variables

Because there are other important factors in examining healthful diet and how well people meet nutrient guidelines, there was a special interest in studying the influence of food insecurity and other related variables possibly affecting the ability of this rural population to achieve the HEI and the Estimated Average Requirement (EAR) or, where determined, the Adequate Intake (AI) for nutritional adequacy. A maximum score in the HEI is 100, with a score of 80 or above indicating a good diet. USDA has used the HEI to assess diet quality in the general US population over time. The HEI has also been used to assess the association of diet quality with risk factors for chronic disease (12,14). The EAR is the intake value that is estimated to meet the requirement defined by a specified indicator of adequacy in 50% of an age- and sex-specific group. At this level of intake, the remaining 50% of the specified group would not have its needs met (27). Both the overall HEI score and HEI score with salt removed are included. The HEI score without salt has a theoretical range of 0 to 90. There was also interest in influences on energy density of the diet in this population that has high levels of obesity. Energy density refers to the amount of energy or kilocalories compared to the weight of the food (kilocalories/grams food).

Statistical Analysis

All nutrient variable calculations were done using SAS version 9.1 and SAS callable SUDAAN (release 9.0.1, 2005, Research Triangle Institute, Research Triangle Park, NC).

All analyses incorporated sampling weights and were calculated using SUDAAN, with variances calculated based on the jackknife method with 60 sets of weights. To compare the mean scores of HEI and its components between the food secure vs food insecure households, a *t* test was used. In addition, tests of proportions were computed to compare the mean proportion of households meeting the EAR or AI for nutrients between the food secure vs food insecure households. Regression models were used to determine the influence of multiple variables that would affect the HEI-related scores. The Dietary Reference Intakes–related scores (0/1) were fit using logistic regression models in SUDAAN estimate with generalized estimating equations. The independent variables are identical for all models: household food security, age group, income group, race, sex, education, and number of persons supported by household income. Significance tests (Wald statistic) for all classification variables (except household size, which is treated as a continuous variable) indicate that there is either evidence that differences exist among means of the relevant populations, or there is insufficient evidence to conclude such differences. A beta test was used to compare within categories to the last category. No corrections for multiple comparisons were made, but the actual *P* value is cited.

Table 1. The relationship between the Healthy Eating Index (HEI) and demographic variables of adults in the Mississippi Delta[a]

Variable	Least squares mean±SE[b]	*P* value[c]	*P* value[d]
Food security			
Food secure	60.35±0.41	0.1090	0.1090
Food insecure	59.14±0.67		
Age group			
18-34 y	59.72±0.67	0.0060	<0.0001
35-44 y	58.02±0.78	0.0002	
45-54 y	58.68±0.85	0.0010	
55-64 y	61.25±1.18	0.0560	
65-74 y	64.59±1.28	0.7163	
75+ y	65.47±1.85		
Household income			
<$15,000	59.23±0.65	0.2308	0.1984
$15,000 to <$30,000	60.63±0.67	0.7444	
$30,000+	60.34±0.57		
Race			
White	60.72±0.51	0.0787	0.0787
African American	59.33±0.57		
Sex			
Men	59.53±0.56	0.1655	0.1655
Women	60.59±0.50		
Education			
0 to 11th grade	58.96±0.76	0.0000	<0.0001
High school/general equivalency diploma/trade school/some college	59.41±0.45	0.0000	—
College degree+	64.28±0.82	—	
Household size	—	—	0.6192

[a]Multiple regressions with HEI score, the outcome, age group, income, race, sex, education, and household size as independent variables.
[b]SE=standard error.
[c]Based on beta comparison of categories.
[d]Based on Wald test of relationship of variables to HEI score.

RESULTS

It is important to determine whether the affect of food insecurity on HEI scores is independent of other factors influencing diet. Although it appears the food secure group had a somewhat higher HEI than the food insecure group, this is not significant (Table 1). Household income, race, and sex were not significantly related to HEI. Age emerged as a significant factor ($P<0.0001$) with younger age groups (younger than age 55 years) having poorer HEI scores. Education was a significant factor ($P<0.0001$); individuals with a college degree had higher HEI scores. Household size, specifically the number of individuals supported by household income, did not factor significantly into the model. Household income, race, and sex were not signif-

Table 2. Mean±standard error (SE) scores of Healthy Eating Index (HEI) and its components in Lower Mississippi Delta adults, by food security status[a]

Variable	FS[b] mean±SE unadjusted n=1,252	FI[c] mean±SE unadjusted n=355	FS-FI *P* value unadjusted n=1,607	FS-FI *P* value adjusted[d] n=1,470
HEI	60.59±0.39	57.37±0.68	0.0001	0.110
HEI-Dairy	4.20±0.12	3.24±0.18	<0.0001	0.098
HEI-Fruit	2.98±0.11	2.92±0.21	0.7865	0.870
HEI-Vegetable	5.64±0.11	4.36±0.19	<0.0001	0.020
HEI-Grain	5.95±0.09	5.64±0.16	0.1086	0.890
HEI-Meat	7.19±0.07	6.97±0.17	0.2638	0.480
HEI-Fat	5.93±0.11	6.24±0.24	0.2360	0.098
HEI-Saturated fat	6.41±0.13	6.70±0.22	0.2219	0.100
HEI-Cholesterol	7.36±0.11	6.81±0.24	0.0410	0.230
HEI-Sodium	7.84±0.09	8.16±0.19	0.1529	0.690
HEI-Variety	7.08±0.12	6.33±0.22	0.0030	0.160
HEI-No sodium	52.75±0.42	49.21±0.68	<0.0001	0.200

[a]HEI scores were compared between food secure individuals and food insecure individuals using a contrast, which is equivalent to a *t* test.
[b]FS=food secure.
[c]FI=food insecure.
[d]Adjusted model based means comparisons. Model includes household food security status (FS, FI), age group (18 to 34 y, 35 to 44 y, 45 to 54 y, 55 to 64 y, 65 to 74 y, and 75 y and older), household income (<$15,000, $15,000 to $29,999, and >$30,000), race (white, African American), sex, education (zero to 11th grade, high school/general equivalency diploma/trade school/some college, college degree), and household size (based on the question, how many people are supported by household income). Sample size for adjusted means drops to 1,470 due to missing values for predictors.

icantly related to HEI. Participation in food assistance programs was later investigated; however, none of the models tested showed it to be significant (data not shown). When sodium was dropped from the HEI calculation, age and education remained significant ($P<0.001$) and race was also significant ($P=0.0239$), with whites having higher scores than African Americans (53.08 vs 51.24, respectively).

Examination of specific parameters that predict single HEI components (data not shown), indicated that for HEI-Dairy age was significant and younger age groups (younger than age 55 years) had poorer HEI-Dairy scores than those older than age 55 years. Race was significant, with whites consuming more dairy than African Americans ($P<0.0001$). Men tended to fare better with HEI-Dairy scores ($P=0.0456$). Finally, education was significant: those with a college degree had higher HEI-Dairy scores than those with less than a college degree ($P=0.0103$). For HEI-Fruit, only age, race, and education were significant factors (all P values <0.0001). For HEI-Vegetable consumption, food secure adults had significantly higher scores than food insecure adults ($P=0.0204$). Race was significant, whites scored 5.76 compared to African Americans' score of 4.91 ($P=0.0002$). Education was also a significant predictor with HEI scores increasing as level of education increased ($P=0.0014$). The regression model for HEI-Grain scores, although determining no difference between food secure and food insecure adults, did point to differences in several other parameters. Age was significant ($P<0.0001$) but there was no consistent pattern and the difference was for only the 45 to 50 years age group. Whites had higher scores than African Americans ($P=0.0230$), men had higher scores than women ($P=0.0033$), and higher educational levels also had higher scores ($P=0.0308$). HEI-Meat scores revealed no differences except for men whose scores were higher than women's ($P=0.0003$). HEI-Cholesterol scores were lower for men compared to women, 6.36 vs 8.04, respectively ($P<0.0001$); no other associations were significant for HEI-Cholesterol. HEI-Fat scores showed differences only related to age ($P=0.0015$). None of the models was significant for HEI-Saturated Fat. HEI-Sodium scores are affected by age ($P<0.0001$). Whites had lower HEI-Sodium scores than African Americans ($P=0.0265$), men have lower scores than women ($P<0.0001$), and education affects HEI-Sodium scores, with those with a college degree and above having the lowest scores ($P=0.0131$). For HEI-Variety, age and education are significant factors ($P<0.0001$), but race ($P=0.0366$) and sex ($P=0.0026$) are also significant.

Mean comparisons between food secure and food insecure adults that related to the HEI are presented in Table 2. Results from the univariate analyses of HEI scores and their components revealed statistically significant differences for the overall score, and four component scores.

Food secure adults scored higher overall on the HEI than did food insecure adults, even though the regression model showed no differences when multiple factors were included, as shown in Table 1. The specific components of the HEI for which food secure adults were significantly different from their food insecure counterparts included dairy, vegetable, cholesterol, and variety. Data on sodium intake are questionable due to the fact that the food composition tables used did not contain salt added in cooking and it was difficult to estimate this accurately. Therefore, sodium was dropped from the overall HEI score. Still it was found that food secure individuals had better scores, whether or not sodium was included. The adjusted means indicated that the only difference

Table 3. Proportion of Lower Mississippi Delta adults (mean±standard error [SE]) achieving nutrient recommendations and energy density,[a] by food secure (FS) or food insecure (FI) status[b]

Variable	FS mean±SE[c] (unadjusted) n=1,252	FI mean±SE (unadjusted) n=355	FS-FI *P* value unadjusted n=1,607	FS-FI *P* value adjusted[d] n=1,470
	←—— % ——→			
Met EAR[e] vitamin A	33.37±1.27	20.10±2.47	<0.0001	0.038
Met EAR vitamin E	10.58±0.87	8.54±1.68	0.3157	0.560
Met EAR thiamin	73.32±1.32	67.34±2.76	0.0731	0.460
Met EAR riboflavin	78.52±1.48	71.58±2.92	0.0352	0.670
Met EAR niacin	81.77±1.27	72.42±2.30	0.0014	0.140
Met EAR vitamin B-6	58.33±1.62	56.72±2.68	0.6197	0.270
Met EAR vitamin B-12	71.91±1.52	64.34±2.84	0.0199	0.550
Met EAR vitamin C	40.35±1.61	39.06±2.88	0.6766	0.930
Met EAR folate	40.25±1.56	32.85±2.86	0.0303	0.600
Met AI[f] calcium	17.20±1.44	11.26±1.51	0.0142	0.830
Met EAR magnesium	24.32±1.54	19.95±2.10	0.1155	0.620
Met EAR phosphorus	83.13±1.07	73.88±2.43	0.0009	0.400
Met EAR iron	84.79±1.31	76.53±2.72	0.0080	0.320
Met EAR copper	72.39±1.47	61.21±2.63	0.0009	0.890
Met EAR selenium	88.23±0.91	80.56±2.07	0.0013	0.035
Met EAR zinc	59.17±1.62	47.65±2.87	0.0022	0.300
Met EAR carbohydrates	91.43±0.62	84.23±2.29	0.0023	0.095
Met EAR protein	70.32±1.46	61.32±2.88	0.0055	0.130
Met AI linoleic acid	44.90±1.67	40.85±2.31	0.1779	0.560
Met AI fiber	6.79±0.71	6.53±1.32	0.8538	0.690
Energy density	0.97±0.01	1.06±0.02	0.0003	0.250

[a]Calculated by dividing total kilocalories by total weight of the food consumed in grams, excluding water.
[b]The proportion meeting a requirement was compared between FS and FI using a *t* test of proportions.
[c]SE=standard error.
[d]Adjusted model based means comparisons. Model includes household food security status (FS, FI), age group (18 to 34 y, 35 to 44 y, 45 to 54 y, 55 to 64 y, 65 to 74 y and 75 y and older), household income (<$15,000, $15,000 to $29,999, and >$30,000), race (white, African American), sex, education (zero to 11th grade, high school/general equivalency diploma/trade school/some college, college degree), and household size (based on the question, how many people are supported by household income). Sample size for adjusted means drops to 1,470 due to missing values for predictors.
[e]EAR=Estimated Average Requirement.
[f]AI=Adequate Intake.

remaining significant was for vegetable consumption (P=0.02).

Another issue in this population is nutritional adequacy of the diet. In a previous article, this population had specific nutrient intakes that were significantly different from the rest of the United States (21). Therefore, it was decided to assess the influence of food insecurity on nutrient intake in this population. The Institute of Medicine has defined a variety of terms upon which to base evaluation of nutrient intake and this was taken into consideration with the decision to use the Dietary Reference Intakes, specifically EAR or AI where appropriate, in the analysis of data from this study. Finally, obesity in this population and the affect of energy density of the diet influenced the decision to look at differences in dietary energy density related to food security of individuals. Table 3 contains comparisons between food secure and food insecure adults in achieving nutrient recommendations and in energy density. Energy density was calculated by dividing total energy by total weight of the food consumed in grams, excluding water.

Obvious differences were noted. With the exceptions of thiamin; vitamins B-6, C, and E; magnesium; fiber; and linoleic acid, there were significant differences between food secure and food insecure adults in the percentage that met current nutrient recommendations for 12 nutrients. Food secure individuals were more likely than food insecure individuals to meet the recommendations. Although food secure adults had a significantly higher percentage meeting the AI for calcium, the fact that less than 20% actually met the AI is of concern. Likewise, there were a significantly higher percentage of food secure adults meeting the EAR for vitamin A, yet only one-third of food secure adults and only 20% of food insecure adults met this recommendation. Low overall percentages for the population as a whole, regardless of food security status, were also observed for vitamins C and E, folate, zinc, and magnesium. Quite obviously, this population's consumption of fiber is well below the current recommendation of 21 to 38 g (dependent on age and sex) (28).

The energy density of the diet was significantly lower for food secure compared to food insecure adults (P=0.0003). This suggests that these individuals consume a low-energy-density diet that would typically be associated with lower body weight. After controlling for other variables, food security status was not a significant predictor for energy density. Although age group was a significant factor ($P=0.0109$), the least squares means did not reveal any trends. Household income was also significant, with the lowest energy density at the highest income level and the highest energy density at the lowest income level ($P=0.0272$). Whites had lower-energy-density diets than African Americans, 0.87 vs 1.11, respectively, $P<0.0001$. Finally, educational level was significant ($P=0.0249$) with the energy density increasing with increasing levels of education. When adjusted model means were compared, only vitamin A ($P=0.038$) and selenium ($P=0.035$) remained significant.

Logistic regression models were computed to identify the variables that were most likely to determine if the population met the Dietary Reference Intakes (data not shown). Significant findings are presented by nutrient.

Copper

The odds ratio (OR) for the percent meeting the EAR was more than double for whites vs African Americans and for men vs women ($P<0.0001$). The OR for education was also significant ($P=0.0042$).

Carbohydrate

Age was a significant predictor of percent meeting the EAR for carbohydrate. The OR was highest for the lowest age grouping (age 18 to 34 years) ($P=0.0012$). For whites, the OR was more than twice that of African Americans (2.10, $P=0.0009$) and for men it was 2.38 times that for women ($P=0.0002$).

Iron

Age was a significant predictor of percent meeting the EAR for iron ($P<0.0001$), sex (OR 5 times higher for men, $P<0.0001$), and education (lower OR at lower educational level, $P=0.0008$) were also significant predictors.

Vitamin A

Percent meeting the EAR for vitamin A was higher for food secure adults (OR 1.48, $P=0.0375$) compared to food insecure adults. Age was a significant predictor as well ($P=0.0017$) with lower OR at younger age groupings and increasing with age. The OR was higher for whites (OR 1.58, $P=0.0004$), and lower at lower educational levels ($P=0.0264$).

Riboflavin

Percent meeting the EAR for riboflavin was significant for race (OR for whites was 1.73, $P=0.0005$), sex (OR for men was 1.37, $P=0.0377$), and education ($P=0.0310$) with lower OR at lower educational levels.

Thiamin

Percent meeting the EAR for thiamin was significant for men compared to women (OR 1.74, $P=0.0002$) and for education ($P=0.0136$) with lower ORs at lower educational levels.

Vitamin B-6

Percent meeting the EAR for vitamin B-6 was also significant for men compared to women (OR 2.16, $P<0.0001$) and for education ($P=0.0067$) with lower ORs at lower educational levels.

Vitamin B-12

Percent meeting the EAR for vitamin B-12 was significant for race with whites having an OR of 1.50 compared to African Americans ($P=0.0106$) and for sex (OR for men 2.18, $P<0.0001$).

DISCUSSION

This research examined relationships between food insecurity status and diet quality (ie, HEI, Dietary Reference Intakes, and energy density), controlling for important demographic variables among adults living in the Lower Mississippi Delta region of Arkansas, Louisiana, and Mississippi. A univariate analysis indicated that food secure adults scored higher on HEI than food insecure adults, but the regression model showed no differences when multiple demographic variables were included. HEI was more strongly related to age and education. When sodium is dropped from the HEI calculation, race is related. This study used the HEI developed in 1999-2000. USDA is currently revising the HEI to incorporate the 2005 Dietary Guidelines and MyPyramid.

The findings of a significant association between food security and HEI in this study confirmed those of Basiotis and colleagues (13) who assessed the diet quality of women aged 19 to 55 years who did not live alone. This group was chosen because prior research has shown them to have higher rates of food insufficiency. Food sufficiency was measured by a woman reporting that her household had enough food to eat (food sufficient households), and food insufficiency was measured by a woman reporting that her household sometimes or often did not have enough to eat (food insufficient households). The sample size was 4,804 women in food sufficient households and 437 women in food insufficient households. Diet quality of women was gauged by HEI (12,14). Their results revealed that women from food insufficient households had a significantly lower diet quality than women in food sufficient households. The average HEI score was 58.8 for women in food insufficient households compared with 62.7 for women in food sufficient households, a 6.2% difference. Both of those scores were higher than the respective scores from this study. However, the average HEI score for both groups of women in the study by Basiotis and colleagues (13) indicated that their diets needed improvement.

After controlling for several important demographic variables, food security status was not related to HEI overall score. Education and age were related. These significant variables may represent an economic index, which reduced the contribution of food security. Basiotis and colleagues (13) did not report adjustments to the HEI.

The findings of differences in HEI component scores reported in this study are similar to those of Basiotis and colleagues (13). In their study, compared with women in food sufficient households, women in food insufficient households had significantly lower HEI component scores for vegetables (5.1 vs 5.8; compared to 4.4 vs 5.6 in this study), fruits (2.2 vs 3.4; compared to 2.9 vs 3.0 in this study), milk (5.2 vs.6.1; compared to 3.2 vs 4.2 in this study), cholesterol (7.4 vs 8.2; compared to 6.8 vs 7.4 in this study), and food variety (6.4 vs 7.3; compared to 6.3 vs 7.1 in this study). There were no statistically significant differences in the remaining HEI component scores between the two groups in their study.

It is important to consider the difference between statistically significant findings and meaningful findings in interpreting the HEI scores. Certainly a difference in scores of 5.64 and 4.36 is a little more than half a serving, nutritionally meaningful for vegetables, whereas other differences in specific HEI scores may not be of practical significance.

HEIs have been assessed by their ability to predict disease and their association with key biomarkers of chronic disease. In general, most studies support the HEI as a measure of diet quality and disease prevention. However, other researchers are deriving and testing other patterns and statistical models of diet quality (29). The overall HEI score in the Delta Nutrition Intervention Research Initiative population was 60.1 ± 0.3. In comparison, means from other studies have been 77.0 ± 11.0 (30) and 72.1 and 75.0 (31), 69.7 and 76.2 (32), and 63.75 ± 0.32 for participants in NHANES III (33). Thus, Delta Nutrition Intervention Research Initiative adults tend to have poorer diet quality than those adults nationwide.

All the component scores in our study were less than those reported for adults in NHANES III (34). The findings with respect to grain consumption are intriguing because grain consumption can aid in reducing the risk for chronic disease, particularly cardiovascular disease (35). In addition, some of the nutrients in grains such as selenium and vitamin E have antioxidant effects (34).

If the HEI component findings of HEI-Dairy, HEI-Vegetable, and HEI-Cholesterol are aggregated, this pattern could represent a deficit or higher risk of food insecure individuals for hypertension, because these components roughly represent some of the key Dietary Approaches to Stop Hypertension diet components. Previously published data (23) revealed that among food insecure individuals the rates of hypertension were higher than among food secure individuals. There are data (36) that demonstrate among food insecure adults 42.3% were obese, a significantly higher rate than food secure adults at 33.2%. Food insecure adults were significantly more likely to report hypertension (45.1% vs 29.5%), diabetes (15.0% vs 9.3%), heart disease (13.5% vs 6.8%), and metabolic syndrome (10.1% vs 4.4%). After controlling for demographic variables, food insecurity was associated with high cholesterol, heart disease, and metabolic syndrome (36).

It has been reported that in the United States about 12.6 million households are food insecure, and if 20% and 33% of the food insecure population met the EAR for vitamin A and folate, respectively, then conversely 80% and 67%, respectively, are not meeting the requirements. This translates into approximately 10.2 and 8.8 million households failing to meet recommendations. Furthermore, reports have demonstrated that for low-income families with chronically ill members, compliance with dietary requirements can be seriously compromised by episodes of food insecurity, for example in controlling diabetes (37). Some of the clinical implications of screening and addressing food insecurity have been elegantly presented by Cook (38), which may prompt the use of a simple screening question for food insufficiency, leading to referral to food assistance programs, if patients are not following dietary guidelines because food insecurity is a factor.

In this population, neither group had all members meeting the recommended intakes for the nutrients studied. As a word of caution in using the Institute of Medicine recommendations, it is important to note that not meeting the AIs (in the case of calcium, for example) does not necessarily indicate the there is an indication of inadequacy. When compared to food insecure individuals, a significantly larger proportion of food secure individuals met their nutrient needs, with the greatest differences seen for vitamin A, copper, and zinc (more than 10%) and very little difference for vitamins C and E. Both populations consumed diets extremely low in fiber, which may be somewhat indicative of food availability in the region. Several reports are in agreement with these findings with respect to vitamin A. Food insecure women in upstate New York were much more likely to consume between none and two servings of fruit and vegetables than their secure counterparts (74.4% vs 54.6%) (1). Rose and Oliveria (6), using data from the 1989-1991 Continuing Survey of Food Intakes by Individuals reported food insecure women were 1.61 times more likely to have low intakes of vitamin A. Dixon and colleagues (8) reported differences in food and nutrient intakes for low-income men and women, specifically that individuals from food insufficient households had biochemical evidence of poor vitamin A intakes with significantly lower fasting blood levels of vitamin A and serum carotenoids.

The findings reported here suggest that perturbations of the nutrient and dietary patterns associated with food insecurity could increase the risk of heart disease, diabetes, and high blood pressure. A healthful nutrient pattern (ie, low intake of cholesterol and saturated fats, and high intake of minerals, micronutrients, and antioxidants) can reduce the risk of developing diabetes, high cholesterol, heart disease, and the metabolic syndrome. A healthful food pattern comprised of diets rich in fruits and vegetables and dietary fiber has been demonstrated to reduce the risk of developing diabetes by improving glucose control and tolerance, and also reduce the risk of developing cardiovascular disease.

The strengths of this research include the study design and methodology, which allowed the survey of rural and impoverished areas of the Lower Mississippi Delta with high survey response rates. Before this survey, both telephone and nontelephone households in the region were sampled and it was found that intakes reported adequately described the population regardless of which methodology (telephone or in-person) was used (20).

It is critically important to define and further describe all areas of the United States that may be at risk for food insecurity. It is also important to reiterate the limitations associated with having a single 24-hour dietary recall. A potential limitation in the comparisons of intakes reported here to the Dietary Reference Intakes is that of basing the analysis on one 24-hour recall. Carriquiry (39) and other experts suggest that there is a definite need to have a second recall on at least a subsample to perform measurement error corrections and also to augment the replicated recalls with a propensity questionnaire to improve estimation of intake distributions by accounting for infrequently consumed foods or supplements.

A perceived limitation might also be the fact that the food security instrument assesses chronic food security and when compared to a single 24-hour recall may be somewhat flawed. This is probably of less concern because the population under study is considered impoverished with limited variation in dietary intakes. With this population, the assumption is that chronic food insecurity that would likely have been present at any time that the interview would have been conducted. This particular region has very high rates of poverty and food insecurity (22). Assumptions cannot be made about individuals. The assumptions about the population draw attention to the problems that go along with food insecurity, food availability, and overall evidence of poverty. Nutrient needs may be compromised as a result of food insecurity. In addition, whereas these data were collected several years ago, food consumption patterns and food access do not appear to change rapidly in this population (21). Nutrition investigators are now including indexes of diet quality, patterns, and variety in their research, such as the HEI. These indexes are generally based on dietary recommendations designed to reduce the risk of chronic disease. However, the ability of the HEI to actually predict disease, to correlate with biomarkers, or to differentiate high risk groups is still under question. Therefore, studies investigating the predictive ability of HEI, regardless of the date of the measure of HEI, are extremely useful in particularly understudied high-risk adults in rural areas with a high prevalence of food insecurity. Worthy of note is that this population is currently being studied and observed patterns of food consumption have not changed and should the data be collected today, it is assumed that essentially identical food intakes would be reported.

These findings point to much needed nutrition interventions in this population directed to improving overall diet quality and concentrating on the need for education efforts to achieve nutrient recommendations that result in improved health and well-being. The Lower Mississippi Delta Nutrition Intervention Research Initiative is currently implementing community-based participatory research in several communities in Louisiana, Arkansas, and Mississippi and these findings will be instrumental in supporting development of nutrition interventions to improve diet quality and the justification for these research efforts.

CONCLUSIONS

Future research in the Delta will be strengthened by targeting the findings from this study. Certainly improvements in diet and consequently nutrient intakes need to be addressed by researchers. Food and nutrition professionals and other concerned clinicians will be able to address with their own patients in rural areas some of the issues presented in this study. It is conceivable that other impoverished areas of the United States will face similar concerns about diet and food security. Clinicians should consider including instruments that help to define this population; when food insecurity is a result, steps need to be taken for appropriate referrals to food assistance programs.

This study was supported in part by the Lower Mississippi Delta Nutrition Intervention Research Initiative, which is a consortium of six academic institutions and the US Department of Agriculture, Agricultural Research Service (USDA/ARS Project No. 6251-53000-003-00D). Members of the consortium have contributed to the design of this study and the development of this article.

References

1. Kendall A, Olson CM, Frongillo EA Jr. Relationship of hunger and food insecurity to food availability and consumption. *J Am Diet Assoc*. 1996;96:1019-1024.
2. Vailas LI, Nitzke SA, Becker M, Gast J. Risk indicators for malnutrition are associated inversely with quality of life for participants in meal programs for older adults. *J Am Diet Assoc.* 1998;98:548-553.
3. Hamelin AM, Habicht JP, Beaudry M. Food insecurity: Consequences for the household and broader social implications. *J Nutr.* 1999; 129(suppl):525S-528S.
4. Klesges LM, Pahor M, Shorr RI, Wan JY, Williamson JD, Guralnik JM. Financial difficulty in acquiring food among elderly disabled women: Results from the women's health and aging study. *Am J Public Health.* 2001;91:68-75.
5. Tarasuk VS. Household food insecurity with hunger is associated with women's food intakes, health and household circumstances. *J Nutr.* 2001;131:2670-2676.
6. Rose D, Oliveira V. Nutrient intakes of individuals from food-insufficient households in the United States. *Am J Public Health.* 1997;87: 1956-1961.
7. Cristofar SP, Basiotis PP. Dietary intakes and selected characteristics of women ages 19-50 years and their children ages 1-5 years by reported perception of food sufficiency. *J Nutr Educ.* 1992;24:53-58.
8. Dixon LB, Winkleby MA, Radimer KL. Dietary intakes and serum nutrients differ between adults from food-insufficient and food-sufficient families: Third National Health and Nutrition Examination Survey, 1988-1994. *J Nutr.* 2001;131:1232-1246.
9. Lee JS, Frongillo EA Jr. Nutritional and health consequences are associated with food insecurity among US elderly persons. *J Nutr.* 2001;131:1503-1509.
10. Adams EJ, Grummer-Strawn L, Chavez G. Food insecurity is associated with increased risk of obesity in California women. *J Nutr.* 2003;133:1070-1074.
11. Nelson K, Cunningham W, Andersen R, Harrison G, Gelberg L. Is food insufficiency associated with health status and health care utilization among adults with diabetes? *J Gen Intern Med.* 2001;16:404-411.
12. Basiotis PP, Carlson A, Gerrior SA, Juan WY, Lino M. The Healthy Eating Index: 1999-2000. Available at: http://www.usda.gov/cnpp/Pubs/HEI/HEI99-00report.pdf. Accessed October 1, 2005.
13. Basiotis PP, Lino M. Food insufficiency and prevalence of overweight among adult women. Insight 26. *Family Econ Nutr Rev.* 2003;15:55-57.
14. Kennedy ET, Ohls J, Carlson S, Fleming K. The Healthy Eating Index: Design and applications. *J Am Diet Assoc.* 1995;95:1103-1108.
15. Bhattacharya J, Currie J, Haider S. Poverty, food insecurity, and nutritional outcomes in children and adults. *J Health Econ.* 2004;23: 839-862.
16. US Department of Commerce, Economic and Statistics Administration Bureau of Census. Census 1990. Summary tape file 3. 1990 census of population and housing. Available at: http://factfinder.census.gov/metadoc/1990stf3td.pdf. Accessed December 14, 2006.
17. Harrison G, ed. *The Lower Mississippi Delta Nutrition Intervention Research Consortium. Nutrition and Health Status in the Lower Mississippi Delta of Arkansas, Louisiana, and Mississippi: A Review of Existing Data*. Rockville, MD: Westat; 1997.
18. Casey P, Horton J, Bogle M, Fomby B, Forsythe W, Goolsby S, Gossett J, Hyman E, Kramer T, Lovejoy J, Rasco M, Robbins J, Simons W, for the Lower Mississippi Delta Nutrition Intervention Research Consortium, USDA/ARS. Self-reported health status of residents of the

Lower Mississippi Delta of Arkansas, Louisiana, and Mississippi. *FASEB J.* 2002;16:A233.
19. Harsha D, Thornton A. Health status of adults. In: Harrison G, ed. *Lower Mississippi Delta Nutrition Intervention Research Consortium. Nutrition and Health Status in the Lower Mississippi Delta of Arkansas, Louisiana, and Mississippi: A Review of Existing Data*. Rockville, MD: Westat; 1997:89-92.
20. Bogle M, Stuff J, Davis L, Forrester I, Strickland E, Casey PH, Ryan D, Champagne C, McGee B, Mellad K, Neal E, Zaghloul S, Yadrick K, Horton J. Validity of a telephone-administered 24-hour dietary recall in telephone and non-telephone households in the rural Lower Mississippi Delta region. *J Am Diet Assoc.* 2001;101:216-222.
21. Champagne CM, Bogle ML, McGee BB, Yadrick K, Allen HR, Kramer TR, Simpson P, Gossett J, Weber J; Lower Mississippi Delta Nutrition Intervention Research Initiative. Dietary intake in the lower Mississippi delta region: Results from the Foods of our Delta Study. *J Am Diet Assoc.* 2004;104:199-207.
22. The Lower Mississippi Delta Nutrition Intervention Research Consortium. High prevalence of food insecurity and hunger in households in rural Lower Mississippi Delta. *J Rural Health.* 2004;20:173-180.
23. Stuff JE, Casey PH, Szeto KL, Gossett JM, Robbins JM, Simpson PM, Connell C, Bogle ML. Household food insecurity status is associated with adult health status. *J Nutr.* 2004;134:2330-2335.
24. Waksberg J. Sampling methods for random digit dialing. *J Am Stat Assoc.* 1978;73:40-46.
25. Kish L. *Survey Sampling*. New York, NY: John Wiley and Sons; 1965.
26. Bickel G, Nord M, Price C, Hamilton W, Cook J. *Measuring Food Security in the United States. Guide to Measuring Household Food Security*. Revised 2000. Alexandria, VA: US Department of Agriculture, Office of Analysis, Nutrition, and Evaluation; 2000.
27. Institute of Medicine, Food and Nutrition Board. *Dietary Reference Intakes: Applications in Dietary Assessment*. Washington, DC: National Academies Press; 2000.
28. Institute of Medicine, Food and Nutrition Board. *Dietary Reference Intakes: Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids*. Washington, DC: National Academies Press; 2002.
29. McCullough ML, Feskanich D, Stampfer MJ, Giovannucci EL, Rimm EB, Hu FB, Spiegelman D, Hunter DJ, Colditz GA, Willett WC. Diet quality and major chronic disease risk in men and women: Moving toward improved dietary guidance. *Am J Clin Nutr* 2002;76:1261-1271.
30. Fung TT, McCullough ML, Newby PK, Manson JE, Meigs JB, Rifai N, Willett WC, Hu FB. Diet-quality scores and plasma concentrations of markers of inflammation and endothelial dysfunction. *Am J Clin Nutr.* 2005;82:163-173.
31. Pick ME, Edwards M, Moreau D, Ryan EA. Assessment of diet quality in pregnant women using the Healthy Eating Index. *J Am Diet Assoc.* 2005;105:240-246.
32. Moeller SM, Taylor A, Tucker KL, McCullough ML, Chylack LT Jr, Hankinson SE, Willett WC, Jacques PF. Overall adherence to the dietary guidelines for Americans is associated with reduced prevalence of early age-related nuclear lens opacities in women. *J Nutr.* 2004;134:1812-1819.
33. Kant AK, Graubard BI. A comparison of three dietary pattern indexes for predicting biomarkers of diet and disease. *J Am Coll Nutr.* 2005; 24:294-303.
34. Ford ES, Mokdad AH, Liu S. Healthy Eating Index and C-reactive protein concentration: Findings from the National Health and Nutrition Examination Survey III, 1988-1994. *Eur J Clin Nutr.* 2005;59: 278-283.
35. Hu FB, Willett WC. Optimal diets for prevention of coronary heart disease. *JAMA.* 2002;288:2569-2578.
36. Stuff JE, Casey PH, Connell CL, Champagne CM, Gossett JM, Harsha D, McCabe-Sellers B, Simpson PM, Szeto KL, Weber JL, Bogle ML. Household food insecurity and obesity, chronic disease, and chronic disease risk factors. *J Hunger Environ Nutr*. 2006;1:43-62.
37. Nelson K, Brown ME, Lurie N. Hunger in an adult patient population. *JAMA.* 1998;279:1211-1214.
38. Cook JT. Clinical implications of household food security: Definitions, monitoring, and policy. *Nutr Clin Care.* 2002;5:152-167.
39. Carriquiry AL. Estimation of usual intake distributions of nutrients and foods. *J Nutr.* 2003;133(suppl):601S-608S.