Current Research

Learner-Centered Nutrition Education Improves Folate Intake and Food-Related Behaviors in Nonpregnant, Low-Income Women of Childbearing Age

EMILY R. CENA, PhD; AMY BLOCK JOY, PhD; KARRIE HENEMAN, PhD; GLORIA ESPINOSA-HALL, MPH, RD; LINDA GARCIA, MS; CONNIE SCHNEIDER, PhD, RD; PATTI C. WOOTEN SWANSON, PhD; MARK HUDES, PhD; SHERI ZIDENBERG-CHERR, PhD

ABSTRACT

Background Recent studies suggest low-income women of childbearing age may be at risk of suboptimal folate intake.

Objective To evaluate the effect of learner-centered nutrition education on folate intake and food-related behaviors among nonpregnant, low-income women of childbearing age, compared to education unrelated to nutrition.

Design Participants were randomly assigned by recruitment site to receive either the nutrition lesson or a control lesson about resource management.

Participants Nonpregnant, low-income (≤185% federal poverty level) women of childbearing age (18 to 45 years, n=155) from five California counties.

Main outcome variables Changes in folate intake and other food-related behaviors.

Statistical analysis Analysis of covariance, adjusting for baseline responses and potential confounders.

Results Adjusting for baseline, participants who received the nutrition education had greater increases in folate intake and use of the Nutrition Facts label than the control group. Change in intake of specific folate-rich foods differed by ethnicity. Participants in the Special Supplemental Nutrition Program for Women, Infants, and Children who received the nutrition education increased folate intake but had no significant changes in other food-related behaviors. Food stamp recipients who received the nutrition education had no significant changes in folate intake but did increase the frequency of eating more than one kind of vegetable each day, compared to controls.

Conclusions This study supports the use of learner-centered approaches to nutrition education for low-income audiences, compared to education unrelated to nutrition. Future work is needed to compare learner-centered techniques to traditional pedagogical nutrition education, and to determine whether observed changes from this study persist over the long term.

J Am Diet Assoc. 2008;108:1627-1635.

To reduce the risk of neural tube defects (NTDs) such as spina bifida and anencephaly, the *Dietary Guidelines for Americans, 2005* recommends that all women of childbearing age should consume at least 400 μg synthetic folic acid from fortified foods and supplements every day, in addition to the natural folate provided by a varied diet (1). Since 1998, most enriched grain products in the United States have been fortified with folic acid. As a result, blood folate levels in the general adult population increased significantly (2,3) and the

E. R. Cena is a lecturer, University of California, Davis; at the time of the study, she was a graduate student researcher, Department of Nutrition, University of California, Davis. A. B. Joy is a cooperative extension specialist, Department of Nutrition, University of California, Davis; at the time of the study, she was director, California Food Stamp Nutrition Education Program, University of California, Davis. K. Heneman is an assistant project scientist, Department of Nutrition, University of California, Davis. G. Espinosa-Hall is program manager, nutrition and physical activity, Shasta County Public Health, Redding, CA; at the time of the study, she was a nutrition, family, and consumer sciences advisor, University of California Cooperative Extension–Shasta and Trinity Counties, Redding. L. Garcia is county director and a nutrition, family, and consumer sciences advisor, University of California Cooperative Extension–Sonoma County, Santa Rosa. C. Schneider is a nutrition, family, and consumer sciences advisor, University of California Cooperative Extension–Fresno County, Fresno. P. C. W. Swanson is a nutrition, family, and consumer sciences advisor, University of California Cooperative Extension–San Diego County, San Diego. M. Hudes is a senior statistician, Department of Nutritional Sciences and Toxicology, University of California, Berkeley. S. Zidenberg-Cherr is a cooperative extension specialist, Department of Nutrition, University of California, Davis.

Address correspondence to: Emily R. Cena, PhD, Department of Nutrition, University of California, Davis, 3135 Meyer Hall, One Shields Ave, Davis, CA 95616. E-mail: emilycena@gmail.com

Manuscript accepted: April 11, 2008.

0002-8223/08/10810-0002$34.00/0
doi: 10.1016/j.jada.2008.07.017

number of NTD-affected pregnancies decreased by 27% from 1995-1996 to 1999-2000 (4). Despite these noteworthy improvements, the reduction in NTD incidence has not reached the 50% to 70% decline predicted by researchers before fortification (5). It is unclear why the observed results have not met expectations, but some researchers recommend the daily use of folic acid-containing supplements for all women of childbearing age, to ensure they meet their needs (6-8).

New evidence suggests reduced influence of the folic acid fortification program in women of childbearing age. The Centers for Disease Control and Prevention recently reported that serum and red blood cell folate levels in nonpregnant women of reproductive age significantly decreased by 16% and 8%, respectively, between 2000 and 2004 (9). Proposed explanations included a decline in the use of folic acid-containing supplements, reduced consumption of foods rich in natural folate or fortified with synthetic folic acid, variations in the amount of folic acid being added to enriched grains, and increased prevalence of conditions that affect blood folate levels, like obesity. Studies have shown that obese individuals may have higher folate needs than normal-weight individuals, due to abnormalities in its release from body stores (10,11).

The recent decline in blood folate status is of particular concern for low-income women of childbearing age, who have been shown to be at risk of suboptimal folate status. Recent studies assessing folate intake among low-income women of childbearing age in California found that 58% to 63% of subjects did not meet the synthetic folic acid intake recommendation for NTD risk reduction (12,13). Low-income women are also less likely to use folic acid-containing supplements than women with higher incomes (14) and women of low socioeconomic status have 16% to 24% lower blood folate levels than their higher-income counterparts (15). Furthermore, knowledge about folic acid and awareness of its importance before pregnancy remains low among low-income women (16).

Nutrition education that is targeted at low-income women of childbearing age may be an effective way to improve folate intake. Nutrition education interventions have been shown to improve several dietary habits in this population, including increased fruit and vegetable consumption, decreased carbonated beverage intake, and improved food safety skills (17,18). Targeted nutrition education for low-income families is a cost-effective way to improve diet and health (19). Whether folate-specific nutrition education is effective among low-income, nonpregnant women of childbearing age remains to be determined.

Learner-centered approaches to adult nutrition education have gained considerable popularity in recent years. The basic premise is that adults have a wide variety of learning styles and therefore require a wide variety of teaching styles, rather than the traditional pedagogical approach used with children (20). Learner-centered education is participatory and focuses on applying, rather than simply acquiring, knowledge. One study of nutrition education for low-income clients reported that a learner-centered approach is more effective than traditional teaching styles (21). The Food Stamp Nutrition Education (FSNE) Program of California has adopted learner-centered approaches for educating low-income clients about purchasing and preparing low-cost, nutritious meals.

The purpose of this study was to evaluate the effectiveness of a learner-centered, folate-focused nutrition lesson that is targeted toward low-income, nonpregnant women of childbearing age. The lesson focuses on food rather than supplements, given that low-income women are least likely to take supplements, and therefore education about food sources of folic acid may help individuals in this population to meet the public health recommendation for $\geq$400 μg synthetic folic acid per day. One specific objective was to determine whether nutrition education in conjunction with food stamps or benefits from the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) would influence folate intake, because it has been reported that neither food stamps alone nor WIC benefits alone influence folate intake in this population (13). It was hypothesized that participants who received the nutrition education would have significant increases in folate intake and healthful food-related behaviors compared to the control group. It was also expected that recipients of food purchasing benefits (either food stamps or WIC benefits) who received the nutrition education would have significantly greater improvements in folate intake and healthful food-related behaviors than benefit recipients in the control group. Last, it was hypothesized that changes in intake of specific folate-rich foods would differ by ethnicity due to possible differences in food preferences between ethnic groups.

METHODS

Participants

Beginning in May 2006, participants were recruited by trained FSNE staff in five California counties: Fresno, San Diego, Sonoma, Shasta, and Trinity. These counties were chosen to provide representation from urban and rural areas. Due to joint program management, Shasta and Trinity were treated as a single county. Eligible participants were nonpregnant, low-income ($\leq$185% of the federal poverty level) women, aged 18 to 45 years. Each participant had to read and understand English or Spanish, and be the primary purchaser and preparer of food for herself and her family. Women were excluded if they had graduated from the FSNE program before or if they had participated in any formal nutrition education programs during the previous year.

The study's 15 recruitment sites included Food Stamp Program offices, WIC clinics, low-income schools, and various community programs serving low-income families and individuals. Within each county, recruitment sites were randomly assigned to either the intervention group (that would receive the nutrition lesson) or the control group (that would receive a lesson about resource management), such that all participants recruited from a given site were assigned to the same treatment group to minimize the risk of contamination bias. Of the 203 women screened for eligibility, 157 met the inclusion criteria and were enrolled in the study (a mean of 13.5 women at each recruitment site). Recruitment of participants and the study protocol were approved by the Institutional Review Board at the University of California, Davis. Written informed consent was discussed and obtained from all study participants before enrollment.

Lesson Development

The folate-focused nutrition lesson tested in this study was developed within the framework of learner-centered education (20). It involved group discussions, participatory activities, worksheets, visual aids, cooking demonstrations, and instructor explanations. The culturally sensitive lesson was targeted to meet the needs of an ethnically and culturally diverse population of low-income women of childbearing age throughout California. Topics included what folate is and why it is important, food sources of folate, and intake recommendations. During the development phase, the lesson was qualitatively pretested for feasibility and acceptability among women from the target population. Once appropriate changes had been made, the lesson materials were translated into Spanish by a team of professional translators. The final lesson was approximately 2.5 hours in length. FSNE representatives from each county were trained to deliver the lesson in the style of learner-centered education while still following a semiflexible lesson script to ensure lessons stayed on topic and that all important points were made.

Data Collection and Intervention

Upon enrollment, participants completed a demographic questionnaire, the Block Dietary Folate Equivalents (DFE) Screener (Block Dietary Data Systems, Berkeley, CA), and a food behavior checklist (FBC) (California FSNE Program, 2006, Davis, CA). All three instruments were available in English and Spanish. Standardized instructions were read aloud for consistency. Detailed descriptions of the survey instruments have been provided elsewhere (13,22). Briefly, the DFE screener measures usual frequency of folate intake from natural food sources, fortified foods, and supplements. The screener has been validated in the population of interest (22,23). The FBC measures the frequency with which a respondent performs each of 21 food-related behaviors, and some items on this instrument have been tested and found to be valid in this population (24).

After baseline data collection, each participant attended her assigned lesson. Women in the intervention group received the folate-focused nutrition education lesson. Women in the control group received a lesson of equal duration about resource management, taken from the *Gateway to a Better Life* curriculum (25). All lessons were taught by trained FSNE educators in English or Spanish. Lessons were conducted either at the recruitment site or at the local FSNE program office. Lessons were audio recorded to ensure that participants in one group did not receive any education intended for the opposite group, and to enable the researchers to evaluate consistency within and between counties. A researcher listened to all of the tapes and used a checklist to compare what was taught to the points that were to be made during each lesson. The first group attended their lesson in early May, and the last group's lesson was in mid-August.

Approximately 4 weeks following each lesson, participants returned for follow-up data collection. At the follow-up visit, participants again completed the DFE screener and the FBC, with standardized instructions read aloud for consistency.

Statistical Analysis

The completed DFE screeners were scanned and scored by Block Dietary Data Systems. Then, all of the survey data (eg, demographics, folate intake, and food behaviors) were entered twice to enable identification of data entry errors. Baseline differences between intervention and control groups were evaluated by independent samples t tests for the continuous variables of age, intake of natural food folate, intake of synthetic folic acid from fortified foods, intake of synthetic folic acid from supplements, total synthetic folic acid intake, and total folate intake from all sources. The χ^2 test for independence was used to evaluate baseline differences between intervention and control groups for the categorical variables of ethnicity, county of residence, receipt of food stamps, and WIC participation. Baseline differences between intervention and control for the ordinal responses to food-related behaviors were evaluated using the Mann-Whitney U test.

Analysis of covariance was used to compare changes in the outcome variables (eg, folate intake, intake of specific foods, and FBC responses) between intervention and control groups, adjusting for respective baseline values. Potential confounders were defined as variables that were at least moderately related ($P<0.20$) to both the outcome variable and the predictor of interest.

All statistical analyses were performed using the Statistical Package for the Social Sciences (version 15.0, 2006, SPSS, Inc, Chicago, IL). Statistical significance was defined as $P<0.05$. Data are presented as mean±standard error of the mean, unless otherwise indicated.

RESULTS

Random assignment of recruitment sites to groups resulted in similar baseline characteristics for the intervention group and control group, with the exception of age. The mean age of the 157 participants was 31.6±0.5 years, with the control group approximately 2 years older, on average, than the intervention group ($P=0.045$). There were no significant baseline differences between groups for ethnicity, county of residence, receipt of food stamps, or WIC participation. The ethnic make-up of the study sample consisted of Hispanic (n=89), white (n=56), Native American/Alaskan Native (n=6), Asian/Pacific Islander (n=2), and mixed ethnicities (n=4). There were 62 food stamp recipients and 83 WIC participants, with 30 women receiving both food stamps and WIC benefits. There were no differences in baseline intake of natural food folate, folic acid from fortified foods, folic acid from supplements, or total folate, between the two groups. The mean intakes of total synthetic folic acid and total folate from all sources were 402.0±23.5 μg synthetic folic acid per day and 864.0±44.0 μg dietary folate equivalents per day, respectively. Although the mean intake of synthetic folic acid at baseline met the recommendation, only 37%

Table 1. Mean folate intakes at baseline and follow-up, and mean changes in folate intake, for low-income, nonpregnant women of childbearing age who received nutrition education about folate (intervention group) vs those who received education about resource management (control group)

Measure	Intervention group (n=77)	Control group (n=78)	*P* value[a]
	← *mean±standard error* →		
Baseline intake			
Total synthetic folic acid (μg/d)	378.7±35.1	425.5±31.4	0.915
Total folate from all sources (μg DFE[b]/d)	818.7±67.0	910.0±56.7	0.587
Intake at follow-up			
Total synthetic folic acid (μg/d)	447.1±39.5	418.8±30.4	0.209
Total folate from all sources (μg DFE/d)	960.9±71.7	890.2±55.2	0.199
Adjusted change[c] in intake			
Naturally occurring food folate (μg/d)	+22.8±8.8	−8.3±8.6	0.009
Synthetic folic acid, fortified foods (μg/d)	+25.2±10.8	−4.4±13.3	0.088
Synthetic folic acid, supplements (μg/d)	+39.4±22.4	−2.3±25.3	0.311
Total synthetic folic acid (μg/d)	+64.5±26.2	−6.7±27.8	0.102
Total folate from all sources (μg DFE/d)	+132.5±47.2	−19.8±49.5	0.045

[a]*P* for difference between intervention and control groups.
[b]DFE=dietary folate equivalents. DFE is a standard unit of folate intake that accounts for differences in bioavailability between natural food folate and synthetic folic acid.
[c]Change in intake for each type of folate was calculated by subtracting baseline intake from follow-up intake.
NOTE: Information from this table is available online at www.adajournal.org as part of a PowerPoint presentation.

of individuals in the study had baseline intakes of ≥400 μg synthetic folic acid per day (13). Responses differed significantly between groups at baseline for three of the 21 food-related behaviors assessed by the FBC. On average and compared to the control group, women assigned to the intervention group reported more frequently thinking about healthful choices when deciding what to feed one's family ($P<0.05$), but also more frequently thawing frozen foods at room temperature ($P<0.01$) and less frequently eating low-fat foods instead of high-fat foods ($P<0.05$).

Of the 157 women who completed the surveys at baseline and attended a lesson, two were lost to follow-up. For the 155 participants who completed the study, change in intake from baseline (before assigned lesson) to follow-up (1 month after lesson) was calculated for five types of folate: natural food folate, synthetic folic acid from fortified foods, synthetic folic acid from supplements, total synthetic folic acid, and total folate from all sources. Table 1 shows mean changes in folate intake, adjusted for baseline, for the intervention group and control group. On average, participants who attended the folate-focused nutrition lesson had significantly greater increases in baseline-adjusted natural food folate ($P=0.009$) and baseline-adjusted total folate from all sources ($P=0.045$), compared to participants who attended the control lesson. Similar, though not statistically significant, trends were observed for the other three types of folate.

The variables of age, ethnicity, county of residence, receipt of food stamps, and WIC participation were investigated for confounding in each of the relationships between lesson assignment and change in folate intake. WIC participation was identified as a potential confounder for three of the relationships: lesson assignment and change in folic acid intake from supplements, lesson assignment and change in total synthetic folic acid intake, and lesson assignment and change in total folate intake from all sources. The relationships between lesson assignment and baseline-adjusted change in folic acid intake, both for supplements and for total synthetic folic acid, remained nonsignificant when WIC participation was added to the respective analysis of covariance models. Upon including WIC participation in the analysis of covariance model for change in total folate intake from all sources, the difference between intervention group and control group was not significant ($P=0.068$), but may have reached significance with a larger sample size.

Changes in intake of three specific folate-rich foods differed between the intervention group and control group. On average, participants who attended the folate lesson had significantly greater increases in the frequency of intake for beans ($P<0.01$), tortillas ($P<0.05$), and oranges and orange juice ($P<0.05$), compared to the control group and adjusting for baseline intake. A similar, though nonsignificant trend was observed for ready-to-eat cold breakfast cereal ($P=0.052$).

Among WIC participants in the study (n=82), those who attended the nutrition lesson had significantly greater increases in baseline-adjusted intakes of natural food folate, folic acid from fortified foods, and total folate from all sources, compared to WIC participants who attended the control lesson (Table 2). When analysis was restricted to only the food stamp recipients in the study (n=61), no significant differences in change in folate intake were observed between intervention and control groups ($P>0.27$ for all five types of folate, data not shown). To evaluate whether the intervention group-folate status relationship significantly differed by food stamp status, intervention group (folate lesson or control)×food stamp status (yes or no) interaction terms were examined. These interactions were statistically significant for the change in folic acid from supplements

Table 2. Baseline-adjusted mean changes in folate intake for 82 low-income, nonpregnant women of childbearing age in the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC) who received either nutrition education about folate (intervention group) or education about resource management (control group)

Adjusted change[a] in intake	Intervention group (n=46)	Control group (n=36)	*P* value[b]
	← *mean±standard error*	→	
Naturally occurring food folate (μg/d)	+27.7±10.4	−18.3±12.3	0.004
Synthetic folic acid, fortified foods (μg/d)	+37.1±11.3	−16.8±17.4	0.009
Synthetic folic acid, supplements (μg/d)	+63.0±27.4	0.0±45.4	0.387
Total synthetic folic acid (μg/d)	+100.1±32.5	−16.8±48.0	0.081
Total folate from all sources (μg DFE[c]/d)	+197.9±58.2	−46.8±85.4	0.035

[a]Change in intake for each type of folate was calculated by subtracting baseline intake from follow-up intake.
[b]For the difference between intervention and control groups, using analysis of covariance.
[c]DFE=dietary folate equivalents. DFE is a standard unit of folate intake that accounts for differences in bioavailability between natural food folate and synthetic folic acid.

(P=0.029), change in total synthetic folic acid (P=0.007), and change in total folate from all sources (P=0.006). Follow-up analysis revealed that the nutrition education intervention was significantly effective at improving each of these three outcome measures only among the non-food stamp recipients in the study (data not shown).

To further investigate the differences between WIC participants and food stamp recipients in their responses to the folate lesson or control lesson, subjects were categorized into four groups: no food stamps, no WIC (n=42); food stamps only (n=32); WIC only (n=53); and food stamps plus WIC (n=30). Significant interaction terms between lesson assignment and food stamp/WIC category were identified for the outcome variables of change in total synthetic folic acid (P=0.016) and change in total folate from all sources (P=0.012). Among the WIC only group, participants who attended the folate lesson increased total synthetic folic acid intake (P=0.003) and total folate intake from all sources (P=0.002) significantly more than WIC only participants in the control group. None of the other food stamp/WIC categories had significant differences between intervention and control.

Changes in food-related behaviors were calculated for each of the 21 FBC items by subtracting the baseline response for an item from the follow-up response. Participants who attended the nutrition lesson had significantly greater increases in frequency of using the Nutrition Facts label (adjusted for baseline use) than participants who attended the control lesson (P<0.05). A similar though nonsignificant trend was observed for the mean change in frequency of planning meals ahead of time (adjusted for baseline) (P=0.055). No potential confounders were identified for either relationship.

Food stamp recipients who attended the nutrition lesson had a larger (though nonsignificant) mean increase in the baseline-adjusted frequency of eating more than one kind of vegetable each day, compared to food stamp recipients in the control group (P=0.052). On average, food stamp recipients in the intervention group reported about a 0.5-unit increase along the Likert scale of the FBC (1=never, 2=rarely, 3=sometimes, 4=often, and 5=usually or always), whereas food stamp recipients in the control group had no change. Baseline-adjusted mean changes in FBC responses did not differ between WIC participants in the intervention group and WIC participants in the control group.

The two ethnic groups with greatest representation in the study were Hispanic (n=88) and non-Hispanic white (n=55). Different results were observed when analysis was limited to each of these ethnic groups separately. Adjusting for baseline intake and compared to Hispanic women in the control group, Hispanic women who attended the folate lesson had larger mean increases in their intake of naturally occurring food folate, total synthetic folic acid, and total folate from all sources (Table 3). In terms of specific food items, Hispanic women in the intervention group had significantly greater mean increases in consumption of beans; string beans, peas, corn, broccoli, or other vegetables; orange juice or oranges; and cold breakfast cereal (Table 3). There were also some nonsignificant differences that may have reached significance with a larger sample size. These included greater increases in intake of green salad with lettuce and other raw vegetables (P=0.051) and tortillas (P=0.053) among Hispanic women in the intervention group compared to Hispanic women in the control group, as well as greater reductions in intake of doughnuts, pastries, sweet rolls, cake, *pan dulce*, and other sweets (P=0.053). Among non-Hispanic white participants, women who attended the folate lesson had significantly greater baseline-adjusted mean increases in intake of natural food folate and intake of spinach and other dark green, leafy vegetables (P<0.05 for both tests, data not shown). It should be noted that the intervention group (folate lesson or control)×ethnicity (Hispanic or non-Hispanic) interaction was not significant for the change in any of the five types of folate intake (all P>0.35), but it was significant for the change in intake of salad (P=0.022).

DISCUSSION

Low-income women of childbearing age have been identified as a population subgroup that may be at risk of suboptimal folate intake, despite the national fortification program. The purpose of this study was to evaluate the impact of learner-centered, folate-focused nutrition

Table 3. Baseline-adjusted mean changes in intake of folate and specific folate-rich foods[ab] for 88 low-income, nonpregnant, Hispanic women of childbearing age who received either nutrition education about folate (intervention group) or education about resource management (control group)

Adjusted change[c] in intake	Intervention group (n=46)	Control group (n=42)	*P* value[d]
	←—— *mean±standard error*	——→	
Naturally occurring food folate (μg/d)	+24.8±10.3	−18.8±13.9	0.042
Synthetic folic acid from fortified foods (μg/d)	+27.5±12.4	−16.1±21.4	0.158
Synthetic folic acid from supplements (μg/d)	+44.4±30.3	−4.8±25.6	0.194
Total synthetic folic acid (μg/d)	+71.9±33.7	−20.9±29.9	0.048
Total folate from all sources (μg DFE[e]/d)	+147.0±58.4	−54.3±57.2	0.020
Foods and food groups			
Beans	+0.5±0.2	−0.2±0.2	0.019
String beans, peas, corn, broccoli, or other vegetables	+0.2±0.2	−0.3±0.2	0.030
Orange juice or oranges	+0.3±0.2	−0.3±0.2	0.035
Cold breakfast cereal	+0.2±0.2	−0.5±0.3	0.049
Green salad	+0.6±0.2	+0.1±0.2	0.051
Tortillas	+0.4±0.3	−0.1±0.2	0.053
Doughnuts, pastries, sweet rolls, cake, *pan dulce*, and other sweets	−0.3±0.2	+0.1±0.2	0.053

[a]Foods or food groups with significant (or near significant) differences between intervention and control groups are shown (out of 19 folate-rich foods and food groups studied).
[b]Intake frequencies for specific food items were scored along a Likert-type scale as follows: 0=≤once/mo, 1=2 to 3 times/mo, 2=1 to 2 times/wk, 3=3 to 4 times/wk, 4=5 to 6 times/wk, 5=every day, 6=≥2 times/day.
[c]Change in intake for each type of folate and for each food item/group was calculated by subtracting baseline intake from follow-up intake.
[d]For the difference between intervention and control groups, using analysis of covariance.
[e]DFE=dietary folate equivalents. DFE is a standard unit of folate intake that accounts for differences in bioavailability between natural food folate and synthetic folic acid.

education that is targeted at low-income, nonpregnant women of childbearing age. It was hypothesized that participants who received the nutrition education would increase their folate intake and improve other food-related behaviors.

The primary outcome of interest in this study was change in folate intake after a nutrition education intervention. As hypothesized, women who received the nutrition education increased their intake of natural food folate (P=0.009) and total folate from all sources (P=0.045), compared to women in the control group. When WIC participation was included as a confounder the difference in the change in total folate intake became nonsignificant (P=0.068). This confounding may be explained by the fact that several WIC-approved foods (such as breakfast cereals, orange juice, and beans) are good sources of folate and therefore individuals already consuming these foods through WIC benefits may have less room for—or less need for—increased intake. Further research is needed to explore this interesting finding.

In terms of specific foods, women who received the nutrition education increased their mean frequency of intake of beans, tortillas, and oranges and orange juice. These findings were consistent with expectations because these foods were discussed at some length during the nutrition lesson. Beans and orange juice, in particular, were part of the cooking demonstrations included in the lesson. It was surprising to find that the change in intake of dark green, leafy vegetables, such as spinach, did not differ between groups because they were also discussed at length in the lesson. This may be explained by reports from county staff that participants were avoiding spinach at the time of the study because of the widely reported news in California about spinach being contaminated with *Escherichia coli*. Other research has indicated that, when provided vouchers for fresh fruits and vegetables, low-income individuals tend to prefer other types of vegetables (such as carrots, tomatoes, and lettuce) instead of dark green, leafy vegetables (26), so this finding could also simply be due to food preferences. As expected, the control group did not have larger increases in any measures of folate intake or folate-rich foods compared to the intervention group.

The dietary recommendation for reducing NTD risk refers specifically to synthetic forms of folic acid (27). In this study, the change in synthetic folic acid intake was not significantly different between intervention and control groups. This may be explained by the nutrition lesson's emphasis on food sources of folate. The lesson does not emphasize dietary supplements because the target audience may not have the disposable income available to spend on such supplements. Food stamps and WIC vouchers, which are intended to increase food purchasing power, cannot be used for vitamin supplements. Furthermore, it is known that low-income women have the lowest rates of folic acid–containing supplement use (14) and therefore the focus of the lesson was on food sources of folate. Though not statistically different from the control group, the mean increase in total synthetic folic acid intake for the intervention group was 64.5±26.2 μg/day (P=0.102). It is interesting to note that adding this value to the intervention group's baseline mean intake (378.7 μg/day) results in a postintervention mean of 443.2 μg synthetic folic acid per day, which meets the dietary recommendation for reducing NTD risk.

In addition to increasing folate intake, it was hypothesized that participants who received the nutrition education would improve other food-related behaviors because nutrition education has been shown to improve nutrition and health outcomes in low-income individuals (17,18,28). As expected, use of the Nutrition Facts label increased and frequency of planning meals ahead of time trended toward an increase in the intervention group. Because the lesson included an introduction to label reading and many ideas for nutritious meals, both of these results seem to indicate the lesson was effective. Several similar though nonsignificant trends were observed for other food behaviors, and we expect that some of those changes would reach statistical significance if the sample size were larger, or if the folate-focused lesson were integrated into a longer series of nutrition lessons.

A third hypothesis for this study was that providing nutrition education to food stamp recipients would result in positive dietary changes because they would be better equipped for spending their food budget on healthful choices and, in this case, folate-rich foods. It has been shown that simply receiving food stamps without any accompanying nutrition education has no influence on folate intake (13). Similar findings have been reported for other nutrients (29). Contrary to the hypothesis, the nutrition education had no effect on folate intake among food stamp recipients in our study. However, the intervention did have a significant positive effect on folate intake among women not receiving food stamps, compared to non–food stamp recipients in the control group. Further work must be done to explain this unexpected result.

Similarly, our study investigated the influence of the nutrition lesson on folate intake and food-related behaviors among WIC participants. As with food stamps, simply participating in WIC had no effect on folate intake at baseline (13). However, unlike the case of food stamp recipients, the nutrition lesson was effective at increasing mean intake of three types of folate among WIC participants. A possible explanation for this outcome is that many WIC-approved foods are good sources of natural food folate (such as dry beans and orange juice) or synthetic folic acid (such as fortified breakfast cereal), so the lesson and WIC vouchers may have worked together to increase folate intake. Another possibility could be that women who choose to participate in WIC may already be more motivated to make dietary changes than income-eligible individuals who choose not to participate. The interaction between intervention group (folate lesson or control) and participation in WIC and/or food stamps indicates that the folate lesson's effectiveness at changing total synthetic folic acid intake and total folate from all sources may depend upon which combination of food stamps and WIC benefits a person receives. Whereas WIC benefits combined with the folate lesson led to significant increases in folate intake, food stamps combined with the lesson did not.

Because previous studies have identified ethnic differences in folate intake (12) and folate status (2,30,31), our study investigated the effect of the nutrition education on specific folate-rich foods for non-Hispanic white participants and Hispanic participants separately. In both ethnic groups, intake of natural food folate increased for women who received the nutrition education, but the specific foods contributing to this increase differed. Among Hispanic women in the study, four folate-rich foods and food groups were found to increase significantly more for those who attended the nutrition lesson, compared to the control group. Only one such food was identified for non-Hispanic white women in the study. The finding that there was no significant interaction between lesson assignment and ethnicity in predicting changes in folate intake suggests that the lesson's effectiveness did not depend on whether participants were Hispanic. A larger sample size of non-Hispanic participants may have revealed other statistically significant changes in intake.

The positive outcome that was observed in Hispanic participants is encouraging for two reasons. First, effective and culturally sensitive nutrition education programs targeted at low-income Hispanic women of childbearing age are especially important because 45% of all food stamp recipients in California are Hispanic (32). In fact, there are more Hispanic food stamp recipients than from any other ethnic group and therefore programs like FSNE must provide culturally sensitive nutrition education if they are to be effective at improving the health and well-being of low-income families. Second, Hispanics have the highest prevalence of homozygosity for the C677T allele in the gene that codes for 5,10-methylenetetrahydrofolate reductase, an enzyme involved in folate metabolism (33). The risk of NTDs is higher for women who have this mutation. Because the 5,10-methylenetetrahydrofolate reductase mutation increases folate requirements above those for the general population (34), it is important to find ways to help people with this mutation meet their folate needs. Our study demonstrates that learner-centered, targeted nutrition education is one way to increase folate intake in low-income, Hispanic women of childbearing age.

The lesson tested in our study was developed in the style of learner-centered education. A helpful reference for nutrition educators interested in using this approach is *From Telling to Teaching: A Dialogue Approach to Adult Learning* (20). Briefly, important components of learner-centered education include setting the learning environment, activating prior learning, using a variety of teaching approaches to appeal to the many types of adult learners, asking open-ended questions, encouraging partner interactions, and reinforcing the learning.

There were a few limitations in this study that must be addressed. First, this research would undoubtedly benefit from a larger sample size. The large variance in folate intake and frequency of food-related behaviors made it difficult to detect statistically significant differences for many of the observed trends. Given that this work was intended to provide insight for future interventions, a power calculation was not performed. With the data now available from this study, it was determined that a sample size of 148 participants in each of the two groups would enable the detection of a 75 μg/day difference between groups in the change of synthetic folic acid intake (α=5%, β=80%). Second, as in any study that relies on self-reported food intake, it is possible that subjects may have over- or underreported their consumption of certain foods. However, even if the actual increase in intake of folate-rich foods was smaller than the reported increase, the fact that participants in the intervention group reported consuming more of the foods discussed in the nutrition lesson suggests that they at least improved their ability to identify folate-rich foods. Additional evaluation is needed to measure changes in knowledge about folate. Finally, this study evaluated the short-term effectiveness of a single nutrition education lesson. Further work must be done to determine whether including this folate-focused lesson in a comprehensive nutrition education curriculum for low-income women of childbearing age is feasible and effective over a longer period of time.

CONCLUSIONS

The results from this study are important to food and nutrition professionals who conduct nutrition education because the findings highlight the fact that education programs should be carefully designed for their specific target groups. In this case, the folate-focused nutrition lesson was designed for nonpregnant women of childbearing age with limited financial resources and therefore it focused on food sources of folate instead of supplement sources. Had the target group been of higher income, it would likely be more appropriate to focus on folic acid supplements. The lesson was qualitatively pretested among women from this target population, but it was discovered that the lesson may have been appropriate for only part of the target group—the lesson was effective at improving folate intake among WIC participants in the study, but not among food stamp recipients. Thorough testing of educational programs, such as the lesson developed in this study, is important for documenting outcomes.

Learner-centered, folate-focused nutrition education is an effective way to increase folate intake and to improve certain food-related behaviors among low-income women of childbearing age. Future work comparing this learner-centered approach to a traditional pedagogical approach, in the context of folate-focused education, is necessary to conclude that the observed changes were due to the learner-centered approach rather than the content of the lesson. The finding that WIC participants had significant improvements in folate intake whereas food stamp recipients did not raises interesting questions about the effect of food assistance programs on nutrition outcomes in individuals with limited resources. Future work is needed to further explore this observation.

Funding for this research was provided by the US Department of Agriculture Fellowship in Human Nutrition (grant no. 02-38420-11727), the FSNE Program/US Department of Agriculture, and the Department of Nutrition at University of California, Davis.

The authors thank the FSNE program representatives for their help with subject recruitment and data collection: Patty Davidson and Yolanda Lopez, Fresno County; Lydia Lopez, Lori Renstrom, and Margarita Schwarz, San Diego County; Lori Coker, Shasta County; Wanda Tapia and Carla Vaughn, Sonoma County; and Tamila Medinnus, Trinity County. The authors also thank Myriam Grajales-Hall, program manager of Spanish Broadcast and Media Services at University of California, Riverside, and her staff for translating the consent forms and survey instructions into Spanish, as well as Torin Block and Block Dietary Data Systems for scanning the Dietary Folate Equivalents screeners.

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