Fundamental dietary patterns and their correlates among US whites

MARILYN TSENG, PhD; ROBERT F. DEVELLIS, PhD

A social history of eating habits in the United States (1) suggests that there are 2 fundamental US dietary patterns. The first, characterized by beef or pork, white flour bread, and potato consumption, is grounded in British culinary heritage. The second, characterized by fruits and vegetables consumed as "protective" foods, that is, to avoid illness, is a result of the development of nutrition science, the growth of food and advertising industries, and efforts of World War I food conservation programs. To confirm the occurrence of these 2 dietary patterns and their sociodemographic and lifestyle correlates, we used principal components analysis on data collected from white participants in a large, national US survey.

MATERIALS AND METHODS

M. Tseng is an assistant member with the Fox Chase Cancer Center, Philadelphia, Pa, and R. F. DeVellis is a research professor in the Department of Health Behavior and Health Education, University of North Carolina, Chapel Hill.

Study Population

Subjects were participants in the third National Health and Nutrition Examination Survey conducted from 1988 to 1994. The survey followed a 4-stage probability sampling design to represent the US population over the age of 2 months, focusing primarily on non-Hispanic whites, African-Americans, and Mexican-Americans (2). Because of potential dietary pattern differences across age and ethnic groups, we limited analyses to 5,794 white, US-born participants aged 20 to 74 years.

Data Collection

Household interviews included a 62-item food frequency questionnaire (FFQ) on the previous month's intake. Other interview information included age, highest school grade completed, family income, longest-held type of work, attempted weight loss during the past 12 months, current smoking status, vitamin/supplement use during the past month, frequency of breakfast consumption, frequency of adding salt to food at the table, physical activity, and number of days participants consumed at least 5 alcoholic beverages in 1 day during the past 12 months.

Poverty-income ratio was calculated as the ratio of family income to a Census Bureau-determined poverty threshold (3), with poverty-income ≤1 considered at or below poverty level. Occupations were considered working class if they fell into any 1 of 8 categories (4): clerical/administrative support; sales; private household service; other service except protective; precision production, craft, and repair; machine operators, assemblers, and inspectors; transportation or material moving; and handlers, equipment cleaners, and laborers. Residences were categorized into 1 of 4 geographic regions: Northeast, Midwest, South, and West (3). Urban residence was defined as location in the central or fringe counties of metropolitan areas with a population ≥1 million (3).

Physical activity level was assessed by summing frequencies during the past month of walking a mile or more at a time without stopping, of 7 leisure-time activities (running, biking, swimming, aerobics, dancing, gardening or yard work, and calisthenics or exercises), and of up to 4 other self-reported activities with an intensity rating of 3.0 or greater (3). Based on summed frequencies of beer, wine, and liquor intake from the FFQ, subjects were categorized as nondrinkers (0 drinks/day) or as light (>0 to <1/2 drink/day), moderate (1/2 to <2 drinks/day), or heavy (≥2 drinks/day) drinkers. Body mass index (measured as kg/m^2), based on measurements made at a mobile examination center, was categorized as <25, 25-<30, and ≥30 (5). Waist-to-hip ratio was calculated as the ratio of waist to buttock circumference. Waist:hip >0.95 for men and >0.8 for women was considered elevated (6).

Data Analysis

Patterns of food intake were identified by principal components analysis on FFQ responses in 5,788 persons with information on at least 50 food items. Because we were interested in fundamental dietary patterns occurring across gender and across geographic regions of the United States, we conducted analyses in women and men separately, and in each of the 4 regions, resulting in separate analyses for each of 8 sex-region groups. For each group, we constructed a matrix of correlations among standardized monthly intake frequencies for the 62 food items. The correlation matrix was entered into the principal components analysis using PROC FACTOR in SAS (version 6.12, 1994, SAS Institute, Cary, NC). The results presented here are

Table 1
Range of factor loadings across 8 sex-region groups[a], and median frequencies of intake per month for foods[b] associated with dietary patterns (N=5,788)

Food item	Range of factor loadings	Lowest (quartile 1)	Middle (quartiles 2-3)	Highest (quartile 4)
Vegetable-fruit pattern				
Tossed salad	56-65	3.5	9	17
Broccoli	53-62	0	3	9
Carrots	52-62	1	4	13
Other fruits besides citrus, melon, and peaches	43-55	4	9	30
Brussels sprouts and cauliflower	42-53	0	1	4
Spinach, greens, collards, kale	36-50	0	1	4
Peppers (green, red, yellow)	33-57	0	2	4
Chicken	30-51	4	8	10
Cabbage	30-47	1	2	4
Dark breads and rolls (including whole wheat, rye, pumpernickel)	30-45	0	9	20
Rice	27-43	1	3	4
Soup/stew	27-41	1	3	4
Fish	19-43	2	4	4
Peaches, nectarines, apricots, guava, mango, papaya	18-47	0	0	3
α coefficient[c]	0.72-0.76	...	...	...
% variation explained[d]	7.2-7.8	...	...	...
Red meat-starch pattern				
Beef	49-69	4	9	17
Processed meats	41-57	1	4	13
White potatoes	40-61	5	13	17
Pork/ham	39-52	1	3	4
Salted snacks	38-52	2	4	13
White bread	36-48	6	17	30
Cheese	32-51	4	9	17
Cheese dishes	25-49	0	2	4
Egg	21-41	2	4	9
α coefficient[c]	0.57-0.67			
% variation explained[d]	4.9-6.1			

[a]Analyses were conducted in women and in men separately, and in the Northeast, Midwest, South, and West regions of the United States separately.
[b]Food items are from food frequency questionnaire used in the third National Health and Nutrition Examination Survey (2).
[c]Calculated as $\left(\frac{N}{N-1}\right)\left(\frac{S^2-\sum S^2_i}{S^2}\right)$, where N=number of food items in questionnaire, S^2=variance of scale scores, and ΣS^2_i=sum of variances of *i* individual scale items (9).
[d]Calculated as eigenvalue for component/total eigenvalues of correlation matrix (9).

based on the unweighted correlation matrix, but the correlation matrix weighted according to the sampling design was similar.

Principal components extraction was followed by orthogonal rotation of retained components. Number of components to retain was based on examination of scree plots (7-9), interpretability (7,9), and other research (1,10-12). Each rotated component was interpreted based on foods with loadings on the component ≥0.30. We used Cronbach's α coefficient (13) to evaluate internal consistency for each component.

To create scales to quantify level of intake of each pattern across all 8 sex-region groups, we first identified sets of definite and possible foods to attach to each pattern. Definite foods had factor loadings ≥0.30 in all 8 groups and lower loadings on other components (<0.25). Possible foods had loadings ≥0.20 in at least 6 of the 8 groups and lower loadings for other components. We then calculated Cronbach's α for definite and possible foods together. If removal of a possible food from the set resulted in a higher average coefficient α for the 8 groups, it was excluded from the scale. Component scores were calculated as the unweighted sum of standardized intake frequencies for foods associated with the pattern.

Dietary pattern correlates were examined among 4,440 subjects with complete covariate information. We performed multivariate logistic regression analyses for polychotomous outcomes using generalized logits to model the odds of falling into either the lowest or highest vs middle quartiles (14), while adjusting for age (single years), sex, and region. Models were run in SUDAAN (version 7.5.3, 1999, Research Triangle Institute, Research Triangle Park, NC) to take into account the sampling design.

RESULTS AND DISCUSSION

The 2-factor principal components analysis solution produced dietary patterns that occurred across all 8 sex-region groups (Table 1). The first pattern, which we labeled "vegetable-fruit," was high in vegetables, fruits, dark bread, poultry, and fish. The second, which we labeled the "red meat-starch" pattern, included red meats, potatoes, white bread, eggs, and cheese. Median monthly intake frequencies of the foods characterizing each pattern ranged from zero or once a month in the lowest quartile to as high as once every day in the highest quartile of intake. Dietary patterns identified beyond the first 2 components were less interpretable and not reproducible across groups.

Generally, characteristics and behaviors associated with high intake of 1 pattern were associated with low intake of the other (Table 2). Factors associated with high intake of the vegetable-fruit pattern and low intake of the red meat-starch pattern were older age, female gender, urban residence, more education, attempted weight loss, more frequent physical activity, and supplement use. Conversely, being male, living at or below poverty level, working class status, adding salt more frequently at the table, and smoking were associated with low intake of the vegetable-fruit pattern and high intake of the red meat-starch pattern. High intake of the vegetable-fruit pattern was also associated with having breakfast every day and wine consumption, while high intake of the red meat-starch pattern was associated with heavy total alcohol drinking.

The 2 dietary patterns we observed resemble those from other principal components analysis-based studies in the US (10-12,15-18), Canada (19,20), and Great Britain (21,22). As in our analysis, other studies found vegetable-rich dietary pat-

Table 2
Adjusted odds ratios[a] and 95% confidence intervals for lowest and highest quartiles of each dietary pattern by sociodemographic and lifestyle characteristics (N=4,440)

Characteristic	N	%	Vegetable-fruit pattern				Red meat-starch pattern			
			Lowest quartile	Range	Highest quartile	Range	Lowest quartile	Range	Highest quartile	Range
Age (y)[b]			0.8	0.7-0.8	1.2	1.1-1.3	1.2	1.2-1.3	0.8	0.7-0.8
Male	2,060	46	1.3	1.1-1.5	0.8	0.7-0.9	0.7	0.6-0.8	2.0	1.7-2.3
Urban	1,620	37	0.7	0.6-0.9	1.3	1.0-1.7	1.6	1.3-1.9	0.6	0.5-0.8
Highest grade completed										
<12	976	22	1.0		1.0		1.0		1.1	
12	1,636	37	0.6	0.5-0.7	1.1	0.8-1.5	1.0	0.7-1.4	0.8	0.6-0.9
>12	1,828	41	0.3	0.2-0.4	2.3	1.8-3.1	1.4	1.1-1.7	0.5	0.4-0.6
Poverty income ratio	358	8	1.7	1.2-2.3	0.9	0.6-1.3	1.0	0.8-1.4	1.6	1.1-2.2
Working class	2,836	64	1.7	1.5-2.0	0.7	0.5-0.8	0.8	0.7-1.0	1.5	1.2-1.7
High waist to hip ratio	1,291	29	1.1	0.9-1.4	0.8	0.6-1.1	0.7	0.6-1.0	1.2	0.9-1.6
Body mass index (kg/m^2)										
<25	1,941	44	1.0		1.0		1.0		1.0	
25-<30	1,475	33	0.9	0.8-1.1	0.9	0.7-1.2	1.0	0.8-1.2	0.8	0.7-1.0
≥30	1,024	23	0.9	0.7-1.1	0.8	0.7-1.0	0.9	0.7-1.1	0.9	0.7-1.1
Attempted weight loss	1,958	44	0.7	0.6-0.9	1.2	1.0-1.5	1.4	1.1-1.7	0.6	0.5-0.8
Physical activity (times/mo)										
<5	1,212	27	1.0		1.0		1.0		1.0	
5-30	1,899	43	0.6	0.5-0.7	1.4	1.1-1.8	1.4	1.1-1.7	0.7	0.5-0.8
>30	1,329	30	0.4	0.3-0.5	2.1	1.6-2.6	1.9	1.5-2.5	0.6	0.5-0.9
Supplement use	2,008	45	0.6	0.5-0.7	1.3	1.2-1.5	1.3	1.1-1.6	1.0	0.8-1.1
Breakfast every day	2,487	56	0.6	0.5-0.7	1.7	1.4-2.1	1.0	0.9-1.2	0.9	0.7-1.1
Add salt at table										
Never	1,756	40	1.0		1.0		1.0		1.0	
Rarely/occasionally	1,792	40	1.1	0.8-1.3	0.8	0.6-1.0	0.8	0.7-1.0	1.4	1.1-1.8
Very often	892	20	1.6	1.2-2.2	0.6	0.4-0.9	0.6	0.4-0.8	2.2	1.8-2.8
Any intake of										
Beer	1,671	38	1.0	0.8-1.1	1.2	0.9-1.5	1.0	0.8-1.2	0.9	0.8-1.1
Wine	1,209	27	0.5	0.4-0.6	1.5	1.2-1.8	1.1	0.9-1.4	0.5	0.4-0.7
Liquor	1,231	28	0.7	0.6-0.8	1.1	0.9-1.3	1.0	0.8-1.2	0.7	0.6-0.9
Level of alcohol intake										
None	2,038	46	1.0		1.0		1.0		1.0	
Light	1,574	36	0.9	0.7-1.0	1.1	0.9-1.3	1.2	1.0-1.4	0.6	0.5-0.8
Moderate	720	16	0.6	0.4-0.8	1.2	0.9-1.5	0.9	0.6-1.2	0.9	0.7-1.1
Heavy	108	2	0.7	0.4-1.2	1.2	0.6-2.4	0.3	0.1-0.7	1.6	1.0-2.6
Ever >5 drinks/day										
Last year	1,242	28	1.0	0.8-1.2	0.9	0.7-1.2	0.9	0.7-1.1	1.2	1.0-1.5
Current smoker	1,253	28	1.9	1.6-2.3	0.6	0.4-0.7	0.7	0.5-0.9	1.8	1.5-2.2

[a]All logistic regression models were for polychotomous outcomes (odds of being in either lowest or highest quartiles) and included age, sex, and geographic region. Odds ratios for dichotomous characteristics were modeled for yes vs no. Odds ratios for polychotomous characteristics were modeled with lowest category as referent (14).
[b]Odds ratios for age are for 10-year increment.

terns to be associated with being female (19,22), having higher socioeconomic position (19-22), and performing health-conscious behaviors (20-23), whereas patterns high in red meat and refined grains were associated with being male (19,20,22), rural residence (21), lower socioeconomic position (22), and smoking (20,23). These findings reflect the transformation of eating habits that occurred early in the 20th century that affected some segments of society more than others (1). Messages targeted at middle-class women by scientists, food corporations, and the government reshaped traditional attitudes toward diet and promoted the idea of eating to stay healthy. In the working and rural poor, however, who had a less secure and less diverse food supply, traditional attitudes prevailed (1).

Most previous studies identified more than 2 dietary patterns, reflecting cultural differences in some instances (12,17,21). More generally, they reflect different criteria for determining the number of components to retain for interpretation. We retained 2 components based on examination of scree plots (7-9), interpretability (7,9), prior knowledge (1,24,25), and reproducibility across geographic regions. Other important patterns may exist. However, their identification should be based on knowledge of their characteristics from social, historical, anthropological, or dietary data, and their measurement requires an appropriate dietary instrument to capture the food items of interest. In our study, a dietary questionnaire designed for use in a broad national sample allowed us to identify the broad dietary patterns underlying national dietary habits. Whether measurement of fundamental patterns is a useful way to characterize intake in diet-disease investigations or whether measurement of more specific patterns is necessary requires further study.

APPLICATIONS

Confirmation of expected associations between dietary patterns and socio-demographic and lifestyle factors supports the validity of principal components analysis-based scales to quantify dietary pattern intake in nutritional epidemiologic studies. Quantitative measurement of dietary patterns has been informative in epidemiologic investigations of various health outcomes (11, 12,17,26,27). By focusing on overall diet, a pattern approach captures multiple nutrient effects not readily studied by focusing on single dietary components. Recent studies have demonstrated the usefulness of a pattern approach in dietary interventions (28,29). Dietary pattern measurement in observational studies will contribute to evaluating the potential of a pattern approach for preventing a wide variety of diseases.

References

1. Levenstein HA. *Revolution at the Table : The Transformation of the American Diet.* New York; NY: Oxford University Press; 1988.

2. US Dept of Health and Human Services, National Center for Health Statistics. *Plan and Operation of the Third National Health and Nutrition Examination Survey, 1988-94.* Hyattsville, Md: Centers for Disease Control and Prevention; 1994.

3. US Dept of Health and Human Services, National Center for Health Statistics. *Third National Health and Nutrition Examination Survey, 1988-1994, NHANES III Household Adult Data File.* [CD-ROM]. Hyattsville, Md: Centers for Disease Control and Prevention; 1996. Public Use Data File Documentation No. 77560.

4. Krieger N. Overcoming the absence of socioeconomic data in medical records: validation and application of a census-based methodology. *Am J Public Health.* 1992;92:703-710.

5. WHO Expert Committee. Physical status: the use and interpretation of anthropometry. Report of a WHO Expert Committee. *World Health Organ Tech Rep Ser.* 1995;854:1-452.

6. US Dept of Agriculture. *Report of the Dietary Guidelines Advisory Committee on the Dietary Guidelines for Americans, 1990.* Washington, DC: US Dept of Agriculture; 1990.

7. DeVellis RF. *Scale Development Theory and Applications.* Newbury Park, Calif: Sage Publications; 1991.

8. Kline P. *An Easy Guide to Factor Analysis.* New York, NY: Routledge; 1994.

9. Hatcher L. *A Step-by-Step Approach to Using the SAS System for Factor Analysis and Structural Equation Modeling.* Cary, NC: SAS Institute, Inc; 1994.

10. Hu F, Rimm E, Smith-Warner S, Feskanich D, Stampfer M, Ascherio A, Sampson L, Willett W. Reproducibility and validity of dietary patterns assessed with a food-frequency questionnaire. *Am J Clin Nutr.* 1999;69:243-249.

11. Slattery ML, Boucher KM, Caan BJ, Potter JD Ma KN. Eating patterns and risk of colon cancer. *Am J Epidemiol.* 1998;148:4-16.

12. Tseng M, DeVellis RF, Kohlmeier L, Khare M, Maurer KR, Everhart JE, Sandler RS. Patterns of food intake and gallbladder disease in Mexican Americans. *Public Health Nutr.* 2000;3:233-243.

13. Cronbach LJ. Coefficient alpha and the internal structure of tests. *Psychometrika.* 1951; 16:297-334.

14. Stokes ME, Davis CS, Koch GG. *Categorical Data Analysis Using the SAS System.* Cary, NC: SAS Institute Inc; 1995.

15. Randall E, Marshall JR, Graham S, Brasure J. Patterns in food use and their associations with nutrient intakes. *Am J Clin Nutr.* 1990;52:739-745.

16. Hebert JR, Kabat GC. Implications for cancer epidemiology of differences in dietary intake associated with alcohol consumption. *Nutr Cancer.* 1991;15:107-119.

17. Wolff CB, Wolff HK. Maternal eating patterns and birth weight of Mexican American infants. *Nutr Health.* 1995;10:121-134.

18. Gallagher ML, Farrior E, Broadhead L, Gillette LS, Rowe ML, Somes G, West P, Kolasa KM. Development and testing of a food frequency recall instrument for describing dietary patterns in adults and teenagers. *Nutr Res.* 1993;13:177-188.

19. Beaudry M, Galibois I, Chaumette P. Dietary patterns of adults in Quebec and their nutritional adequacy. *Can J Public Health.* 1998;89:347-351.

20. Nolan CC, Gray-Donald K, Shatenstein B, O'Loughlin J. Dietary patterns leading to high fat intake. *Can J Public Health.* 1995;86:389-391.

21. Barker ME, McClean SI, Thompson KA, Reid NG. Dietary behaviours and sociocultural demographics in Northern Ireland. *Br J Nutr.* 1990;64:319-329.

22. Whichelow MJ, Prevost AT. Dietary patterns and their associations with demographic, lifestyle and health variables in a random sample of British adults. *Br J Nutr.* 1996;76:17-30.

23. Randall E, Marshall JR, Graham S, Brasure J. High-risk health behaviors associated with various dietary patterns. *Nutr Cancer.* 1991;16: 135-151.

24. McIntosh EN. *American Food Habits in Historical Perspective.* Westport, Conn: Praeger Publishers; 1995.

25. Pillsbury R. *No Foreign Food: The American Diet in Time and Place.* Boulder, Colo: Westview Press; 1998.

26. Randall E, Marshall JR, Brasure J, Graham S. Dietary patterns and colon cancer in western New York. *Nutr Cancer.* 1992;18:265-276.

27. Hu FB, Rimm EB, Stampfer MJ, Ashcerio A, Spiegelman D, Willett WC. Prospective study of major dietary patterns and risk of cornoary heart disease in men. *Am J Clin Nutr.* 2000;72:912-921.

28. Appel L, Moore T, Obarzanek E, Vollmer W, Svetkey L, Sacks F, Bray G, Vogt T, Cutler J, Windhauser M, Lin P, Karanja N. A clinical trial of the effects of dietary patterns on blood pressure. *N Engl J Med.* 1997;336:1117-1124.

29. de Lorgeril M, Salen P, Martin J, Monjaud I, Boucher P, Mamelle N. Mediterranean dietary pattern in a randomized trial: prolonged survival and possible reduced cancer rate. *Arch Intern Med.* 1998;158:1181-1187.

The authors thank Joanne Dorgan, MPH, PhD, and Alison Evans, ScD, for their comments regarding the development of this article. This research was supported by grant No. R25 CA57708 from the National Institutes of Health.