Dietary Patterns Using the Food Guide Pyramid Groups Are Associated with Sociodemographic and Lifestyle Factors: The Multiethnic Cohort Study[1,2]

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ABSTRACT Dietary patterns have been used to identify typical combinations of foods that may be associated with disease risks. We defined dietary patterns among 195,298 participants of the Multiethnic Cohort Study in Hawaii and Los Angeles in 1993–1996. Intakes of Food Guide Pyramid groups were calculated from a quantitative FFQ for subjects of 5 ethnic groups (African Americans, Hawaiians, Japanese Americans, Latinos, and whites). Three distinct dietary patterns, "Fat and Meat," "Vegetables," and "Fruit and Milk," were identified by exploratory factor analysis with a varimax rotation and validated by confirmatory factor analysis. Similar factor loadings were found for each of 10 ethnic-gender groups in stratified analyses. The odds ratios (OR) for being above the median scores for each factor were calculated. Age, gender, and ethnicity had relatively strong associations with dietary patterns whereas education showed only weak associations. BMI $\geq$ 30 was strongly positively associated with the Fat and Meat pattern (OR = 2.14, 95% CI: 2.08–2.20, vs. BMI $<$ 25). Current smokers showed a positive association with the Fat and Meat pattern (OR = 1.67, CI: 1.62–1.72, vs. nonsmokers) and inverse associations with the Vegetables (OR = 0.66, CI: 0.64–0.68) and Fruit and Milk patterns (OR = 0.53, CI: 0.52–0.55). Physical activity was positively associated with the Vegetables and Fruit and Milk patterns but not with the Fat and Meat pattern. These findings support the hypothesis that dietary patterns are influenced by interrelated sociocultural, demographic, and other lifestyle factors and may be useful in investigations of diet-disease relations. J. Nutr. 135: 843–849, 2005.

KEY WORDS: • *dietary patterns* • *factor analysis* • *food frequency questionnaire* • *ethnicity*

Diet plays an important role in most of the chronic diseases that have been the largest cause of morbidity and mortality in the world (1,2). Although the role of individual dietary components has been a focus of considerable research, foods are consumed in many combinations that are likely to be complex. As a result, nutrient intakes are often highly correlated with each other and may have interactive and synergistic effects (3,4). Dietary pattern analysis, which reflects the complexity of dietary intake, has recently received greater attention from nutritional epidemiologists (5–7). Researchers have examined health outcomes in relation to dietary patterns created by a variety of approaches, including simple or complex scores to assess desirable dietary characteristics and statistical techniques (8). Among these approaches, factor analysis has been used to identify the number and nature of the underlying factors that are responsible for covariation in the data; an advantage of factor analysis is that the resulting factors are uncorrelated variables that often can account for most of the variability in the original data (9,10).

In dietary pattern analysis, foods are usually aggregated into food groups. Various schemes for food grouping have been used, which makes a comparison of the results from different studies difficult. There is inconsistency not only in the grouping method, but also in allocating foods that are part of mixed dishes (11). Food group servings developed by the USDA for the Food Guide Pyramid might be helpful in standardizing food grouping methods (12).

Ethnic groups in the United States have different dietary cultures and distinct rates of chronic disease (13,14). However, ethnic differences have rarely been the focus of the diet-disease studies using dietary pattern analysis. We defined dietary patterns among subjects in the Hawaii-Los Angeles Multiethnic Cohort Study, a large study of 5 ethnic groups (15). We also examined the relation of the patterns with nutrient intake, sociodemographic, and health-related characteristics.

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[2] The stratified analyses by ethnic-gender group are included in the Appendix tables available with the online posting of this paper at www.nutrition.org.

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SUBJECTS AND METHODS

Study population. The Hawaii-Los Angeles Multiethnic Cohort Study recruited >215,000 adults aged 45–75 y in 1993 at the time of cohort creation. The cohort was designed to include males and females of 5 principal ethnic groups (African Americans, Hawaiians, Japanese Americans, Latinos, and whites) who lived in Hawaii and Los Angeles, California. Subjects completed a mailed survey instrument for baseline information between 1993 and 1996 (15). For this analysis, individuals with extreme diets were excluded based on energy and macronutrient intakes. First, the top and bottom 10% tails of the log energy distribution were excluded, and a robust SD (RSD)[4] was computed assuming a truncated normal distribution. Then all energy values out of the range (mean ± 3 RSD) were excluded. A similar procedure was performed to exclude individuals with extreme fat, protein, or carbohydrate intakes (outside the range of mean ± 3.5 RSD). Among the remaining 206,679 subjects, 11,381 did not self-identify as 1 of the 5 primary ethnic groups. Therefore, analyses were performed on 195,298 participants.

Data collection. The baseline questionnaire included various demographic, lifestyle, and medical history items as well as a quantitative food frequency questionnaire (QFFQ). Three-day measured food records were used to develop a single, self-administered QFFQ appropriate for all ethnic groups (15,16). The minimal set of foods contributing at least 85% of the intakes of fat, dietary fiber, vitamin A, carotenoids, and vitamin C were selected for each ethnic group. In addition, unique ethnic foods were included regardless of nutrient contribution. The questionnaire included 8 frequency categories for foods and 9 for beverages, with 3 choices of portion size to permit adequate specificity in defining daily intakes. For food items, the highest frequency category was ≥2 times/d, whereas for beverages the highest category was ≥4 times/d. As an aid to quantification, photographs showing selected foods in representative portion sizes were provided at the top of several pages of the questionnaire. A calibration substudy was conducted and showed satisfactory correlations between the QFFQ and three 24-h recalls for all ethnic and gender groups being studied (16).

Food groupings. Food Guide Pyramid servings were computed for each cohort member as follows. The Pyramid Servings Database file identified the number of servings from 30 food groups provided per 100 g for the wide variety of foods reported during the 1994–1996 Continuing Survey of Food Intake by Individuals (12). Foods that were mixtures were first disaggregated into their components and each ingredient was assigned to the appropriate Pyramid food group. The Cancer Research Center of Hawaii food composition table was linked to this database so Pyramid servings could be calculated for the basic foods in the table. Food Guide Pyramid servings of many traditional mixtures consumed in Hawaii were determined using local recipes. The daily number of Food Guide Pyramid servings was computed for each individual by summing the servings across the reported food items (11,17,18). The 30 Pyramid food groups include the 5 main food groups in the Food Guide Pyramid (grains, vegetables, fruits, dairy, and meat), 22 subgroups, and a further 3 groups that make up the Pyramid tip (added sugars, discretionary fat, and alcohol) (see supplemental Appendix A). Added sugars are defined as all sugars in the diet that have been added to foods during processing, preparation, or at the table. Discretionary fat is defined as all fat in the diet that could have been avoided by making lower fat choices; it includes all fat from dairy products, fat in all but the leanest meats, and all fat added to foods. In our data, a few food groups, notably soybean products, yogurt, and organ meats, had a high proportion of non- or very rare consumers (46, 40, and 22%, respectively). Because such high proportions of null values will violate the assumptions of the factor analysis, the servings of these 3 groups were combined with other food groups having a similar nutrient profile. Soybean products were combined with cooked dry beans and peas and nuts and seeds; yogurt with milk; and organ meats with meat. Thus, 21 food groups were available in the pattern analyses; however, 1 additional group, alcohol, had to be eliminated (see below), leaving a total of 20.

Statistical analysis. All analyses were performed with SAS software, version 8.2 (SAS Institute). Because the gender and age group distribution differed across ethnic groups, we adjusted sociodemographic and health-related characteristics by gender and age for descriptive analyses. This adjustment was completed by the poststratification method described by Rossi et al. (19), weighted to the gender and 10-y age group distribution of the entire cohort of 195,298. Because the distribution of the dietary variables was not normal, data were transformed using the Box-Cox transformation (see supplemental Appendix A for a list of the transformations). Two types of analyses were performed: *1*) exploratory factor analysis [essential fatty acids (EFA)] to determine dietary patterns using principal components factor analysis and *2*) confirmatory factor analysis (CFA) to validate the factor model. For the EFA, we used principal component factor analysis using the PROC FACTOR procedure to define dietary patterns among the study population, while PROC CALIS was used for the CFA (10).

First, the entire sample was divided randomly into 2 groups. EFA was performed with 1 group, and then the other group was used to confirm the model by CFA. We excluded 1 variable, alcohol, from the analysis because the normality assumption for factor analysis could not be met with transformation. Therefore, the remaining 20 food groups were used in EFA. Factors were retained based on the following criteria: eigenvalue >1.25, a scree plot, and the interpretability of the factors. An orthogonal rotation was then used to achieve a structure with independent factors. To increase the interpretability of the factor structure, the food groups not contributing to a pattern significantly were excluded based on the criterion that the factor loadings be >0.6. EFA was performed again using the remaining food groups to obtain the final factor model.

Second, CFA was performed on the second half of the sample to verify the final factor model found by EFA. By splitting the sample in half, we can determine whether the 3-factor model with the factor loadings found in the EFA described that data set specifically or whether it broadly describes patterns from the underlying population. The measurement model consisted of the identified patterns and the corresponding indicator variables. The process for determining whether a model fit the data involved review of overall goodness of fit statistics [the comparative fit index (CFI), the non-normed fit index (NNFI), and the root mean squared error approximation (RMSEA)] and a more detailed fit assessment (significance test for factor loadings). The chi-square test was not used, since with large sample sizes it can indicate that the model is not a good fit even if the model fits the data well. CFI and NNFI values >0.9 indicate that the model provides an acceptable fit. A RMSEA value <0.1 suggests an acceptable fit of the model. Verification of the importance of independent variables contributing to the factors was judged by the significance of the parameters, based on the t test, as well as visual inspection to ensure that factor loadings were relatively large (10). This process was repeated for the overall cohort and separately by ethnic-gender group.

Finally, we applied the final EFA model to the entire study population of 195,298 to obtain factor scores. Factor scores were created for each subject as the linear combination of the dietary variables, weighted by an equivalent of the factor loadings. The scores were then used to study the association between dietary patterns and the other variables.

Partial Pearson's correlation coefficients adjusted for energy were calculated between factor scores and nutrient intakes. A pattern's association with age, gender, ethnicity, and health characteristics was assessed using multivariate logistic regression analysis to model the odds of being in the upper half of the factor scores. The logistic regression was performed with 182,998 subjects with complete covariate information. The results were similar when a linear regression approach was also used to model the continuous factor scores. These results are not shown because the coefficients are difficult to interpret because the scale of the factor scores is not meaningful.

[4] Abbreviations used: CFA, confirmatory factor analysis; CFI, comparative fit index; CRCH, Cancer Research Center of Hawaii; CSFII, 1994–1996 Continuing Survey of Food Intake by Individuals; EFA, exploratory factor analysis; NNFI, nonnormed fit index; QFFQ, quantitative FFQ; RMSEA; root mean squared error approximation; RSD, robust standard deviation.

RESULTS

The proportions of the study population who were male varied from 37% for African Americans to 48% for Latinos (**Table 1**). More Hawaiians were in the youngest age group (45–54 y), while more African Americans were in the oldest group (65–75 y). Other characteristics, adjusted for the gender and age group distributions, varied by ethnicity. More whites graduated from college than individuals in other ethnic groups. Fewer Japanese Americans were obese compared with the other 4 ethnicities, whereas more African Americans and Hawaiians were obese (BMI = 30 or more). Also, these 2 ethnic groups had a higher proportion of current smokers. About half of the white participants consumed at least 1 drink of alcohol per week. Over 50% of Hawaiians reported physical activity (long enough to work up a sweat) at least 3 or more times a week, and their mean intake of energy and food groups was also higher than that of other ethnicities.

EFA identified 3 dietary patterns according to eigenvalues >1.25, the scree plot test, and interpretability. Seven variables were considered nonsignificant because their factor loadings did not meet the criterion of being >0.6 for at least 1 of the 3 factors: whole grains, other starchy vegetables, tomatoes, poultry, fish, added sugars, and cooked dry beans and peas/soybean products/nuts and seeds. A reanalysis with the remaining 13 variables yielded essentially the same structure as the analysis with all 20 variables. The factor loadings were obtained after varimax rotation (**Table 2**). The 3 factors explained 63.5% of the total variance. This 3-factor structure was tested with CFA, which gave various indexes for goodness of fit. The CFI and the NNFI were 0.90 and 0.88, respectively, close to the recommended value of 0.90. The RMSEA was 0.095, slightly lower than the recommended value of 0.10. All factor loadings were significant in the CFA model ($P < 0.001$), and the standardized loadings were all relatively large (>0.6) except for 1 variable, milk and yogurt (0.34). However, we decided not to delete this variable from the

TABLE 1

General characteristics of the subjects, Hawaii-Los Angeles Multiethnic Cohort Study at baseline, 1993–1996[1]

	African Americans	Hawaiians	Japanese Americans	Latinos	Whites	Total
n	33,349	13,890	54,890	45,615	47,554	195,298
Age distribution, %						
45–54	27.3	47.7	28.6	25.6	37.2	31.1
55–64	28.0	30.4	29.2	45.6	30.5	33.2
65–75	44.7	22.0	42.2	28.8	32.3	35.7
Gender, *% male*	36.6	43.6	47.3	48.2	46.3	45.2
Education,[2] %						
≤High school	40.3	57.4	38.0	68.7	27.6	44.6
Vocational/some college	37.3	27.0	30.2	21.2	31.4	29.3
≥Graduated college	22.4	15.6	31.9	10.1	41.1	26.2
BMI,[2] *kg/m², %*						
<25	32.1	32.2	65.7	34.3	51.5	46.7
25–30	40.6	38.1	28.7	44.8	33.8	36.3
≥30	27.3	29.7	5.7	20.9	14.7	17.0
Smoking status,[2] %						
Never	35.6	39.2	50.4	50.1	38.8	44.0
Former	40.6	40.7	37.6	36.1	45.1	40.0
Current	23.8	20.1	12.0	13.8	16.2	16.1
Alcohol consumption,[2] *≥1 drink/wk, %*	31.6	33.9	25.8	32.1	50.2	34.8
Physical activity,[2,3] *times/wk, %*						
Never	30.0	22.7	31.0	31.2	25.7	28.8
1–2	25.2	25.6	32.7	25.5	28.1	28.1
≥3	44.9	51.7	36.2	43.3	46.2	43.0
Dietary supplement use,[2,4] %	63.8	50.7	68.2	61.8	69.2	65.0
Personal history of cancer,[2] %	9.3	10.1	8.2	7.7	22.4	11.7
Family history of cancer,[2] %	33.8	36.4	41.3	28.9	40.2	36.6
Energy,[2] *kJ/d, mean ± SD*	8557 ± 4525	10,545 ± 5387	8435 ± 3151	9914 ± 5259	8422 ± 3305	8964 ± 4371
Food Guide Pyramid intake,[2] *servings/d, mean ± SD*						
Grains	6.7 ± 4.0	9.3 ± 5.1	8.5 ± 3.5	8.5 ± 4.9	6.9 ± 3.3	7.9 ± 4.2
Vegetables	4.1 ± 3.0	5.7 ± 4.2	4.6 ± 2.8	5.0 ± 3.7	4.7 ± 2.9	4.7 ± 3.2
Fruits	3.5 ± 3.4	3.8 ± 3.8	3.1 ± 2.6	4.1 ± 4.0	3.2 ± 2.7	3.5 ± 3.3
Dairy	1.1 ± 0.9	1.2 ± 1.1	0.8 ± 0.7	1.7 ± 1.3	1.5 ± 1.0	1.3 ± 1.1
Meat, *oz/d*	6.0 ± 3.9	6.4 ± 4.2	5.0 ± 2.7	6.9 ± 4.9	4.6 ± 2.6	5.6 ± 3.9
(Meat, g/d)	(169 ± 111)	(181 ± 119)	(142 ± 77)	(195 ± 139)	(132 ± 75)	(159 ± 109)
Discretionary fat, *g/d*	60.5 ± 38.2	68.4 ± 42.6	50.2 ± 25.2	67.5 ± 42.2	56.1 ± 29.1	58.8 ± 35.9
Added sugars, *tsp/d*	13.7 ± 13.8	15.3 ± 15.6	10.1 ± 8.4	13.2 ± 13.2	12.2 ± 10.5	12.3 ± 12.0
(Added sugar, g/d)	(54.6 ± 55.3)	(61.4 ± 62.3)	(40.5 ± 33.7)	(52.6 ± 52.6)	(48.7 ± 41.9)	(49.3 ± 48.0)
Alcohol, *drinks/d*	0.62 ± 1.97	0.72 ± 2.18	0.47 ± 1.40	0.55 ± 1.83	0.98 ± 1.98	0.65 ± 1.86

[1] Among over 215,000 participants, only 5 main ethnic groups were included.
[2] Proportions and means ± SD were adjusted for gender and age group by poststratification.
[3] Vigorous physical activity long enough to work up a sweat.
[4] Used 1 or more of the following supplements at least once a week during the past year: multivitamins or multivitamins with minerals, vitamin A, vitamin C, vitamin E, β-carotene, calcium, selenium, or iron.

model because its inclusion helped explain variability in dietary patterns among the ethnic groups.

We named the first pattern (Factor 1) "Fat and Meat" because of the high loadings in discretionary fat, meat, eggs, and cheese. The second pattern (Factor 2) was named "Vegetables," with high loadings for the 3 vegetable groups, and the final pattern (Factor 3) was "Fruit and Milk," characterized by high loadings on milk and yogurt and fruit groups. The Vegetables pattern had relatively high loadings for fruit groups (>0.35) but not for the dairy group. The Fruit and Milk pattern also showed a relatively high loading for cheese (0.35).

When the factor analysis was stratified by ethnicity and gender, similar results were found. Three factors were found for each group, with loadings to that described from the overall model. The first factor that explained the most variance was Fat and Meat for all groups. The variability explained by the first factor varied from 27% for white women to 33% for Hawaiian women. Vegetables and Fruit and Milk were the second and the third factors for all groups. The total variability explained by the 3 factors was between 59% for white women and 69% for Hawaiian women.

Factor scores were computed for all cohort members using the overall model in Table 2, and associations with other factors were examined. All factors were positively correlated with total energy intake (**Table 3**). Therefore, correlations of other nutrients were adjusted for energy intake. The Fat and Meat pattern had the strongest correlation with energy, as might be expected, and showed a positive relation with fats and a negative relation with carbohydrates, vitamins, and dietary fiber in men and women. The correlation coefficients between pattern scores and the energy-adjusted nutrient intakes differed across 3 dietary patterns. The Vegetables pattern showed negative correlations with fat and positive correlations with vitamins and dietary fiber. The Fruit and Milk pattern had a positive correlation with calcium and iron intakes as well as with vitamin C and dietary fiber.

TABLE 2

Final factor-loading matrix for dietary patterns in the Multiethnic Cohort at baseline, 1993–1996[1]

	Dietary pattern		
Food group[2]	Fat and Meat	Vegetables	Fruit and Milk
Discretionary fat	88[3]	14	22
Meat and organ meats	83[3]	10	−9
Frankfurters, sausage, and luncheon meats	72[3]	2	−7
White potatoes	68[3]	15	12
Non-whole grains	68[3]	22	8
Eggs	67[3]	6	3
Cheese	63[3]	−8	35
Dark-green vegetables	6	87[3]	6
Other vegetables	28	86[3]	13
Deep-yellow vegetables	12	79[3]	25
Milk and yogurt	24	−7	71[3]
Other fruits	−4	44	71[3]
Citrus fruits, melons, and berries	−3	36	71[3]
% Variation explained	30.0	19.7	13.8

1 Factor loadings are multiplied by 100 and rounded to the nearest integer.
2 Seven food items were excluded in the final factor analysis; whole grains, other starchy vegetables, tomatoes, poultry, fish, added sugars, and cooked dry beans and peas/soybean products/nuts and seeds.
3 Foods with factor loadings greater than 60.

TABLE 3

Pearson correlation coefficients between dietary pattern score and total energy and nutrient intake by gender in the Multiethnic Cohort[1]

	Fat and Meat		Vegetables		Fruit and Milk	
	Male	Female	Male	Female	Male	Female
Energy	0.72	0.71	0.33	0.33	0.33	0.42
Protein	0.31	0.26	0.16	0.11	0.02	−0.08
Fat	0.61	0.63	−0.20	−0.29	−0.08	−0.31
Saturated fat	0.60	0.61	−0.36	−0.43	0.05	−0.13
P/S ratio[2]	−0.35	−0.33	0.47	0.47	−0.20	−0.21
Cholesterol	0.57	0.56	−0.13	−0.17	−0.17	−0.27
Carbohydrate	−0.49	−0.62	0.25	0.25	0.34	0.39
Calcium	−0.04	−0.12	−0.13	−0.10	0.65	0.60
Iron	−0.14	−0.19	0.17	0.17	0.31	0.20
Sodium	0.43	0.41	0.14	0.11	−0.15	−0.31
Vitamin A	−0.27	−0.35	0.56	0.60	0.29	0.22
Vitamin C	−0.46	−0.56	0.43	0.46	0.54	0.50
β-Carotene	−0.32	−0.40	0.64	0.64	0.20	0.19
Vitamin E	−0.06	−0.11	0.20	0.19	0.21	0.11
Dietary fiber	−0.38	−0.51	0.37	0.46	0.46	0.40

1 Correlations for all nutrients, other than energy, are partial correlations, adjusted for energy. All correlation coefficients are significantly different from 0 ($P < 0.0001$).
2 P/S, polyunsaturated fat (g)/saturated fat (g).

Independent associations between the dietary patterns and selected population characteristics were examined by estimating the odds ratios for being in the upper half of the scores for each dietary pattern (**Table 4**). Generally, associations of characteristics and behaviors showed the opposite trend for the Fat and Meat pattern compared to the Vegetables pattern and the Fruit and Milk pattern, although there were some exceptions for BMI and alcohol consumption. The dietary pattern representing a diet high in Fat and Meat was significantly positively associated with male gender, Hawaiian and Latino ethnicity, BMI, smoking status, and alcohol consumption and negatively with age. Hawaiians and Japanese Americans were more likely to be in the upper half of the Vegetables pattern than other ethnicities. The Vegetables pattern score was also positively associated with age, physical activity level, and dietary supplement use. As age increased, the likelihood of a higher score on the Fruit and Milk pattern increased. Latinos and whites were more likely to have a high score on the Fruit and Milk pattern than the other 3 ethnicities. Age, gender, and ethnicity had relatively strong associations with dietary pattern scores, while education showed only weak associations. BMI was strongly associated with the Fat and Meat pattern score but not with the other 2 patterns. Current smokers showed a high score on the Fat and Meat pattern and lower scores on the Vegetables and Fruit and Milk patterns. Physical activity was associated with the Vegetables and Fruit and Milk scores but not with the Fat and Meat scores. A personal or family history of cancer did not have strong associations with any of the dietary pattern scores.

DISCUSSION

In this analysis, 3 distinct dietary patterns were identified from FFQ assessing adult diet in the Multiethnic Cohort Study. We performed CFA to test this 3-factor model and obtained an acceptable goodness of fit. In addition, similar factor loadings were found in an analysis stratified by gender

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TABLE 4

Adjusted OR[1] and 95% CI for each dietary pattern by sociodemographic and health characteristics in the Multiethnic Cohort

	Fat and Meat	Vegetables	Fruit and Milk
		OR (95% CI)	
Age			
45–54	1.0	1.0	1.0
55–64	0.67 (0.66–0.69)	1.23 (1.20–1.26)	1.32 (1.29–1.36)
65–75	0.51 (0.49–0.52)	1.31 (1.28–1.35)	1.95 (1.90–2.00)
Male	2.32 (2.27–2.37)	0.71 (0.70–0.73)	0.80 (0.78–0.82)
Ethnicity			
Whites	1.0	1.0	1.0
African Americans	0.80 (0.77–0.82)	0.99 (0.96–1.02)	0.64 (0.62–0.66)
Hawaiians	1.26 (1.21–1.31)	2.27 (2.18–2.36)	0.55 (0.53–0.58)
Japanese Americans	0.86 (0.84–0.89)	2.71 (2.64–2.79)	0.28 (0.27–0.29)
Latinos	1.35 (1.31–1.40)	0.89 (0.86–0.91)	1.32 (1.28–1.36)
Education			
≤High school	1.0	1.0	1.0
Vocational/some college	0.89 (0.87–0.91)	1.04 (1.01–1.06)	1.09 (1.06–1.12)
≥Graduated college	0.76 (0.74–0.79)	1.18 (1.15–1.21)	1.24 (1.21–1.27)
BMI, *kg/m²*			
<25	1.0	1.0	1.0
25–30	1.41 (1.38–1.44)	0.97 (0.95–0.99)	0.93 (0.91–0.95)
≥30	2.14 (2.08–2.20)	1.00 (0.97–1.03)	0.86 (0.84–0.89)
Smoking status			
Never	1.0	1.0	1.0
Former	1.05 (1.03–1.07)	0.97 (0.95–0.99)	0.79 (0.77–0.81)
Current	1.67 (1.62–1.72)	0.66 (0.64–0.68)	0.53 (0.52–0.55)
Alcohol consumption, ≥*1 drink/wk*	1.40 (1.37–1.43)	1.11 (1.09–1.14)	0.80 (0.78–0.82)
Physical activity, *times/wk*			
Never	1.0	1.0	1.0
1–2	1.10 (1.07–1.13)	1.24 (1.21–1.27)	1.09 (1.06–1.12)
≥3	0.98 (0.96–1.01)	1.73 (1.69–1.77)	1.44 (1.40–1.47)
Dietary supplement use	0.89 (0.87–0.91)	1.29 (1.27–1.32)	1.42 (1.40–1.45)
Personal history of cancer	0.99 (0.96–1.03)	1.00 (0.97–1.03)	1.04 (1.01–1.07)
Family history of cancer	1.03 (1.01–1.05)	1.00 (0.98–1.02)	1.00 (0.98–1.02)

[1] Odds ratio of being in the upper half of dietary pattern scores. Odds ratios for polychotomous characteristics were modeled with the lowest category as a reference. Odds ratios for dichotomous characteristics were modeled for yes vs. no.

and ethnicity. Other studies have also reported similar patterns for men and women when only 2 or 3 patterns, often called major dietary patterns, were extracted, or only the first few of 6 or 7 patterns were considered (9,20–23).

Several researchers have reported dietary patterns derived from FFQ in cohort studies using factor analysis. Although several distinct patterns were defined, 2 patterns were relatively dominant. One is a healthful or prudent or vegetable-fruit dietary pattern characterized by low fat and high fruit, vegetable, and whole grain intake. The other is a Western or traditional or red meat-starch pattern characterized by high fat, meat, and refined grain consumption. Additionally, "sweet," "drinker," and "Southern" patterns have been identified (1,9,24–27). Food intakes were represented by different methods in past factor analyses. Some studies used individual food items in the questionnaire for factor analysis. Others aggregated food items for the FFQ into food groups to reduce the number of variables considered and improve their distribution. Some authors did food groupings based on the similarity of nutrient profiles or culinary usage, while others used predefined food groups. The resulting number of food group variables input into factor analysis differed widely, from 26 to 49. We used a different scheme of aggregating foods, where groups were based on the Food Guide Pyramid groups and servings defined by the USDA. Although some mixed dishes may contribute to distinct dietary patterns (5), the USDA system groups basic foods and ingredients to define dietary patterns. The use of USDA food groupings may provide a common system for comparison of results from many different dietary pattern studies.

The first pattern found in our study, Fat and Meat, was characterized in other studies as the Western pattern. The second and third patterns, Vegetables and Fruit and Milk, respectively, appear consistent with a set of food items that has been labeled the "prudent" pattern. This pattern did not necessarily include dairy products, even low-fat dairy products, as ours did. Interestingly, in our study fruits and milk were extracted as 1 pattern but vegetables did not load with any dairy products. The Vegetables pattern showed relatively high loadings for fruits but small negative loadings for cheese and milk and yogurt. This result suggests that vegetables and fruits should not be aggregated into 1 food group. In this study, milk and yogurt were associated with fruits, resulting in separate patterns for fruits and vegetables. When we tried to extract only 2 factors instead of 3, fruits and vegetables were defined in the same pattern. But the loading of milk and yogurt weakened significantly and did not contribute to either factor. Additionally this 2-factor model did not show an acceptable goodness of fit of the data when modeled by CFA.

Initially, EFA based on 20 food groups was performed separately for the 5 ethnic groups and for women and men, resulting in 10 ethnic-gender groups (see supplemental Appendix A). Other starchy vegetables loaded in Factor 2 for 7 ethnic-gender groups, but did not make it into the overall model (loading = 0.59). Whole grains loaded for 6 groups and added sugars for 2 groups in Factor 3, although they did not load in the overall model (loading of 0.59 and 0.46, respectively). Therefore, the pattern for Factor 3, Fruit and Milk in the final factor model, may be a breakfast pattern. EFA, with 13 food groups, showed almost identical patterns across 10 ethnic-gender groups, although factor loadings for the food groups varied slightly (see supplemental Appendix B). Additionally, CFA proved that the indices for the goodness of fit of the data to the model were acceptable for all groups. Therefore, we applied the 3-factor solution to the whole study population rather than using separate factors for each gender and ethnic group. This may result in a decrease in the accuracy of the measurement of ethnic- or gender-specific dietary patterns. However, using the same weightings allowed for comparison of the differences in mean scores between men and women and among ethnicities.

Previous studies have reported that women tended to have generally higher scores on healthy dietary patterns (28–32). Similarly, our results showed that men had much higher scores for the Fat ant Meat pattern and slightly lower scores on the Vegetables and Fruit and Milk patterns than women. We also found differences in pattern scores across ethnicities. Hawaiians and Latinos had high scores for the Fat and Meat pattern, but the differences in the Vegetables and Fruit and Milk patterns across ethnicities were much larger. Japanese Americans showed the highest score on the Vegetables pattern, whereas they showed the lowest score on the Fruit and Milk pattern. A few studies have compared dietary patterns among different ethnicities. Kerver et al. (32) reported that African Americans and Mexican Americans tended to have lower scores for an "American-healthy" pattern than did whites, whereas North and Emmett (33) reported that more nonwhite children showed healthy patterns than white children in the United Kingdom. In contrast, Bell et al. (34) found no significant differences among whites, African Americans, and Native Americans.

Our observation that the 3 dietary patterns are differently related to age and health characteristics is consistent with earlier studies. Age showed a negative association with a Western or red meat-starch pattern and a positive association with vegetable-fruit patterns in other studies as well as ours (1,9,21). More educated people showed higher scores for the Vegetables and Fruit and Milk patterns and lower scores for the Fat and Meat pattern, which was also observed in other studies (9,21).

In our study, the Fat and Meat pattern was positively associated with BMI, smoking, and alcohol consumption but negatively associated with dietary supplement use, whereas Vegetables and Fruit and Milk patterns were negatively associated with smoking but positively associated with physical activity and supplement use. Similar findings have been reported in previous studies (1,9,21,22). Although our 2 healthy patterns showed similar relations with covariates, only the Fruit and Milk pattern was negatively associated with BMI and alcohol consumption. Thus the Fruit and Milk pattern was more strongly associated with healthy lifestyles than the Vegetables pattern.

We did not find any effect of baseline personal or family history of cancer on dietary patterns. However, other studies have found an association between dietary patterns and later risk of cancer, although the findings are inconsistent (20,25,35–40). Further investigations of the association of baseline dietary patterns with subsequent cancer incidence are planned for the Multiethnic Cohort Study.

There are several strengths to this study. A very large multiethnic population was used to determine the patterns, and we were able to perform both EFA and CFA. Several methodological concerns have been pointed out in dietary pattern analysis such as the food grouping scheme, quantifying and transforming input variables, and deriving patterns separately for gender and ethnicity (6,7). We were able to overcome many of these problems in our study.

However, there are still some limitations. The Food Guide Pyramid was developed to focus on Americans' diets; therefore this food grouping scheme might not be appropriate in non-U.S. populations. Also, the study sample for the Multiethnic Cohort is from Hawaii and California, which may not be nationally representative. Furthermore, the statistics for the goodness of fit from CFA were acceptable but not excellent on the basis of the recommendation that CFI and NNFI should both exceed 0.9 and, ideally, be equal to 1.0 (10). Schulze et al. (41) reported a good fit of the 2-factor model using only 8 food groups. In factor analysis, a good fit is represented by variables having a relatively high factor loading on only 1 factor and near zero loadings on the other factors. However, in pattern analysis of foods, most researchers have over 20 food group variables, many of which have relatively high loading on more than 1 factor. Thus it may be difficult to get an excellent fit of the model from CFA in dietary pattern analysis.

In conclusion, 3 factors explained 63.5% of the variability in diet in the Multiethnic Cohort, and these same factors were found in each ethnic-gender group. Our data also show that dietary patterns were associated with age, gender, ethnicity, education, and health behavior in this large multiethnic population. These findings support the hypothesis that dietary patterns are influenced by interrelated sociocultural, demographic, and other lifestyle factors, which may be important for the implementation of programs to improve public health through dietary modification. In future analyses of dietary patterns and disease associations in the Multiethnic Cohort and other studies, these variables must be considered potential confounding factors.

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