

Food Combination and Alzheimer Disease Risk

A Protective Diet

Yian Gu, PhD; Jeri W. Nieves, PhD; Yaakov Stern, PhD; Jose A. Luchsinger, MD, MPH; Nikolaos Scarmeas, MD, MS

Arch Neurol. 2010;67(6):699-706

eTable 1. List of Food Items Included in Each of the 30 Food Groups Used in RRR Analysis

| Food Group (n=30) | Member Food Items |
|------------------------|---|
| Fruits | Fresh apples or pears, oranges; peaches, apricots, or plums; bananas; other fruits |
| Fruit juice | Orange juice or grapefruit juice |
| Green leafy vegetables | Cooked spinach or collard greens |
| Cruciferous vegetables | Broccoli; cabbage, cauliflower, or brussels sprouts |
| Dark leafy vegetables | Yams or sweet potatoes; carrots-raw; carrots-cooked; yellow (winter) squash |
| Tomato | Tomato |
| Legume | Peas or lima beans; beans or lentils |
| Other vegetables | String beans; corn |
| Nuts | Nuts; peanut butter |
| Fish | Fish |
| Salad dressing | Oil and vinegar dressing |
| Low-fat dairy | Skim or low-fat milk; yogurt |
| High-fat dairy | Whole milk; ice cream; cottage/ricotta cheese; other cheese |
| Butter | Butter |
| Margarine | Margarine |
| Eggs | Eggs |
| Organ meat | Liver |
| Poultry | Chicken or turkey, with or without skin |
| Processed meat | Bacon; hot dogs; processed meats, eg, sausage, salami, bologna |
| Red meat | Hamburger; beef, pork, or lamb as a sandwich or main dish |
| Snacks | Potato chips or corn chips |
| Sweets | Pie, home baked or ready-made; chocolate; candy without chocolate; cake; cookies |
| Potato | French-fried potatoes; potatoes, baked, boiled, or mashed |
| Refined grains | White bread; rice or pasta |
| Whole grain | Dark bread |
| Cold cereal | Cold breakfast cereal |
| High-energy drink | Carbonated beverage with sugar (eg, regular colas), lemonade, or other fruit drinks |
| Low-energy drink | Low-calorie carbonated beverage (eg, diet colas) |
| Coffee | Coffee |
| Tea | Tea |

Abbreviation: RRR, reduced rank regression.

eTable 2. Characteristics of the Study Population by Disease Status

| Characteristic | No. (%) | | | P Value ^a |
|-----------------------------------|--------------|---------------------------|---------------------|----------------------|
| | All (N=2148) | Without Dementia (n=1895) | Incident AD (n=253) | |
| Age, y, mean (SD) | 77.2 (6.6) | 76.5 (6.3) | 81.9 (6.9) | <.001 |
| Female | 1457 (68) | 1289 (68) | 168 (66) | .59 |
| Education, y, mean (SD) | 10.0 (4.8) | 10.4 (4.6) | 7.0 (4.5) | <.001 |
| Ethnicity | | | | |
| White | 596 (28) | 568 (30) | 28 (11) | <.001 |
| Black | 693 (32) | 612 (32) | 81 (32) | |
| Hispanic | 823 (38) | 684 (36) | 139 (55) | |
| Other | 36 (2) | 31 (2) | 5 (2) | |
| Presence of APOE ε4 allele | 508 (27) | 436 (27) | 72 (32) | .08 |
| Current smoker | 268 (13) | 235 (12) | 33 (13) | .76 |
| Comorbidity index, mean (SD) | 1.9 (1.4) | 1.9 (1.4) | 1.9 (1.5) | .96 |
| Caloric intake, kcal/d, mean (SD) | 1426 (515) | 1419 (509) | 1476 (552) | .10 |
| BMI, mean (SD) | 27.4 (5.5) | 27.5 (5.4) | 26.5 (5.9) | .01 |
| Moderate alcohol drinking | 693 (32) | 640 (34) | 53 (21) | <.001 |
| DP score 2, mean (SD) | 4.3 (1.7) | 0.04 (1.1) | -0.28 (1.0) | <.001 |
| Low DP score 2 tertile | 749 (35) | 632 (33) | 117 (46) | <.001 |
| Middle DP score 2 tertile | 717 (33) | 631 (33) | 86 (34) | |
| High DP score 2 tertile | 682 (32) | 632 (33) | 50 (20) | |

Abbreviations: AD, Alzheimer disease; APOE, apolipoprotein E; BMI, body mass index (calculated as weight in kilograms divided by height in meters squared); DP, dietary pattern.

^aP values for trend from χ^2 test for categorical variables and from analysis of variance for continuous variables.

eTable 3. Factor Loadings of Food Groups Associated With the 7 DPs^a

| Food Group ^b | DP 1 ^c | DP 2 | DP 3 | DP 4 | DP 5 | DP 6 | DP 7 |
|-------------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
| Fruits | -0.34 ^d | 0.17 ^e | -0.02 | 0.04 | -0.10 | 0.19 ^e | 0.10 |
| Fruit juice | -0.30 ^d | 0.12 | 0.08 | 0.37 ^e | 0.12 | -0.09 | -0.09 |
| Green leafy vegetables | -0.15 ^d | 0.15 ^e | 0.19 ^e | 0.32 ^e | 0.11 | 0.30 ^e | -0.02 |
| Cruciferous vegetables | -0.26 ^d | 0.21 ^e | 0.23 ^e | 0.27 ^e | -0.02 | 0.06 | 0.03 |
| Dark leafy vegetables | -0.29 ^d | 0.16 ^e | 0.08 | 0.14 | 0.06 | 0.01 | 0.05 |
| Tomato | -0.14 | 0.23 ^e | 0.20 ^e | 0.13 | 0.00 | 0.07 | 0.11 |
| Legume | -0.31 ^d | 0.01 | 0.07 | 0.24 ^e | 0.16 | -0.34 ^d | -0.08 |
| Other vegetables | -0.24 ^d | 0.04 | 0.07 | 0.12 | 0.02 | -0.06 | -0.05 |
| Nuts | 0.14 | 0.32 ^e | 0.07 | 0.35 ^e | -0.49 ^d | 0.03 | 0.12 |
| Fish | -0.07 | 0.27 ^e | 0.15 ^e | -0.20 ^d | 0.40 ^e | 0.38 ^e | -0.39 ^d |
| Salad dressing | 0.09 | 0.51 ^e | 0.11 | -0.12 | 0.24 ^e | -0.28 ^d | 0.19 ^e |
| Low-fat dairy | -0.17 ^d | 0.00 | -0.06 | -0.18 ^d | -0.04 | 0.13 | 0.10 |
| High-fat dairy | 0.14 | -0.32 ^d | 0.04 | 0.19 ^e | 0.46 ^e | -0.03 | 0.56 ^e |
| Butter | 0.12 | -0.15 ^d | 0.03 | 0.12 | 0.18 | 0.06 | 0.17 ^e |
| Margarine | 0.12 | 0.12 | 0.04 | -0.05 | 0.02 | -0.01 | 0.03 |
| Eggs | 0.18 ^e | -0.05 | 0.08 | 0.20 ^e | -0.01 | 0.09 | -0.08 |
| Organ meat | -0.05 | -0.18 ^d | 0.83 ^e | -0.24 ^d | -0.13 | -0.11 | 0.00 |
| Poultry | 0.02 | 0.22 ^e | -0.03 | -0.14 | 0.12 | 0.12 | -0.04 |
| Processed meat | 0.29 ^e | -0.12 | 0.10 | 0.17 | -0.08 | 0.06 | -0.32 ^d |
| Red meat | 0.28 ^e | -0.29 ^d | 0.10 | 0.19 ^e | 0.01 | -0.04 | -0.38 ^d |
| Snacks | 0.12 | 0.04 | 0.07 | 0.02 | -0.19 | -0.09 | 0.08 |
| Sweets | 0.29 ^e | 0.03 | -0.12 | -0.10 | -0.23 ^d | -0.10 | -0.05 |
| Potato | -0.13 | -0.04 | -0.09 | -0.04 | -0.02 | -0.06 | -0.12 |
| Refined grains | -0.14 | -0.07 | -0.14 | -0.21 ^d | -0.04 | -0.34 ^d | 0.03 |
| Whole grain | -0.01 | 0.12 | -0.01 | -0.06 | 0.01 | 0.10 | -0.01 |
| Cold cereal | -0.10 | 0.04 | 0.02 | -0.10 | -0.27 ^d | 0.52 ^e | 0.33 ^e |
| High-energy drink | -0.02 | -0.14 | -0.18 ^d | -0.26 ^d | -0.14 | -0.13 | -0.08 |
| Low-energy drink | 0.05 | -0.02 | 0.00 | 0.01 | 0.04 | 0.04 | -0.08 |
| Coffee | 0.02 | -0.07 | -0.03 | 0.00 | 0.01 | -0.10 | -0.03 |
| Tea | 0.01 | 0.03 | 0.05 | -0.01 | 0.05 | 0.05 | -0.06 |

Abbreviation: DP, dietary pattern.

^aFactor loadings represent the magnitude and direction of each food group's contribution to a specific DP score. A positive factor loading indicates an increased intake of the food group. A negative loading indicates less intake of the food group.

^bFood components of each food group are presented in eTable 1.

^cPatterns were derived with reduced rank regression with 7 nutrients (saturated fatty acids, monounsaturated fatty acids, ω-3 polyunsaturated fatty acids, ω-6 polyunsaturated fatty acids, vitamin E, vitamin B₁₂, and folate) as response variables and 30 foods and food groups as the independent variables. The number of factors identified is equal to the number of response variables included in the reduced rank regression model.¹

^dFactor loading 0.15 or more.

^eFactor loading -0.15 or less.

Table 4. Associations of Food Groups, Nutrients, and AD Risk With DP 2

| | 7 Nutrients ^a | 7 Nutrients + Vitamin C | 7 Nutrients + β-Carotene | 7 Nutrients + Vitamin C + β-Carotene |
|--|--------------------------|----------------------------|-----------------------------|---|
| Explained % of Variation in Nutrients | | | | |
| SFA | 19.37 | 5.73 | 3.61 | 1.28 |
| MUFA | 0.59 | 2.18 | 3.27 | 7.06 |
| ω-3 PUFA | 36.34 | 41.07 | 41.47 | 42.22 |
| ω-6 PUFA | 48.75 | 62.33 | 61.00 | 65.50 |
| Vitamin E | 13.85 | 15.50 | 15.64 | 15.46 |
| Vitamin B ₁₂ | 6.05 | 2.63 | 0.95 | 0.89 |
| Folate | 5.30 | 2.31 | 2.28 | 0.95 |
| Vitamin C | NA | 5.18 | NA | 1.75 |
| β-Carotene | NA | NA | 11.97 | 7.20 |
| Explained proportion of variation in all nutrients | 18.61 | 17.12 | 17.53 | 15.81 |
| Explained proportion of variation in all food groups | 5.17 | 4.62 | 4.68 | 4.40 |
| Correlation Coefficients Between Pattern Scores and Nutrients | | | | |
| SFA | -0.44 | -0.24 | -0.19 | -0.11 |
| MUFA | -0.08 | 0.15 | 0.18 | 0.27 |
| ω-3 PUFA | 0.60 | 0.64 | 0.64 | 0.65 |
| ω-6 PUFA | 0.70 | 0.79 | 0.78 | 0.81 |
| Vitamin E | 0.37 | 0.39 | 0.40 | 0.39 |
| Vitamin B ₁₂ | -0.25 | -0.16 | -0.10 | -0.09 |
| Folate | 0.23 | 0.15 | 0.15 | 0.10 |
| Vitamin C | NA | 0.23 | NA | 0.13 |
| β-Carotene | NA | NA | 0.35 | 0.27 |
| Effect Loadings for Food Groups^b | | | | |
| Salad dressing | 0.51 | 0.56 | 0.53 | 0.55 |
| Nuts | 0.32 | 0.40 | 0.38 | 0.41 |
| Fish | 0.27 | 0.25 | 0.27 | 0.25 |
| Tomato | 0.23 | 0.24 | 0.24 | 0.24 |
| Poultry | 0.22 | 0.21 | 0.20 | 0.19 |
| Cruciferous vegetables | 0.21 | 0.21 | 0.24 | 0.22 |
| Fruits | 0.17 | <0.15 | <0.15 | <0.15 |
| Dark leafy vegetables | 0.16 | <0.15 | 0.23 | 0.17 |
| Green leafy vegetables | 0.15 | <0.15 | 0.22 | 0.19 |
| Butter | -0.15 | >-0.15 | >-0.15 | >-0.15 |
| Organ meat | -0.18 | >-0.15 | >-0.15 | >-0.15 |
| Red meat | -0.29 | -0.20 | -0.17 | >-0.15 |
| High-fat dairy | -0.32 | -0.27 | -0.20 | -0.22 |
| HR (95% CI)^c | | | | |
| Lowest tertile | | | | |
| Middle tertile | 0.72 (0.54-0.96) | 0.69 (0.52-0.93) | 0.69 (0.51-0.92) | 0.70 (0.52-0.94) |
| Highest tertile | 0.59 (0.42-0.82) | 0.63 (0.45-0.88) | 0.58 (0.41-0.82) | 0.55 (0.39-0.78) |
| <i>P</i> for trend ^d | .001 | <.001 | .001 | <.001 |

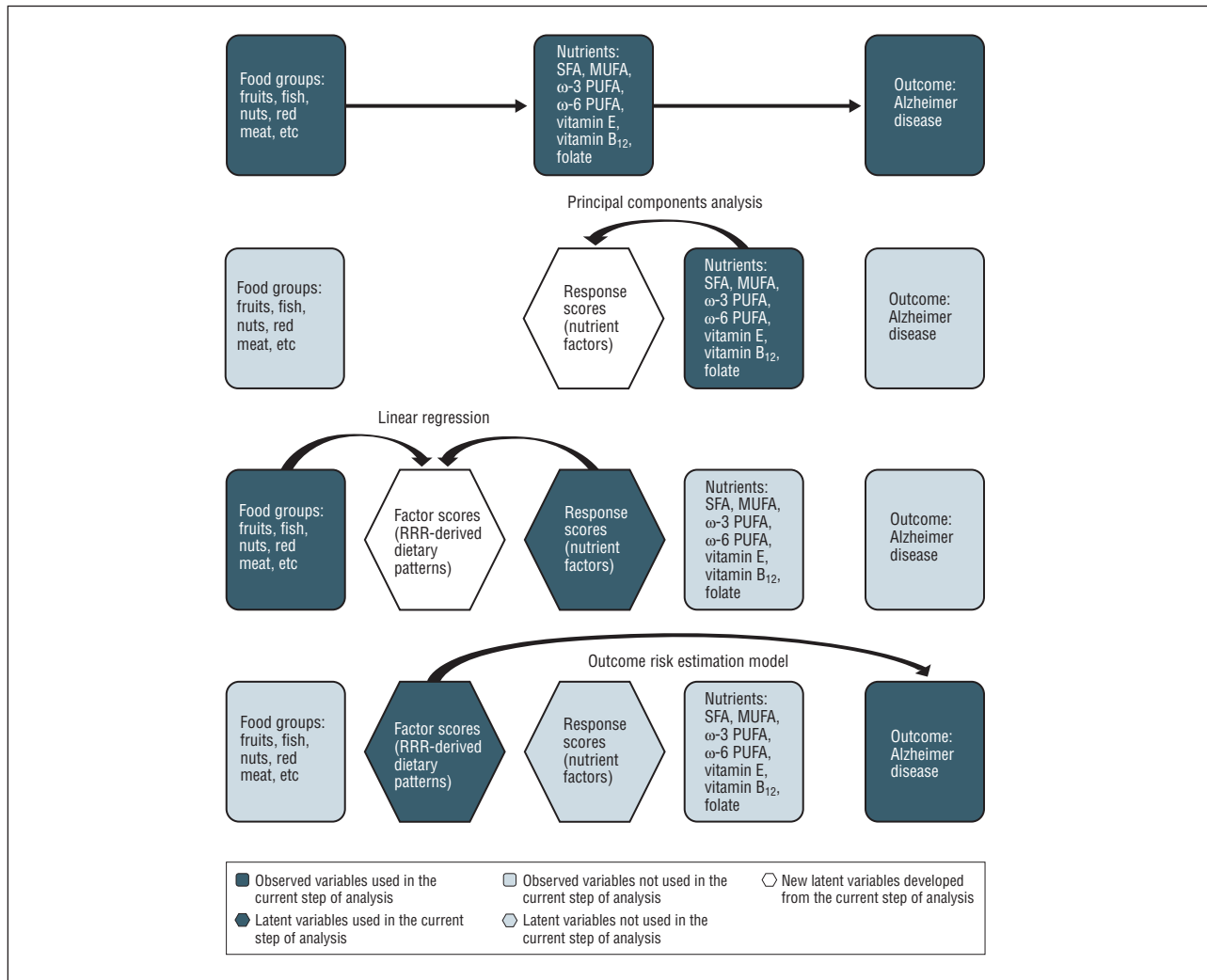
Abbreviations: AD, Alzheimer disease; CI, confidence interval; HR, hazard ratio; MUFA, monounsaturated fatty acids; NA, not applicable; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

^aThe 7 nutrients include SFA, MUFA, ω-3 PUFA, ω-6 PUFA, vitamin E, vitamin B₁₂, and folate.

^bOnly food groups with absolute effect loadings greater than 0.15 are presented in the Table.

^cAdjusted for recruitment cohort, age, education, ethnicity, and sex.

^dTests for trend with 2-sided *P* values were evaluated by entering the tertile terms as an ordinal variable in the Cox proportional hazard model.



eFigure. Overview of the reduced rank regression (RRR) procedure. MUFA indicates monounsaturated fatty acids; PUFA, polyunsaturated fatty acids; SFA, saturated fatty acids.

REFERENCE

- Hoffmann K, Schulze MB, Schienkiewitz A, Nothlings U, Boeing H. Application of a new statistical method to derive dietary patterns in nutritional epidemiology. *Am J Epidemiol.* 2004;159(10):935-944.