

Dietary Patterns Associated with the New Onset of Chronic Kidney Disease Using Clustering Algorithm

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Table S1. Classification of 21 food groups, 106 food items, and seven food categories.

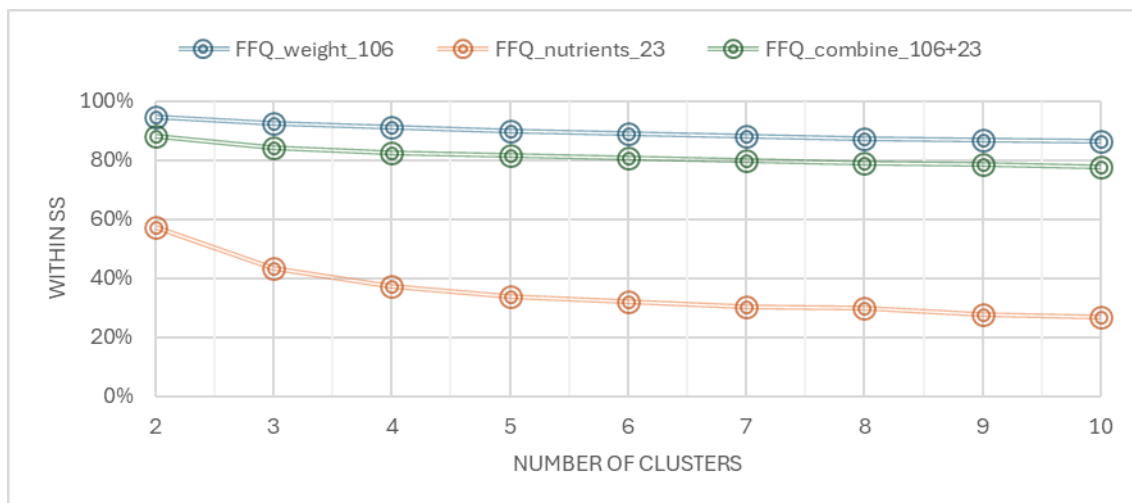
Food groups	Food items	Food categories ^a
Rice	Cooked rice, rice cake, rice cake with soup, other rice cakes	Grains
Other grains	Cooked rice with soybean, cooked rice with other cereals, half-and-half cooked well-milled rice and rice with soybean, half-and-half cooked well-milled rice and rice with other cereals, parched cereal powder	Grains
Noodles and dumplings	Ramen, wheat noodles with soup, chajang myon, jambbong, buckwheat vermicelli, buckwheat noodle, dumpling, dumpling with soup	Grains
Wheat flour and bread	Cereals, corn flakes, loaf bread, sandwich, toast, bread with small red bean, other breads, cakes, choco pie, pizza, hamburger, cookie, cracker, snack	Grains
Potatoes	Starch jelly, potatoes, sweet potatoes, starch vermicelli	Grains
Sweets	Candy, chocolate, coffee sugar	Sugary and Caffeinated Consumables
Soybean pastes	Soup and stew with soybean paste, soybean paste	fish and meat
Bean, tofu, and soymilk	Legumes, tofu, soybean milk	fish and meat
Nuts	Nuts	Fats
Vegetables	Radish, salted radish, Korean cabbages, Korean cabbage soup, spinach, lettuce, perilla leaf, vegetable wrap, vegetable salad, other green vegetables, deoduck, doraji, bean sprouts, bracken, sweet potato stalk, stem of taro, pepper leaves, chamnamul, aster scaber, crown daisy, leek, water dropwort, cucumber, carrot, carrot juice, onion, green pepper, pumpkin (immature), pumpkin (mature), pumpkin juice	Vegetables

Kimchi	Kimchi, Korean cabbage, kakdugi, small-radish kimchi, kimchi with water, radish with water, other kimchi, Korean-style pickles	Vegetables
Mushroom	Oyster mushroom, other mushrooms	Vegetables
Fruits	Strawberry, muskmelon, melon, watermelon, peach, plum, banana, persimmon, tangerine, pear, pear juice, apple, apple juice, orange, orange juice, grape, grape juice, tomato, cherry tomato, tomato juice	Fruits
Red meat and its products	Pork, ham, sausage, edible viscera, steak, beef, dog meat, beef soup, beef soup with vegetables	Fish and Meat
White meat and its products	Chicken	Fish and Meat
Eggs	Eggs	Fish and Meat
Fish and shellfish	Sashimi, mackerel, Pacific saury, Spanish mackerel, hairtail, eel, yellow croaker, sea bream, flatfish, Alaska pollock, cuttlefish, octopus, dried anchovies, tuna, salt-fermented fish, clam, whelk, oyster, crab, shrimp, fish paste, crab-flavored	Fish and Meat
Seaweeds	Laver, kelp, sea mustard	Vegetables
Milk and dairy products	Milk, yogurt, ice cream, cheese, coffee cream	Milk and Dairy Products
Beverage	Carbonated drinks, other drinks	Sugary and Caffeinated Consumables
Coffee and tea	Coffee, green tea	Sugary and Caffeinated Consumables

^aFood categories were classified by modifying the Food Exchange List Guidelines published by the Korean Diabetes Association.

Figure S1. Determination of optimal cluster number based on within-cluster sum of squares and chronic kidney disease (CKD) risk differentiation. **(A)** Proportion of within-cluster sum of squares (Within SS) relative to the total sum of squares according to the number of clusters, stratified by variable type: FFQ_weight_106 (dietary item weights, blue), FFQ_nutrients_23 (energy and 22 nutrient variables, orange), and FFQ_combine_106+23 (combined features, green). A lower Within SS indicates greater clustering tightness. **(B)** Statistical significance of inter-cluster differences in CKD incidence, visualized as $-\log_{10}(p\text{-value})$ by number of clusters for the same variable types. Higher values represent stronger statistical separation of CKD risk across clusters. Based on the combined evaluation of Within SS and statistical significance, the optimal number of clusters was determined to be three, balancing interpretability and discrimination of CKD risk.

(A)



(B)

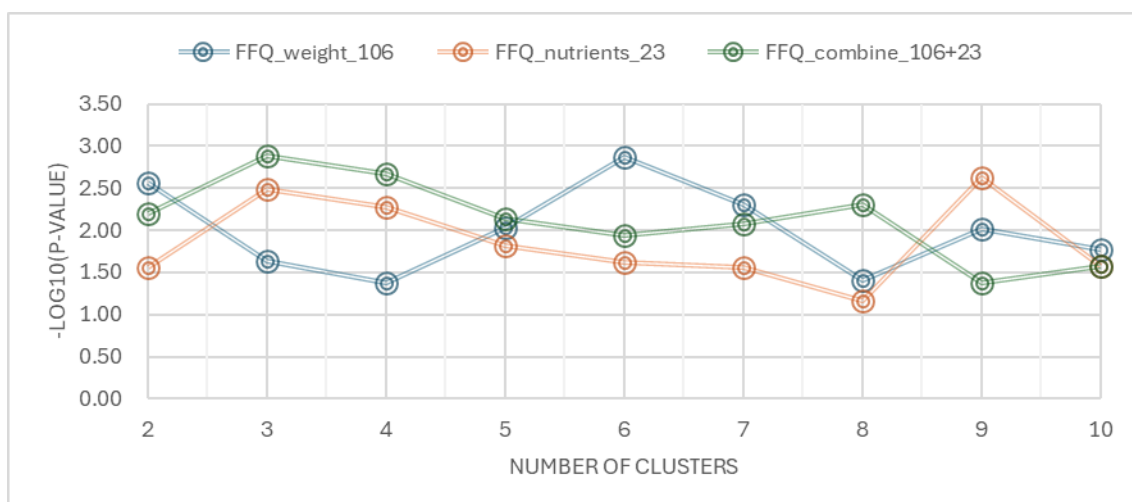


Table S2. Post-*hoc* analysis results.

Continuous variables	<i>P</i> -values		
	A vs. B	A vs. C	B vs. C
Age	0.008	<0.001	<0.001
Systolic blood pressure	0.270	<0.001	<0.001
Body mass index	0.004	<0.001	<0.001
eGFR	0.479	<0.001	<0.001
Hemoglobin	0.101	0.421	<0.001
Albumin	0.076	0.054	0.862
Total cholesterol	0.407	0.240	<0.001

Abbreviation: eGFR, estimated glomerular filtration rate.

Table S3. Unsupervised learning (k-means) results.

Variables	Clusters			Total
	A	B	C	
Total number, n (%)	4,152 (7.3)	22,127 (38.7)	30,934 (54.1)	57,213 (100.0)
CKD numbers, n	24	179	322	525
% of outcome, %	0.58	0.81	1.04	0.92

Abbreviation: CKD, chronic kidney disease.

Table S4. Intake values of 21 food groups according to clusters.

Categories	Food groups	Overall ^a	Cluster A ^a	Cluster B ^a	Cluster C ^a	F statistics	P-value
Original values	Rice (Grains)	39.6 (81.2)	35.5 (76.8)	36.1 (78.8)	42.6 (83.2)	47.68	<0.001
	Other grains (Grains)	94.7 (55.2)	101.5 (54.6)	101.4 (54.4)	89.0 (55.2)	367.63	<0.001
	Noodles & dumplings (Grains)	10.2 (13.5)	16.1 (20.7)	12.8 (15.9)	7.6 (9.2)	1,229.62	<0.001
	Wheat flour & bread (Grains)	2.9 (4.6)	6.0 (8.2)	3.8 (5.2)	1.8 (2.7)	1,828.49	<0.001
	Potatoes (Grains)	4.9 (6.4)	11.8 (13.2)	6.1 (6.3)	3.2 (3.8)	2,565.97	<0.001
	Seaweeds (Vegetables)	3.9 (4.1)	7.0 (7.2)	4.4 (4.1)	3.1 (3.2)	1,269.04	<0.001
	Soybean pastes (Fish & Meat)	11.9 (16.7)	27.8 (30.9)	14.8 (17.5)	7.7 (10.6)	2,171.28	<0.001
	Bean & tofu & soymilk (Fish & Meat)	4.7 (5.2)	10.5 (10.3)	6.1 (5.2)	2.9 (2.7)	4,357.11	<0.001
	Nuts (Fats)	3.9 (6.3)	7.5 (13.3)	4.8 (6.4)	2.7 (4.1)	1,167.08	<0.001
	Vegetables (Vegetables)	11.9 (14.8)	21.2 (24.8)	15.2 (16.0)	8.3 (10.4)	2,017.33	<0.001
	Kimchi (Vegetables)	2.7 (2.6)	7.3 (5.4)	3.4 (2.1)	1.6 (1.1)	8,457.11	<0.001
	Mushroom (Vegetables)	6.0 (5.5)	17.3 (11.1)	7.2 (3.7)	3.7 (2.3)	10,549.2	<0.001
	Fruits (Fruits)	29.1 (23.2)	59.2 (39.9)	34.7 (22.0)	21.0 (15.1)	4,768.79	<0.001
	Red meat & its products (Fish & Meat)	4.6 (6.7)	12.9 (14.5)	5.9 (6.3)	2.6 (3.3)	3,399.49	<0.001
	White meat & its products (Fish & Meat)	1.7 (1.8)	2.1 (2.2)	2.0 (1.9)	1.5 (1.6)	576.14	<0.001
	Eggs (Fish & Meat)	18.4 (18.3)	38.2 (35.3)	23.7 (18.0)	11.9 (10.3)	4,812.65	<0.001
	Fish & shellfish (Fish & Meat)	24.5 (27.6)	48.4 (46.8)	31.0 (28.7)	16.6 (18.9)	2,877.89	<0.001
	Sweets (Sugary & Caffein)	1.6 (3.7)	3.5 (6.6)	2.2 (4.2)	1.0 (2.3)	1,017.58	<0.001
	Milk & dairy products (Milk & Daily)	1.0 (1.1)	2.3 (2.0)	1.3 (1.0)	0.7 (0.6)	4,119.34	<0.001
	Beverage (Sugary & Caffein)	15.7 (34.8)	37.6 (62.3)	20.2 (39.3)	9.6 (22.3)	1,012.79	<0.001
	Coffee & tea (Sugary & Caffein)	26.1 (45.7)	49.6 (66.0)	32.6 (49.8)	18.3 (36.6)	1,005.1	<0.001
Adjusted normalized values	Rice (Grains)	0.0 (1.0)	-0.1 (0.9)	-0.1 (1.0)	0.0 (1.0)	72.0	<0.001
	Other grains (Grains)	0.0 (1.0)	0.1 (1.0)	0.1 (1.0)	-0.1 (1.0)	402.2	<0.001

Noodles & dumplings (Grains)	0.0 (1.0)	0.4 (1.5)	0.2 (1.2)	-0.2 (0.7)	1,085.4	<0.001
Wheat flour & bread (Grains)	0.0 (1.0)	0.7 (1.8)	0.2 (1.1)	-0.2 (0.6)	1,683.0	<0.001
Potatoes (Grains)	0.0 (1.0)	1.1 (2.1)	0.2 (1.0)	-0.3 (0.6)	2,689.0	<0.001
Seaweeds (Vegetables)	0.0 (1.0)	0.8 (1.7)	0.1 (1.0)	-0.2 (0.8)	1,364.5	<0.001
Soybean pastes (Fish & Meat)	0.0 (1.0)	1.0 (1.9)	0.2 (1.0)	-0.2 (0.6)	2,152.3	<0.001
Bean & tofu & soymilk (Fish & Meat)	0.0 (1.0)	1.1 (2.0)	0.3 (1.0)	-0.3 (0.5)	4,139.5	<0.001
Nuts (Fats)	0.0 (1.0)	0.6 (2.1)	0.1 (1.0)	-0.2 (0.7)	1,018.4	<0.001
Vegetables (Vegetables)	0.0 (1.0)	0.6 (1.7)	0.2 (1.1)	-0.2 (0.7)	1,921.2	<0.001
Kimchi (Vegetables)	0.0 (1.0)	1.7 (2.1)	0.3 (0.8)	-0.4 (0.4)	8,311.4	<0.001
Mushroom (Vegetables)	0.0 (1.0)	2.1 (2.0)	0.2 (0.7)	-0.4 (0.4)	10,548.9	<0.001
Fruits (Fruits)	0.0 (1.0)	1.3 (1.7)	0.2 (0.9)	-0.3 (0.7)	4,721.1	<0.001
Red meat & its products (Fish & Meat)	0.0 (1.0)	1.2 (2.2)	0.2 (0.9)	-0.3 (0.5)	3,411.2	<0.001
White meat & its products (Fish & Meat)	0.0 (1.0)	0.2 (1.2)	0.1 (1.1)	-0.1 (0.9)	520.1	<0.001
Eggs (Fish & Meat)	0.0 (1.0)	1.1 (1.9)	0.3 (1.0)	-0.4 (0.6)	4,989.8	<0.001
Fish & shellfish (Fish & Meat)	0.0 (1.0)	0.9 (1.7)	0.2 (1.0)	-0.3 (0.7)	2,941.0	<0.001
Sweets (Sugary & Caffein)	0.0 (1.0)	0.5 (1.8)	0.2 (1.1)	-0.2 (0.6)	1,087.2	<0.001
Milk & dairy products (Milk & Dairy)	0.0 (1.0)	1.2 (1.8)	0.2 (1.0)	-0.3 (0.6)	4,296.8	<0.001
Beverage (Sugary & Caffein)	0.0 (1.0)	0.6 (1.8)	0.1 (1.1)	-0.2 (0.6)	931.2	<0.001
Coffee & tea (Sugary & Caffein)	0.0 (1.0)	0.5 (1.4)	0.1 (1.1)	-0.2 (0.8)	908.5	<0.001

^amean (standard deviation)

Table S5. Energy and nutrient intake values according to clusters.

Categories	Energy and Nutrients	Overall ^a	Cluster A ^a	Cluster B ^a	Cluster C ^a	F statistics	P-value
Original values	Energy (kcal)	1,740.9 (506.0)	2,613.4 (536.7)	1,984.9 (376.0)	1,449.2 (322.4)	21,416	<0.001
	Protein (g)	58.8 (23.0)	108.5 (28.2)	69.9 (13.8)	44.2 (10.3)	35,931	<0.001
	Fat (g)	27.3 (15.7)	55.0 (23.1)	34.2 (12.6)	18.7 (7.9)	17,206	<0.001
	Sugar (g)	310.7 (85.8)	423.3 (96.0)	346.2 (73.8)	270.2 (65.2)	10,962	<0.001
	Ca (mg)	446.5 (252.0)	978.3 (340.5)	550.2 (168.6)	300.9 (121.2)	24,252	<0.001
	P (mg)	888.8 (330.6)	1,624.6 (362.7)	1,054.6 (177.2)	671.4 (150.0)	44,730	<0.001
	Fe (mg)	10.0 (4.6)	21.1 (5.9)	12.0 (2.3)	7.1 (1.8)	43,484	<0.001
	K (mg)	2,243.6 (1,008.6)	4,564.3 (1,111.4)	2,728.8 (518.2)	1,585.1 (445.7)	46,300	<0.001
	Zinc (ug)	7.9 (3.3)	14.3 (5.5)	9.3 (2.2)	6.1 (1.6)	20,457	<0.001
	Vitamin A (R.E.)	479.2 (334.2)	1,242.2 (522.8)	589.9 (213.2)	297.7 (132.6)	22,127	<0.001
	Vitamin E (mg)	8.1 (4.1)	17.2 (4.8)	9.9 (2.5)	5.6 (1.7)	34,660	<0.001
	Vitamin B1 (mg)	1.0 (0.4)	1.8 (0.5)	1.2 (0.3)	0.7 (0.2)	31,078	<0.001
	Vitamin B2 (mg)	0.9 (0.4)	1.8 (0.5)	1.1 (0.2)	0.6 (0.2)	38,125	<0.001
	Niacin (mg)	14.4 (5.6)	26.5 (6.9)	17.1 (3.4)	10.8 (2.6)	34,023	<0.001
	Vitamin B6 (mg)	1.6 (0.6)	3.1 (0.7)	1.9 (0.3)	1.2 (0.3)	49,447	<0.001
	Vitamin C (mg)	107.7 (68.0)	244.7 (99.9)	134.4 (49.5)	70.3 (32.2)	19,462	<0.001
	Folate (ug)	217.9 (117.5)	487.6 (159.0)	264.1 (70.1)	148.6 (50.4)	29,644	<0.001
	Na (mg)	2,466.8 (1,378.6)	4,971.2 (1,928.9)	2,977.3 (1,068.8)	1,765.4 (823.7)	14,421	<0.001
	Retinol (ug)	68.8 (57.3)	152.3 (102.0)	87.6 (51.3)	44.2 (31.5)	8,186	<0.001
	Carotene (ug)	2,394.4 (1830.9)	6,364.6 (3121.8)	2,926.1 (1,280.9)	1,481.2 (753.0)	15,761	<0.001
	Ash (mg)	14.9 (9.4)	33.5 (16.3)	18.0 (7.3)	10.2 (4.0)	14,396	<0.001
	Fiber (g)	5.8 (2.8)	11.9 (3.7)	6.9 (1.8)	4.1 (1.3)	26,762	<0.001
	Cholesterol (mg)	165.8 (115.5)	360.8 (174.6)	211.1 (96.1)	107.3 (63.3)	13,380	<0.001

Adjusted normalized values	Energy (kcal)	0.0 (1.0)	1.7 (1.1)	0.5 (0.7)	-0.6 (0.6)	21,168.0	<0.001
	Protein (g)	0.0 (1.0)	2.2 (1.2)	0.5 (0.6)	-0.6 (0.5)	35,151.0	<0.001
	Fat (g)	0.0 (1.0)	1.8 (1.5)	0.4 (0.8)	-0.5 (0.5)	16,901.0	<0.001
	Sugar (g)	0.0 (1.0)	1.3 (1.1)	0.4 (0.9)	-0.5 (0.8)	10,699.0	<0.001
	Ca (mg)	0.0 (1.0)	2.1 (1.3)	0.4 (0.7)	-0.6 (0.5)	24,305.0	<0.001
	P (mg)	0.0 (1.0)	2.2 (1.1)	0.5 (0.5)	-0.7 (0.5)	43,061.0	<0.001
	Fe (mg)	0.0 (1.0)	2.4 (1.3)	0.4 (0.5)	-0.6 (0.4)	41,727.0	<0.001
	K (mg)	0.0 (1.0)	2.3 (1.1)	0.5 (0.5)	-0.6 (0.4)	44,586.0	<0.001
	Zinc (ug)	0.0 (1.0)	1.9 (1.7)	0.4 (0.7)	-0.5 (0.5)	19,960.0	<0.001
	Vitamin A (R.E.)	0.0 (1.0)	2.3 (1.6)	0.3 (0.6)	-0.5 (0.4)	21,677.0	<0.001
	Vitamin E (mg)	0.0 (1.0)	2.3 (1.2)	0.4 (0.6)	-0.6 (0.4)	33,352.0	<0.001
	Vitamin B1 (mg)	0.0 (1.0)	2.1 (1.2)	0.5 (0.6)	-0.6 (0.5)	30,727.0	<0.001
	Vitamin B2 (mg)	0.0 (1.0)	2.2 (1.2)	0.5 (0.6)	-0.6 (0.5)	36,660.0	<0.001
	Niacin (mg)	0.0 (1.0)	2.2 (1.2)	0.5 (0.6)	-0.6 (0.5)	33,419.0	<0.001
	Vitamin B6 (mg)	0.0 (1.0)	2.4 (1.1)	0.5 (0.5)	-0.6 (0.4)	47,507.0	<0.001
	Vitamin C (mg)	0.0 (1.0)	2.0 (1.5)	0.4 (0.7)	-0.6 (0.5)	19,533.0	<0.001
	Folate (ug)	0.0 (1.0)	2.3 (1.4)	0.4 (0.6)	-0.6 (0.4)	29,086.0	<0.001
	Na (mg)	0.0 (1.0)	1.8 (1.4)	0.4 (0.8)	-0.5 (0.6)	14,130.0	<0.001
	Retinol (ug)	0.0 (1.0)	1.5 (1.8)	0.3 (0.9)	-0.4 (0.6)	7,914.0	<0.001
	Carotene (ug)	0.0 (1.0)	2.2 (1.7)	0.3 (0.7)	-0.5 (0.4)	15,620.0	<0.001
	Ash (mg)	0.0 (1.0)	2.0 (1.7)	0.3 (0.8)	-0.5 (0.4)	14,180.0	<0.001
	Fiber (g)	0.0 (1.0)	2.2 (1.3)	0.4 (0.6)	-0.6 (0.5)	26,476.0	<0.001
	Cholesterol (mg)	0.0 (1.0)	1.7 (1.5)	0.4 (0.8)	-0.5 (0.6)	12,885.0	<0.001

^amean (standard deviation)

Figure S2. Radar plot of adjusted normalized values for seven food groups according to clusters. Cluster A showed relatively higher intakes of fishes, meat, and vegetables. The range of the axes is the z-score value, normalized to a mean of 0 and a standard deviation of 1.

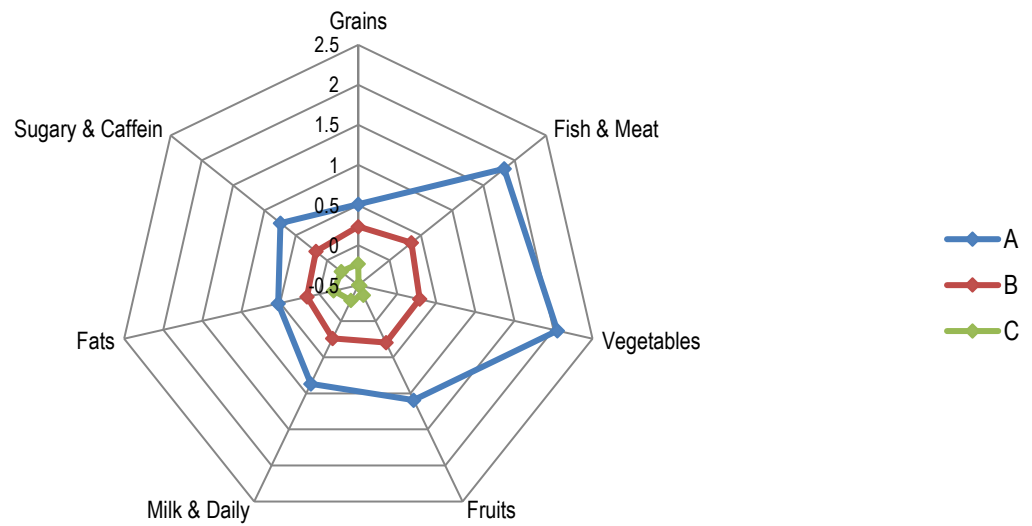


Table S6. Intake values of seven food categories according to clusters.

Categories	Food groups	Overall ^a	Cluster A ^a	Cluster B ^a	Cluster C ^a	F statistics	P-value
Original values	Grains	28.5 (8.2)	32.6 (9.5)	30.4 (8.2)	26.5 (7.5)	2064	<0.001
	Fish & Meat	4.6 (3.4)	10.8 (5.5)	5.8 (2.7)	2.9 (1.6)	13,569	<0.001
	Vegetables	9.8 (6.7)	23.6 (11.1)	11.8 (4.9)	6.6 (3.4)	13,413	<0.001
	Fruits	18.4 (18.3)	38.2 (35.3)	23.7 (18.0)	11.9 (10.3)	4,813	<0.001
	Milk & Daily	24.5 (27.6)	48.4 (46.8)	31.0 (28.7)	16.6 (18.9)	2,878	<0.001
	Fats	1.6 (3.7)	3.5 (6.6)	2.2 (4.2)	1.0 (2.3)	1,018	<0.001
	Sugary & Caffein	12.7 (17.4)	25.8 (27.6)	15.9 (18.7)	8.6 (12.6)	1,916	<0.001
Adjusted normalized values	Grains	0.0 (1.0)	0.5 (1.2)	0.2 (1.0)	-0.2 (0.9)	1,995	<0.001
	Fish & Meat	0.0 (1.0)	1.8 (1.7)	0.3 (0.8)	-0.5 (0.5)	13,103	<0.001
	Vegetables	0.0 (1.0)	2.0 (1.7)	0.3 (0.7)	-0.5 (0.5)	13,247	<0.001
	Fruits	0.0 (1.0)	1.1 (1.9)	0.3 (1.0)	-0.4 (0.6)	4,990	<0.001
	Milk & Daily	0.0 (1.0)	0.9 (1.7)	0.2 (1.0)	-0.3 (0.7)	2,941	<0.001
	Fats	0.0 (1.0)	0.5 (1.8)	0.2 (1.1)	-0.2 (0.6)	1,087	<0.001
	Sugary & Caffein	0.0 (1.0)	0.7 (1.6)	0.2 (1.1)	-0.2 (0.7)	1,756	<0.001

^amean (standard deviation)

Table S7. Number of events and person-years in each cluster.

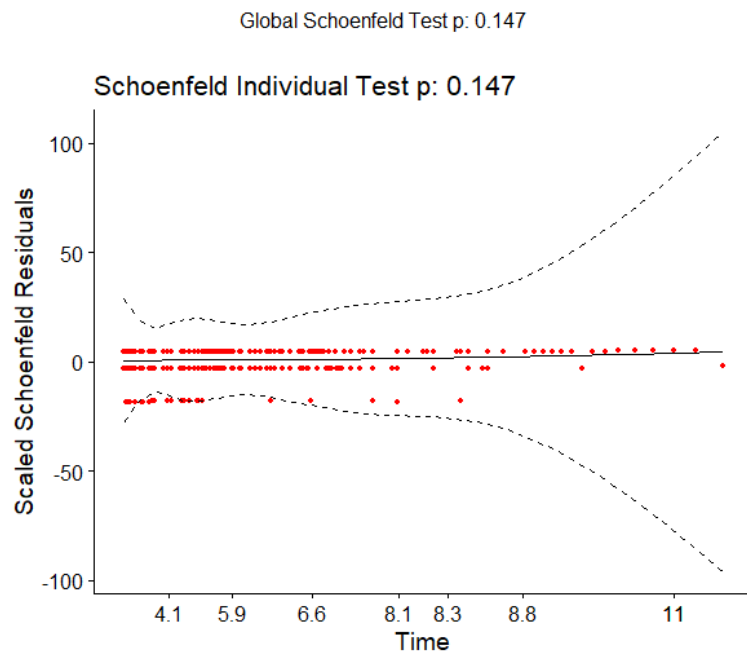
Clusters	Subjects	Number of events	Person-years	Incidence rate per 1000 person-year (95% CI)
A	4,152	24	21,302	1.13 (0.72–1.68)
B	22,127	179	107,760	1.66 (1.43–1.92)
C	30,934	322	149,989	2.15 (1.92–2.39)

Abbreviation: CI, confidence interval.

Figure S3. Schoenfeld residuals tests performed to verify that the Cox proportional hazards assumption.

For the primary variable of interest, the cluster group, no statistically significant violations were identified ($P = 0.0991$).

Model I:



Model IV:

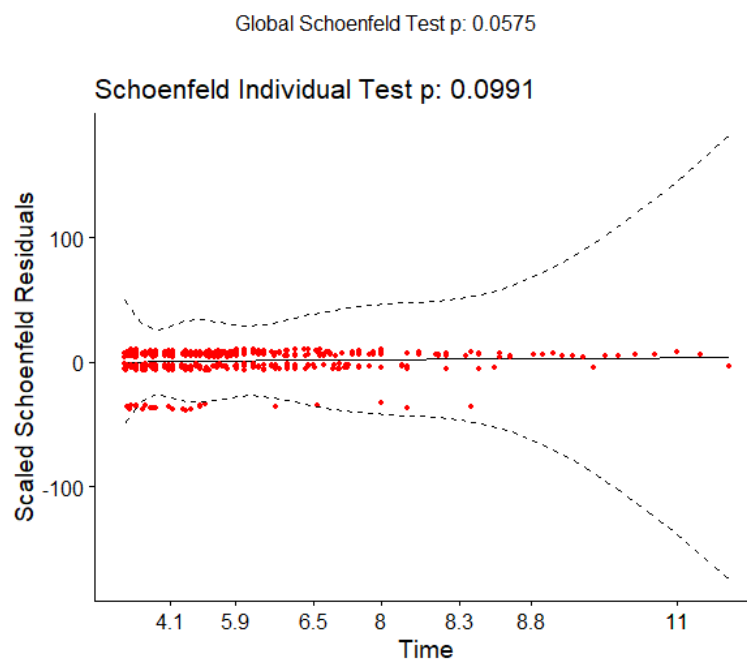


Table S8. Cox regression results for subgroup analyses.

	Subgroups	Participants (%)	Adjusted HR ^a (95% CI)	P value	Plots for adjusted HR and 95% CI	P for interaction
Age	<65 years old	51,423 (89.9)	1.03 (0.65–1.65)	0.895		0.581
	≥65 years old	5,790 (10.1)	3.58 (1.31–9.77)	0.013		
Sex	Male	19,227 (33.6)	2.00 (1.08–3.71)	0.028		0.173
	Female	37,986 (66.4)	1.12 (0.63–1.99)	0.704		
DM	No	52,143 (91.1)	1.53 (0.93–2.52)	0.091		0.309
	Yes	5,065 (8.9)	1.50 (0.67–3.33)	0.320		
HTN	No	41,313 (72.2)	2.03 (0.94–4.36)	0.070		0.449
	Yes	15,900 (27.8)	1.31 (0.79–2.17)	0.289		
CVD	No	55,089 (96.3)	1.24 (0.80–1.93)	0.331		0.493
	Yes	2,124 (3.7)	4.62 (1.08–19.72)	0.039		
SBP	<130 mmHg	38,763 (67.8)	1.18 (0.65–2.13)	0.593		0.617
	≥130 mmHg	18,370 (32.1)	1.96 (1.08–3.56)	0.026		
BMI	<25 kg/m ²	38,993 (68.2)	1.05 (0.65–1.72)	0.831		0.008
	≥25 kg/m ²	18,220 (31.8)	3.62 (1.48–8.84)	0.005		

^aAdjusted hazard ratio (HR) for Class C compared to Class A food groups, fully adjusted model.

Abbreviations: BMI, body mass index; CI, confidence interval; CVD, cardiovascular diseases; DM, diabetes mellitus; HTN, hypertension; HR, hazard ratio; SBP, systolic blood pressure.