Article

Optimal dietary patterns for healthy aging

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As the global population ages, it is critical to identify diets that, beyond preventing noncommunicable diseases, optimally promote healthy aging. Here, using longitudinal questionnaire data from the Nurses' Health Study (1986–2016) and the Health Professionals Follow-Up Study (1986–2016), we examined the association of long-term adherence to eight dietary patterns and ultraprocessed food consumption with healthy aging, as assessed according to measures of cognitive, physical and mental health, as well as living to 70 years of age free of chronic diseases. After up to 30 years of follow-up, 9,771 (9.3%) of 105,015 participants (66% women, mean age = 53 years (s.d. = 8)) achieved healthy aging. For each dietary pattern, higher adherence was associated with greater odds of healthy aging and its domains. The odds ratios for the highest quintile versus the lowest ranged from 1.45 (95% confidence interval (CI) = 1.35–1.57; healthful plant-based diet) to 1.86 (95% CI = 1.71–2.01; Alternative Healthy Eating Index). When the age threshold for healthy aging was shifted to 75 years, the Alternative Healthy Eating Index diet showed the strongest association with healthy aging, with an odds ratio of 2.24 (95% CI = 2.01–2.50). Higher intakes of fruits, vegetables, whole grains, unsaturated fats, nuts, legumes and low-fat dairy products were linked to greater odds of healthy aging, whereas higher intakes of trans fats, sodium, sugary beverages and red or processed meats (or both) were inversely associated. Our findings suggest that dietary patterns rich in plant-based foods, with moderate inclusion of healthy animal-based foods, may enhance overall healthy aging, guiding future dietary guidelines.

The US population of older adults has steadily increased in the past few decades; however, 80% of older adults have at least one chronic health condition, highlighting the complex health challenges facing this demographic shift[1]. Promoting healthy aging is a global priority[1,2]. This commitment is driven by the goal of promoting a high quality of life, supporting continued contribution to society and reducing healthcare costs. Diet is the first leading behavioral risk factor for noncommunicable diseases and mortality burden globally[3], and the second after tobacco use in US older adults [4].

Recently, the World Health Organization acknowledged that prioritizing the preservation of functional ability and the prevention of capacity decline should be central to the model of healthy aging[5]. This shift moves away from the traditional disease-centric approach to aging, aiming to offer older adults enhanced care[5]. Intervention and observational studies have provided compelling evidence that a better-quality diet is beneficial for the prevention of cardiovascular disease[6,7], type 2 diabetes[8] and premature mortality[9]. Studies have also evaluated the effects or the associations of foods and nutrients

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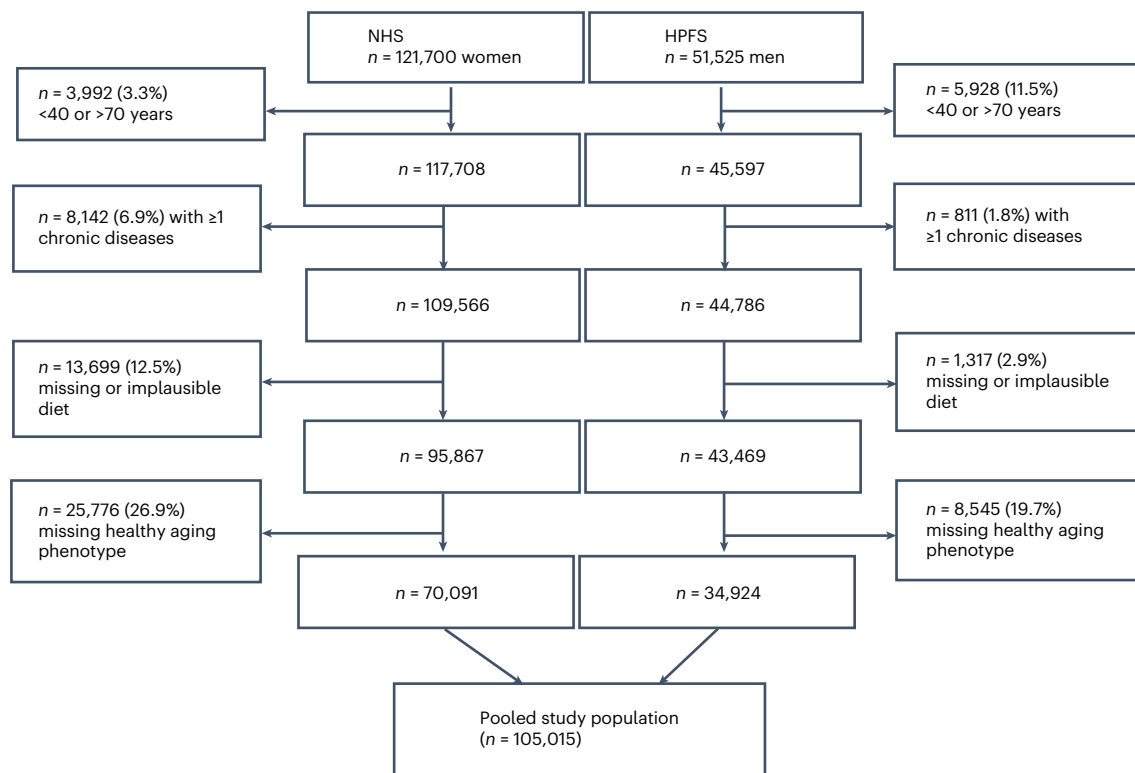
Fig. 1 | Flow diagram of the study participants. This flow diagram shows the initial sample sizes in the NHS and HPFS followed by the sequential application of exclusion criteria for each cohort. The final study population includes a total of 105,015 participants.

with age-related cognitive and physical performance outcomes[10,11] and depressive symptoms[12–14]. However, few studies have examined the association of dietary patterns with a multidimensional model of healthy aging[15–20]. Examining and contrasting dietary patterns in relation to healthy aging will inform public health recommendations aimed at fostering the overall health and well-being of older adults, encompassing cognitive, physical and mental health, and the prevention of chronic diseases.

In this study, we examined the association between long-term adherence to eight healthy dietary patterns, including the Alternative Healthy Eating Index (AHEI), Alternative Mediterranean Index (aMED), the Dietary Approaches to Stop Hypertension (DASH), the Mediterranean-DASH Intervention for Neurodegenerative Delay (MIND), the healthful plant-based diet (hPDI), the Planetary Health Diet Index (PHDI), the empirically inflammatory dietary pattern (EDIP), the empirical dietary index for hyperinsulinemia (EDIH) and ultra-processed food (UPF) consumption, and healthy aging after 30 years in two large prospective US cohorts. We then examined these associations in specific subgroups, including stratification according to sex, ancestry, socioeconomic status (SES) and lifestyle factors. We also examined the associations of individual foods and nutrients contributing to such dietary patterns.

Results

Of 105,015 participants, 70,091 were women (NHS) and 34,924 were men (HPFS) (Fig. 1). After a follow-up of up to 30 years, 9,771 (9.3%) participants achieved healthy aging, 7,602 (10.8%) in the NHS and 2,169 (6.2%) in the HPFS. In the pooled cohorts, 39,769 (37.9%) reached the age of 70 years, 23,908 (22.8%) remained free of 11 chronic diseases, 35,555 (33.9%) maintained intact cognitive function, 29,543 (28.1%) maintained intact physical function and 27,842 (26.5%) maintained intact mental health.

The age-standardized characteristics of the study population are shown in Table 1 (pooled data) and in Extended Data Tables 1 and 2 (according to cohort). Participants in the highest energy-adjusted dietary pattern score quintile were more likely to have a higher SES, use multivitamins, have a higher level of physical activity and slightly lower body mass index (BMI); they were also less likely to have a history of depression compared to the lowest quintile. Participants in the highest quintile for the AHEI, MIND, hPDI, PHDI, reverse EDIH (rEDIH) and reverse EDIP (rEDIP) consumed more alcohol, while those in the highest quintile for DASH and aMED consumed less. While a higher proportion of participants were women in the highest quintile for aMED, PHDI, rEDIH and rEDIP, a higher proportion were men in the highest quintile for AHEI, DASH, MIND and hPDI. Extended Data Fig. 1 shows the Spearman correlations between all dietary pattern scores and UPF consumption.

Higher adherence to all dietary patterns was associated with greater odds of healthy aging (Fig. 2 and Extended Data Table 3); components of the dietary patterns are shown in Fig. 3. The multivariable-adjusted odds ratios (ORs) (95% confidence intervals (CIs)) comparing the highest quintile to the lowest ranged from 1.45 (1.35–1.57; $P < 0.0001$) to 1.86 (1.71–2.01; $P < 0.0001$). The AHEI showed the strongest association followed by the rEDIH; the hPDI showed the weakest association. Based on the differences in ORs between pairs of scores and paired t-tests, the AHEI showed higher odds of healthy aging compared to the MIND, hPDI and rEDIP. The aMED, DASH, PHDI and rEDIH also demonstrated higher odds of healthy aging compared to the hPDI (Fig. 2). Using dietary pattern scores modeled as continuous variables, the associations with healthy aging were also the strongest for the AHEI and the weakest for the hPDI (Extended Data Table 3). The OR (95% CI) per standardized unit increase (representing the increment between the 10th and 90th percentiles) ranged from 1.40 (1.32–1.49) to 1.71 (1.60–1.82). Absolute risks, calculated based on the healthy

Table 1 | Age-standardized characteristics in the lowest and highest quintiles of energy-adjusted dietary pattern scores in the pooled cohorts (n = 105,015) between 1986 and 2010

Characteristic	Q1, n=21,003	Q5, n=21,003	Q1, n=21,003	Q5, n=21,003	Q1, n=21,003	Q5, n=21,003	Q1, n=21,003	Q5, n=21,003
Dietary score	AHEI-2010		aMED		DASH		MIND	
Energy-adjusted score	41.5 (4.2)	68.6 (4.6)	2.2 (0.6)	6.3 (0.6)	18.1 (1.8)	29.5 (1.7)	6.0 (0.6)	9.6 (0.6)
Women	70.2	59.7	57.2	69.5	67.1	61.3	67.1	61.0
Age at baseline	53.5 (7.8)	53.1 (7.7)	53.8 (7.6)	53.8 (7.5)	51.6 (7.7)	55.3 (7.6)	54.4 (7.7)	52.8 (7.7)
Ancestry								
European	95.2	94.1	95.6	94.1	94.5	94.8	95.5	93.5
Asian	0.6	1.4	0.7	1.3	1.1	0.9	0.6	1.7
African	1.1	1.4	0.8	1.5	1.4	1.2	0.8	1.6
Other	3.1	3.0	3.0	3.1	3.0	3.1	3.1	3.1
SES score at baseline	−0.8 (3.3)	0.9 (4)	−0.6 (3.4)	−0.6 (3.4)	−0.6 (3.5)	0.5 (3.9)	−0.9 (3.3)	0.8 (3.9)
Alone, ever	28.0	27.7	27.2	27.2	27.2	28.9	30.2	25.4
History of depression, yes	16.3	12.3	14.5	14.5	15.6	12.1	16.2	12.0
History of cancer, yes	4.5	3.9	4.1	4.2	3.8	4.3	4.3	3.8
History of diabetes, yes	3.3	2.7	2.7	2.8	1.9	4.0	3.2	2.9
History of CVD, yes	5.3	5.4	4.7	5.7	4.2	6.7	5.2	5.7
Family history of dementia, yes	11.9	13.2	10.8	13.8	12.1	12.2	11.7	12.5
Multivitamin use, ever	78.6	91.0	79.2	90.2	78.8	89.7	79.5	90.0
BMI, kg m⁻²	26.6 (5.1)	25.2 (4)	26.6 (4.9)	25.2 (4.1)	26.5 (5)	25.2 (4.2)	26.5 (5)	25.3 (4)
Never smoker, %	71.4	60.2	67.2	63.9	63.4	69.3	69.8	63.5
Physical activity, MET-h week⁻¹	1.2 (2.1)	3.7 (3.7)	1.5 (2.5)	3.3 (3.5)	1.4 (2.2)	3.5 (3.6)	1.3 (2.3)	3.6 (3.7)
Alcohol intake, g per day	7.4 (14.3)	8.1 (8.4)	8.4 (14.4)	7.5 (8.5)	8.8 (13.4)	6.3 (9.2)	6.2 (11.6)	8.4 (10.3)
Energy intake, kcal	1804 (494)	1831 (493)	1839 (532)	1811 (445)	1819 (514)	1842 (468)	1815.1 (524.9)	1826.2 (476.5)
Healthy agers, %	5.6	13.7	6.4	12.5	7.7	10.2	5.3	13.0
Dietary score	hPDI		PHDI		rEDIH		rEDIP	
Energy-adjusted score	47.0 (2.4)	62.8 (2.9)	65.2 (5.1)	93.4 (5.1)	−0.6 (0.2)	0 (0.1)	−0.3 (0.2)	0.4 (0.2)
Women	66.8	63.5	61.0	63.5	34.1	83.9	52.9	71.7
Age at baseline	52.5 (7.8)	54.2 (7.7)	53.5 (8)	53 (7.6)	52.9 (8.4)	53.4 (7.4)	53.7 (8.1)	52.3 (7.5)
Ancestry								
European	95.4	93.9	95.3	93.4	94.9	95.3	92.9	96.5
Asian	0.6	1.5	0.6	1.9	1.1	0.8	1.8	0.4
African	1.1	1.5	1.0	1.5	1.5	0.7	2.2	0.3
Other	2.9	3.2	3.1	3.1	2.5	3.3	3.1	2.8
SES score at baseline	−0.2 (3.5)	0.3 (3.9)	−0.6 (3.5)	0.7 (3.9)	−0.6 (3.4)	0.7 (4)	−0.5 (3.5)	0.5 (3.9)
Alone, ever	27.9	27.6	27.5	27.0	22.3	31.5	24.8	28.5
History of depression, yes	14.7	12.6	14.7	12.7	10.9	15.3	14.4	13.6
History of cancer, yes	4.1	4.2	4.4	3.8	4.1	4.0	4.1	3.9
History of diabetes, yes	1.9	4.1	3.2	2.6	5.3	1.4	5.4	1.5
History of CVD, yes	4.3	6.2	5.2	5.2	6.3	3.7	7.0	3.3
Family history of dementia, yes	12.5	12.5	10.5	13.7	7.3	16.7	9.9	14.5
Multivitamin use, ever	81.1	88.6	78.2	91.3	78.8	89.8	80.8	87.6
BMI, kg m⁻²	26.5 (4.9)	25.4 (4.3)	26.4 (4.9)	25.3 (4)	27.4 (4.9)	24.4 (3.8)	27.5 (5.2)	24.8 (3.8)
Never smoker, %	67.0	64.7	71.3	59.7	73.6	56.2	73.0	56.2
Physical activity, MET-h week⁻¹	1.5 (2.4)	3.3 (3.6)	1.5 (2.5)	3.5 (3.6)	2.2 (3.1)	2.8 (3.2)	2.0 (3.0)	2.7 (3.1)
Alcohol intake, g per day	6.7 (10.4)	8.1 (11.7)	7 (11.8)	8.3 (10.8)	7.2 (11.4)	11.3 (13.1)	4.6 (9)	14.4 (14.8)
Energy intake, kcal	1824 (474)	1824 (508)	1821 (543)	1814 (466)	1950 (543)	1849 (474)	1902 (535)	1853 (489)
Healthy agers, %	8.0	11.2	5.8	13.6	5.5	13.5	5.5	13.1

Values are the mean (s.d.) for continuous variables and % for categorical variables. CVD, cardiovascular disease; MET, metabolic equivalent of task.
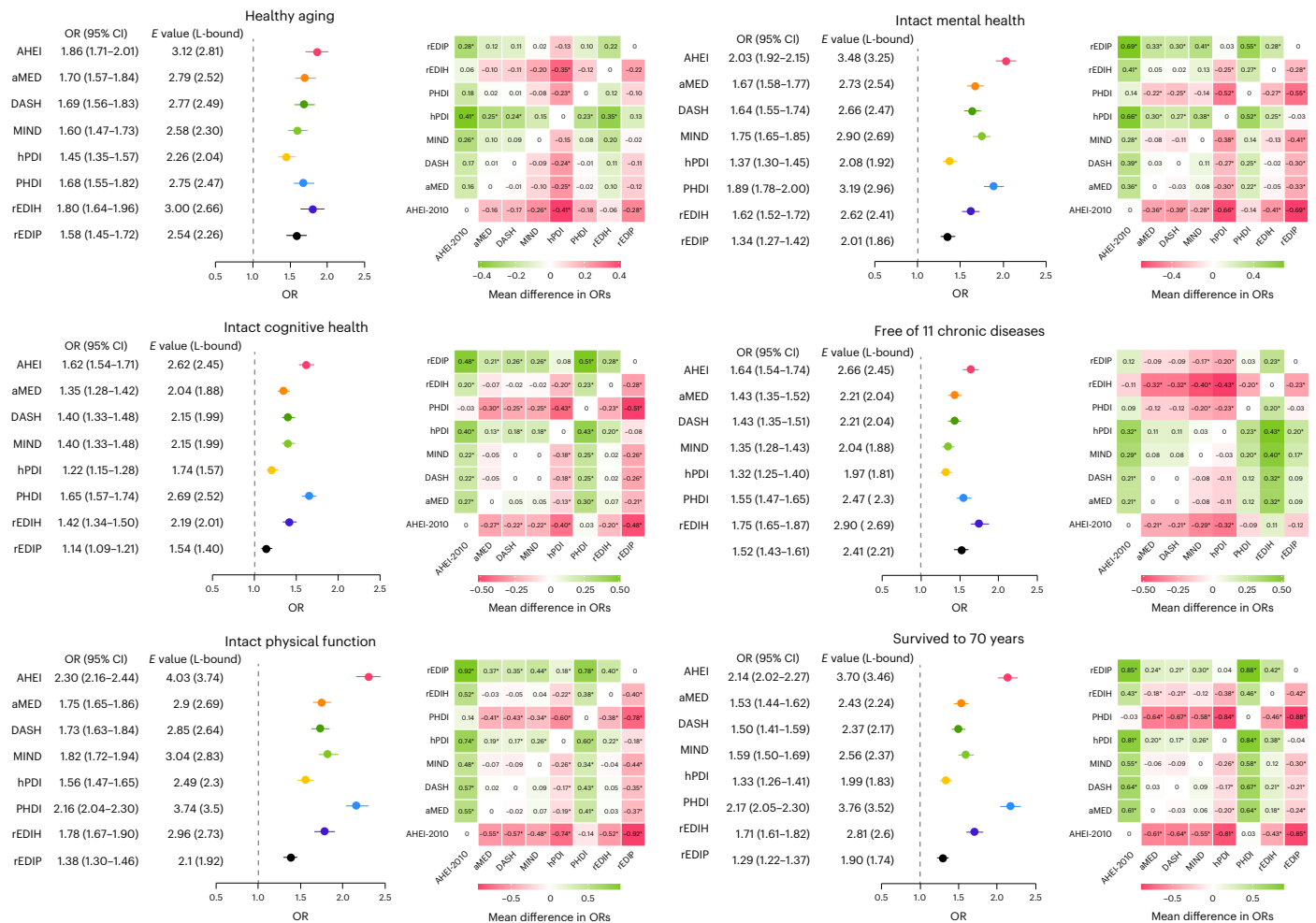
Fig. 2 | Associations of average dietary patterns with healthy aging and its domains. In the main pooled dataset ($n = 105,015$), the average dietary pattern scores were calculated from 1986 to 2010. The forest plots show the ORs comparing Q5 to Q1 for each of the dietary patterns (visually represented by the centers of the error bars), the 95% CIs (visually represented by the error bars) and E values and their lower bound. Logistic regressions were used to estimate ORs and were adjusted for age at baseline (1986), cohort (sex), BMI ($kg m^{-2}$), ancestry (European, Asian, African-American, Other), smoking status (never, former, current smoker: 1–14 cigarettes per day, 15–24 cigarettes per day and ≥25 cigarettes per day), alcohol intake (g per day) (for DASH, hPDI, PHDI), physical activity (MET-h $week^{-1}$), multivitamin use ever (yes/no), family history of

myocardial infarction (yes/no), family history of type 2 diabetes, family history of cancer, family history of dementia (yes/no), postmenopausal status (yes/no) and menopausal hormone use (no, past or current hormone use; only women), SES at baseline, marital status (yes/no), living alone ever (yes/no) and history of depression (yes/no) in the pooled cohorts. rEDIH and rEDIP are reversed scores to allow comparison with other scores. All two-sided $P < 0.0001$. The heatmaps show the OR difference between all pairs of scores. Positive differences are denoted in green and negative differences in pink; a darker color indicates a greater difference. *Two-sided $P < 0.05$ based on a paired t-test comparing ORs (not adjusted for multiple comparisons).

aging prevalence and adjusted ORs, indicated 8.4% to 12.4% chances of achieving healthy aging among individuals with higher adherence to the dietary patterns (Extended Data Table 4).

When examining associations with each healthy aging domain, higher adherence to all dietary patterns was associated with all individual domains (Fig. 2 and Extended Data Table 3). The significant multivariable-adjusted ORs (95% CIs) comparing the highest quintile to the lowest ranged from 1.22 (1.15–1.28; $P < 0.0001$) to 1.65 (1.57–1.74; $P < 0.0001$) for intact cognitive health, with the PHDI showing the strongest association and the hPDI showing the weakest association. For intact physical function, the ORs (95% CIs) ranged from 1.38 (1.30–1.46; $P < 0.0001$) to 2.30 (2.16–2.44; $P < 0.0001$), with the AHEI showing the strongest association and the rEDIP showing the weakest association. For intact mental health, the ORs (95% CIs) ranged from 1.37 (1.30–1.45; $P < 0.0001$) to 2.03 (1.92–2.15; $P < 0.0001$), with the AHEI showing the strongest association and the hPDI showing the weakest association. For being free of chronic diseases, the ORs (95% CIs) ranged from 1.32 (1.25–1.40; $P < 0.0001$) to 1.75 (1.65–1.87; $P < 0.0001$), with

the rEDIH showing the strongest association and the hPDI showing the weakest association. For surviving to the age of 70 years, the ORs (95% CIs) ranged from 1.33 (1.26–1.41; $P < 0.0001$) to 2.17 (2.05–2.30; $P < 0.0001$), with the PHDI showing the strongest association and the hPDI showing the weakest association.

Figure 4 illustrates the associations between individual dietary factors and healthy aging and its individual domains. While higher intakes of fruits, whole grains, vegetables, added unsaturated fats, nuts, legumes and low-fat dairy were associated with greater odds of healthy aging, higher intakes of trans fats, sodium, total meats, and red and processed meats were associated with lower odds. These foods or nutrients were also consistently associated with each healthy aging domain. Added unsaturated fat intake, including polyunsaturated fatty acids, was particularly associated with surviving to the age of 70 years, and intact physical and cognitive functions.

While adherence to all dietary patterns was significantly associated with healthy aging in both men and women, the associations were stronger in women (P interaction: 0.0226 to <0.0001; Fig. 5)

Dietary factors	AHEI-2010	aMED	DASH	MIND	hPDI	PHDI	rEDIH	rEDIP
Fruits	green	green	green		green	green		green
Berries				green				
Tomatoes							pink	pink
Vegetables	green	green	green	green	green	green		
Starchy vegetables						gray		
Leafy-green vegetables				green			green	green
Dark-yellow vegetables								green
Other vegetables								pink
Potatoes					pink			
Whole grains	green	green	green	green	green	green		
Refined grains					pink			pink
Nuts and legumes	green		green					
Nuts		green		green	green	green		
Legumes		green		green	green	green		
Beans								
Soybean						green		
Total meats					pink			
Red and processed meats	pink	pink	pink	pink	pink	gray		
Red meat							pink	pink
Processed meats							pink	pink
Organ meats								pink
Poultry				green		gray	pink	
Eggs					pink	gray	pink	
Fish and seafood		green			pink	green		
Other fish							pink	
Miscellaneous animal-based foods					pink			
Sweets and desserts				pink	pink			
Fast and fried foods				pink				
French fries							pink	
Snacks								green
Pizza								
Animal fat					pink			
Butter and margarine				pink				
Butter							pink	
Margarine							pink	
Vegetable oils					green			
Creamy soup							pink	
Olive oil				green				
Sugar-sweetened beverages and fruit juices	pink							
Sugar-sweetened beverages			pink		pink		pink	pink
Low-energy beverages							pink	pink
Fruit juices					pink			green
Total alcohol	gray	gray						
Wine				gray			green	green
Beer								green
Tea and coffee					green			
Tea								green
Coffee							green	green
Total dairy					pink	gray		
Low-fat dairy			green				pink	
High-fat dairy							green	
Cheese				pink				
Trans fats	pink							
Long-chain n-3 (omega-3) fatty acids	green							
Polyunsaturated fatty acids	green							
Mono-unsaturated fatty acid:saturated fatty acid		green						
Added unsaturated fats						green		
Added saturated fat and trans fats						pink		
Added sugar and fruit juices						pink		
Sodium	pink		pink					

Fig. 3 | Dietary factors of dietary patterns. Pink: lower points or negative weights were assigned to higher intakes for this dietary factor; green: higher points or positive weights were assigned to higher intakes for this dietary factor; gray: higher points or positive weights were assigned to moderate intake. The EDIH and EDIP are presented as reversed scores to allow for comparison with other dietary scores.

except for rEDIH and rEDIP (no interaction). The associations were also stronger in smokers (for AHEI, aMED, DASH, MIND, hPDI; P interaction 0.047 to <0.0001), in participants with a BMI greater than 25 kg m^{-2} (for AHEI, MIND, hPDI, rEDIH, rEDIP; P interaction 0.042 to <0.0001) and in participants with a physical activity level below the median (for AHEI, aMED, DASH, MIND, hPDI, PHDI, rEDIP; P interaction 0.038 to <0.0001; Fig. 5). A significant interaction between SES and rEDIH (P interaction = 0.013) and rEDIP (P interaction = 0.017) was observed. No interaction was found for ancestry (European versus non-European).

Secondary analyses showed consistency with the main results. When using a higher age cutoff of 75 years, the AHEI also showed the strongest association (Extended Data Table 5). When applying linear weights to dietary pattern scores, results were consistent with the main analysis (Extended Data Table 6).

Higher UPF consumption (comparing the highest quintile to the lowest) was associated with 32% lower odds of healthy aging (95% CI = 27–37%; Extended Data Table 7). Higher consumption of UPFs was also associated with lower odds of maintaining intact cognitive

function, physical function and mental health, living free of chronic diseases and reaching the age of 70 years (Extended Data Table 7).

Discussion

In two large prospective cohorts of US women and men, we found that higher adherence to dietary patterns, namely the AHEI, aMED, DASH, MIND, hPDI, PHDI, rEDIP and rEDIH, during mid-life was associated with greater odds of healthy aging after a 30-year follow-up. Among dietary patterns, AHEI was the most strongly associated with healthy aging and hPDI was the least associated. Compared to participants in the lowest quintile, those who were in the highest AHEI quintile (energy-adjusted mean score = 68.6 ± 4.6) had 86% greater odds of achieving healthy aging using an age cutoff of 70 years and 2.24 times greater odds using an age cutoff of 75 years. The AHEI was closely followed by the rEDIH, aMED, DASH, PHDI, MIND, rEDIP and lastly the hPDI. Associations were independent of other lifestyle factors, including physical activity level, smoking and BMI. The AHEI was also the most strongly associated with maintaining intact physical function and mental health among individual healthy aging domains. The PHDI was most strongly associated with maintaining intact cognitive health and surviving to the age of 70 years. The rEDIH was the most strongly associated with being free of chronic diseases. A higher intake of UPFs was inversely correlated with higher diet quality scores and was also associated with lower odds of healthy aging. Our findings provide evidence to support that adherence to healthy dietary patterns represents a potential strategy for healthy aging, patterns that particularly are richer in fruits, vegetables, whole grains, unsaturated fats, nuts and legumes, that include some dairy products, and that are lower in trans fats, sodium, and red and processed meats.

While all dietary patterns share similarities such as promoting an intake of fruits, vegetables and whole grains, while reducing the amount of red and processed meats, each pattern emphasizes specific components. For instance, while the aMED diet focuses on the Mediterranean staples of olive oil, fish and nuts[21], MIND further highlights the cognitive benefits of berries[22]. The DASH diet prioritizes sodium restriction for blood pressure control[23], the PHDI emphasizes healthy low greenhouse gas emission foods, such as plant-sourced protein food[24], and the hPDI uniquely attributes positive scoring to healthy plant-based foods and negative scoring to animal-derived foods[25]. In a previous report, adherence to the AHEI and aMED, assessed in 1984–1986, was associated with 34% (95% CI = 9–66%) and 46% (95% CI = 17, 83) greater odds of healthy aging, respectively, in the NHS (n = 10,670; 15-year follow-up)[19]. This analysis examined two dietary patterns with healthy aging in 2000 using the same definition as in the current study, but the Telephone Interview for Cognitive Status was used to assess the cognitive health domain. Our analysis, which included both the NHS and HPFS, involved long-term dietary assessment of eight dietary patterns over a period of 14 years, with an assessment of

healthy aging conducted 30 years after baseline. The results showed consistent and stronger associations for these two scores (84% greater odds for AHEI and 62% for aMED). The association between dietary
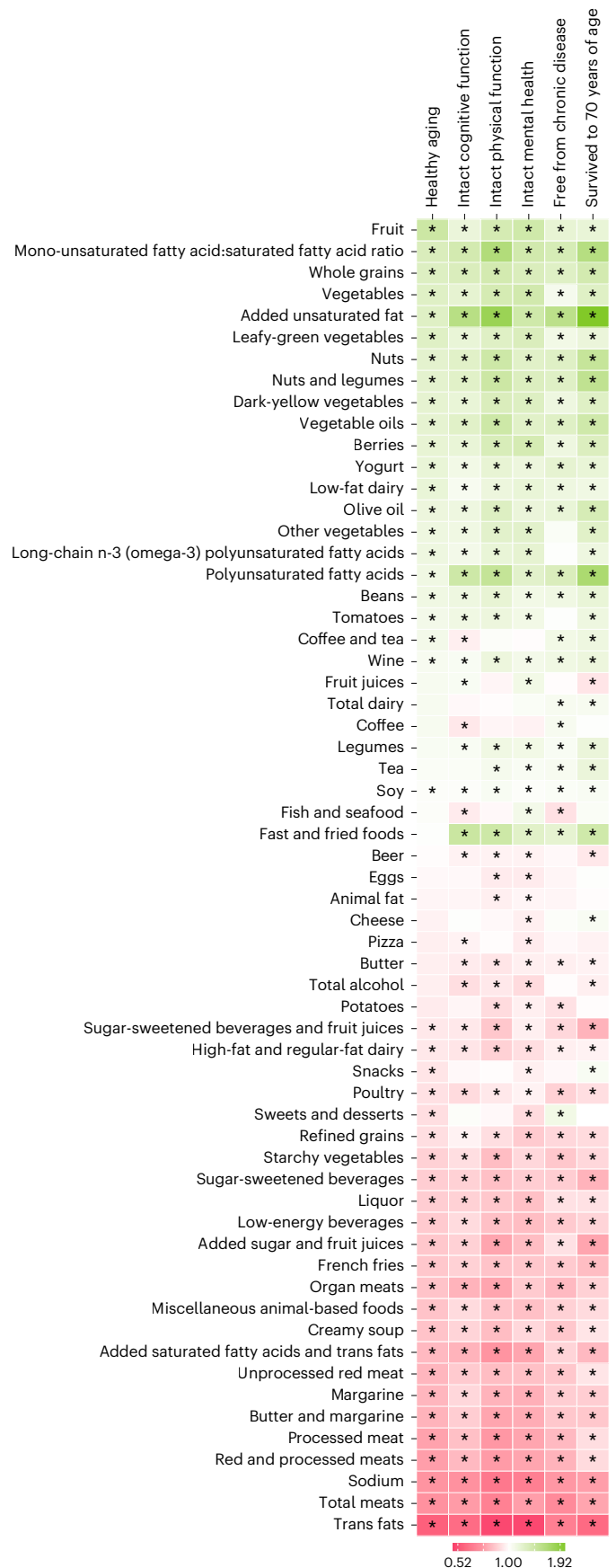

Fig. 4 | Multivariable-adjusted associations between dietary factors and healthy aging and its domains in the main pooled dataset (n = 105,015). Each heatmap square represent the OR comparing the 90th to the 10th percentile for each of the dietary factors. Logistic regressions were used to estimate ORs and were adjusted for age at baseline (1986), cohort (sex), BMI (kg m⁻²), ancestry (European, Asian, African-American, Other), smoking status (never, former, current smoker: 1–14 cigarettes per day, 15–24 cigarettes per day and ≥25 cigarettes per day), alcohol intake (g per day), physical activity (MET-h week⁻¹), multivitamin use ever (yes/no), family history of myocardial infarction (yes/no), family history of type 2 diabetes, family history of cancer, family history of dementia (yes/no), postmenopausal status (yes/no) and menopausal hormone use (no, past, or current hormone use; women only), SES at baseline, marital status (yes/no), living alone ever (yes/no) and history of depression (yes/no) in the pooled cohorts. ORs greater than 1.0 are denoted in green; ORs below 1.0 are denoted in pink; a darker color indicates a stronger association. *Two-sided P values corrected for multiple comparisons using a false discovery rate (FDR) < 0.05.
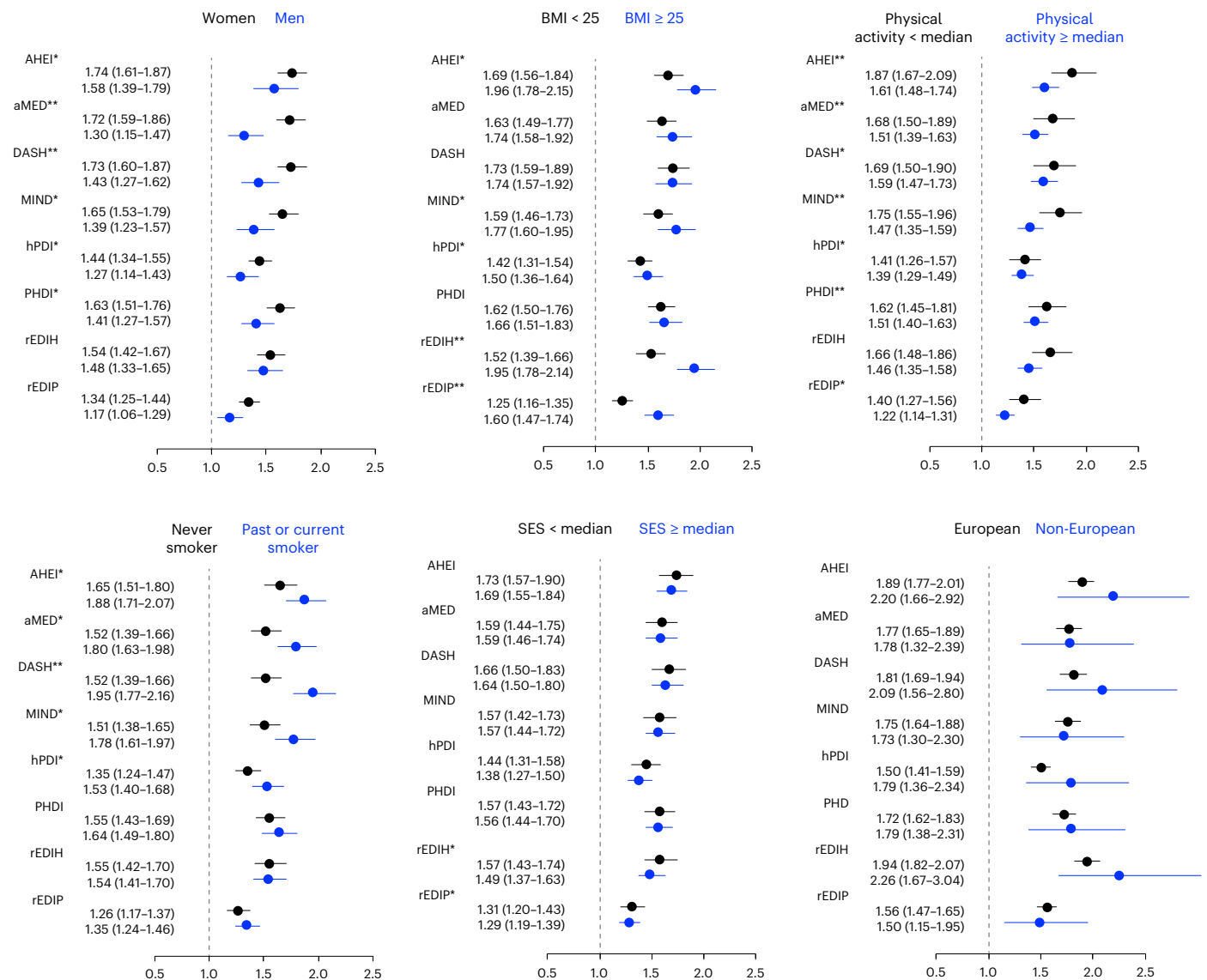
Fig. 5 | Subgroup analysis of the associations between average dietary pattern scores and healthy aging in the main pooled dataset (n = 105,015). The forest plots show the ORs comparing the 90th to the 10th percentile for each of the dietary patterns (visually represented by the centers of the error bars) and 95% CIs (visually represented by error bars). Logistic regressions were used to estimate the ORs and were adjusted for age at baseline (1986), cohort (sex), BMI (kg m^{-2}), ancestry (European, Asian, African-American, Other), smoking status (never, former, current smoker: 1–14 cigarettes per day, 15–24 cigarettes per day and ≥25 cigarettes per day), alcohol intake (g per day), physical activity (MET-h week^{-1}), multivitamin use ever (yes/no), family history of myocardial infarction (yes/no), family history of type 2 diabetes, family history of cancer, family history of dementia (yes/no), postmenopausal status (yes/no) and menopausal hormone use (no, past, or current hormone use; women only), SES at baseline, marital status (yes/no), living alone ever (yes/no) and history of depression (yes/no), excluding the stratified variable where applicable, in the pooled cohorts. ** two-sided P interaction <0.0001 (not adjusted for multiple comparisons). *Two-sided P interaction < 0.05 (not adjusted for multiple comparisons); sex, AHEI $P = 0.022$; MIND $P = 0.001$; hPDI $P = 0.002$; PHDI $P = 0.0008$; BMI, AHEI $P = 0.001$; MIND $P = 0.024$; and hPDI $P = 0.015$. For physical activity, DASH $P = 0.0003$; hPDI $P = 0.0005$; rEDIP $P = 0.023$. For smoking, AHEI $P = 0.005$; aMED $P = 0.010$; MIND $P = 0.0007$; hPDI $P = 0.002$. For SES, rEDIH $P = 0.019$; rEDIP $P = 0.023$.

patterns and healthy aging was also examined in other populations, namely in France[16], Australia[17,18], China[15] and Israel[20], and corroborated our findings. In the SUpplementation en VItamines et Minéraux AntioXydants study (n = 3,012, 38% healthy agers, 13-year follow-up) and Singapore Chinese Health Study (SCHS) (n = 14,159, 20% healthy agers, 20-year follow-up), higher adherence to a Mediterranean-style diet was associated with 36% (95% CI = 12–65%; tertile 3 versus tertile 1) and 53% (95% CI = 35–73%; quartile 4 versus quartile 1) greater likelihood of achieving healthy aging, respectively. The AHEI, HEI 2015 and adherence to the Australian National Dietary Guidelines were similarly associated with healthy aging with ORs ranging from 1.34 to 1.73 in the SCHS, the Israeli National Health and Nutrition Survey of Older Adults

(n = 1,770, 13.7% healthy agers; 40% excluding deaths; median follow-up of 12.6 years) and the Blue Mountains Eye Study (n = 1,609, 15.5% healthy agers, 10-year follow-up). Among the dietary patterns also examined in other cohorts, we found significant interactions between sex and DASH, aMED, AHEI and hPDI; between physical activity level and the AHEI, aMED and hPDI; between smoking and the AHEI, aMED, DASH and hPDI; and between BMI and the AHEI and hPDI. Differences in the study populations regarding sex, lifestyle factors and BMI may explain the variations observed in the ORs across studies. The methods for assessing diet varied across studies, as did the definitions of healthy aging. Differences included age cutoffs, questionnaires or measures used for assessing domains, consideration of chronic diseases and

the inclusion or exclusion of additional clinical measures. Moreover, some studies excluded deceased individuals from the sample population, potentially resulting in varying proportion of healthy agers and discrepancies in the classification of healthy agers. Standardization of a composite healthy aging outcome is warranted to allow proper comparison of research studies; deaths should be considered as usual agers and be included in the analyses to avoid selection bias.

Using a data-driven approach, Hodge et al.[18] discerned four dietary patterns that were associated with healthy aging in the Melbourne Collaborative Cohort Study (*n* = 6,308, 18.6% healthy agers; median follow-up of 11.7 years for survivors). The dietary pattern that showed the strongest positive association with healthy aging predominantly consisted of fruits, whereas the pattern inversely associated with healthy aging primarily featured red meat. Assman et al.[16] examined the individual dietary factors of the Mediterranean-style diet and their association with healthy aging in the SUpplementation en VItamines et Minéraux AntioXydants cohort and found a higher intake of fruits and vegetables to be favorably associated with healthy aging, and meat and alcohol to be unfavorably associated[16]. These findings agree with our results showing that a higher intake of fruits (overall and berries) and vegetables (overall, leafy green and dark yellow) was associated with greater odds of healthy aging, whereas a higher intake in trans fats, sodium, meats (total, red and processed and unprocessed) and liquor was associated with lower odds of healthy aging. In the Blue Mountains Eye Study, Gopinath et al.[26] only found an association for fruits (healthy aging OR = 1.57, 95% CI = 1.06–2.34; quartiles 2 + 3 versus quartile 1; not significant for quartile 4 versus quartile 1) among the individual dietary factors examined. In the current study, most of the individual foods associated with healthy aging were consistently associated with the healthy aging domains individually, except for a few including fast and fried foods away from home, and snacks, which were positively associated with surviving to the age of 70 years. Although the consumption of fried food has been associated with an increased risk of cardiovascular events, evidence suggests no association with an all-cause mortality risk. The social aspect related to eating away from home may explain part of the association with living to the age of 70 years[27], although more research in this area is needed to explain these associations.

Our findings showed that each dietary pattern examined was associated with each specific individual component of healthy aging. One prospective study also examined associations of dietary patterns, specifically the aMED, DASH, AHEI, PDI and hPDI, with the healthy aging domains[15]. Consistent with our results, Zhou et al.[15] found significant associations between the aMED, DASH, AHEI and hPDI, and maintaining intact cognitive function; AHEI and DASH for staying free of chronic diseases; aMED, DASH, AHEI, hPDI and PDI for maintaining physical function and mental health (no clinical depression) in the SCHS study. However, no association was found between aMED, PDI and hPDI and the chronic disease component, and the PDI and the cognitive function component. Extensive evidence from intervention and observational studies supports that higher adherence to healthy dietary patterns is protective or associated with a lower risk of chronic diseases[28]. There is also accumulating evidence supporting the association of dietary patterns and dietary factors with mental, physical and cognitive health (reviewed in refs. [29,30]). Beyond traditional measures of chronological age or disease burden, healthy aging is multifaceted as recognized by the World Health Organization in their first World report on ageing and health[31]. While examining domains in isolation provides more targeted insights into the potential mechanisms, investigating healthy aging as a multi-component outcome may inform holistic health strategies[32]. Our findings allow us to capture the multidimensional nature of aging and evaluate dietary patterns and food intake associations comprehensively.

Strengths of this study include the prospective design and large population size for robustly powered analyses. Repeated measurements of diet, body weight and lifestyle variables enabled us to consider long-term adherence to healthy dietary patterns and potential confounding factors, and mitigate random measurement errors. The long 30-year follow-up allowed the examination of the mid-life diet and its association with healthy aging in later life. Nevertheless, the results of this study need to be interpreted in the context of its limitations. First, although a lag of 6 years between the last diet update and healthy aging assessment was considered, reverse causation cannot be completely excluded. While it is plausible that higher adherence to healthy diets could be indicative of a higher SES and overall healthy lifestyle, our results remained consistent after accounting for such factors. However, residual confounding may still exist because of other unmeasured factors, such as environmental influences, although the E values indicate that our results are robust to potential confounding. Also, the cognitive and physical function domains were assessed using validated self-reported questionnaires instead of objective measurements, which limits in-depth assessment and classification. Lastly, our population included health professionals, which may limit the generalizability of our results. Replicating the analyses in populations with diverse SES and ancestries would offer further insights into their generalizability.

Greater long-term adherence to a healthy diet during mid-life was associated with greater odds of healthy aging and of its individual domains in US adults. Among the eight dietary patterns examined in this study, a diet that was developed to predict chronic disease risk as measured by the AHEI may confer the highest benefit for healthy aging in both men and women. Beyond the prevention of chronic disease, our findings extend recommendations to promote overall healthy aging, encompassing cognitive, physical and mental health.

Online content

Any methods, additional references, Nature Portfolio reporting summaries, source data, extended data, supplementary information, acknowledgements, peer review information; details of author contributions and competing interests; and statements of data and code availability are available at https://doi.org/10.1038/s41591-025-03570-5.

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Methods

Study population

Analyses were performed in the NHS and HPFS. The NHS was established in 1976 and included 121,700 US female registered nurses aged 30–55 years[33]. The HPFS was initiated in 1986 and recruited 51,525 male health professionals aged 40–75 years[34]. Details about the cohorts were published previously[33,34]. Biennial assessments of lifestyle factors and medical history were conducted through mailed questionnaires, maintaining a follow-up rate exceeding 90%. High validity and reproducibility of self-reported health information in the cohorts has been reported previously[35–37]. For both cohorts, the baseline for this analysis was 1986, that is, when the food frequency questionnaires (FFQ) allowed for computing all dietary pattern scores.

Figure 1 shows the flow diagram of the study. Participants included in this analysis had answered the 1986 questionnaires and had a chance of attaining 70 years at the end of the follow-up (aged between 39 and 69 years at baseline; n = 9,920 excluded). Participants with a history of one or more of 11 major chronic diseases, including cancer (except for non-melanoma skin cancers), diabetes, myocardial infarction, coronary artery disease, congestive heart failure, stroke, kidney failure, chronic obstructive pulmonary disease, Parkinson disease, multiple sclerosis and amyotrophic lateral sclerosis, at baseline (n = 8,953), with missing data for one or more dietary pattern scores between 1986 and 2010, or who reported implausible total energy intakes (<500 or >3,500 kcal d^{-1} for women and <800 or >4,200 kcal d^{-1} for men) (n = 15,016) and with missing healthy aging phenotype (n = 34,321) were excluded.

The study protocol was approved by the institutional review boards (IRBs) of the Brigham and Women's Hospital (BWH), Harvard T.H. Chan School of Public Health (HSPH) and participating registries (IRB protocol nos. 2001P001945/BWH and 10372) as required. Per long-standing IRB-approved procedures at BWH and HSPH, the completion and return of the baseline and subsequent follow-up questionnaires implies consent. Before 2006, consenting practices varied and many collections were conducted with implied consent. A waiver of documentation for informed consent was granted for these studies. Written informed consent was required for medical record acquisition.

Dietary assessment

Dietary intake was measured using a validated FFQ with more than 130 items administered in 1986 and every 4 years thereafter. The validity and reliability of the FFQ for measuring nutrient, food and food group intakes have been reported previously[38,39]. Participants were asked how frequently they consumed specific foods in the past 12 months. Nutrients were calculated using the United States Department of Agriculture (USDA) and Harvard University Food Composition Databases[40], and supplemented with biochemical analyses. Based on the reported nutrient and food intakes, eight dietary pattern scores were computed, including the AHEI, aMED, DASH, MIND, hPDI, PHDI, EDIP and EDIH, as well as UPF consumption. The AHEI, aMED, DASH, MIND, hPDI, and PHDI scores, and UPF consumption, have been developed based on dietary recommendations and available evidence. The scores showed moderate-to-high validity and reproducibility[41] and were associated with risk of health outcomes[28,42–44]. The EDIP and EDIH were empirically derived using biomarkers of chronic inflammation[45] and hyperinsulinemia[46], respectively.

The AHEI score was computed based on the intake of 11 foods and nutrients that have been positively or inversely associated with chronic disease risk, including fruits, vegetables, nuts and legumes, alcohol, red and processed meat, whole grains, sodium, trans fats and long-chain n-3 (omega-3) fatty acids[47]. Each component was scored on a scale from 0 to 10 and the AHEI ranged from 0 to 110, a higher score indicating better overall diet quality. Adherence to the Mediterranean diet was assessed using a modified version of the 9-point aMED score[21]. The score was calculated based on adherence to nine food items (with either higher or lower intake) that characterize the Mediterranean diet: vegetables; legumes; fruits; nuts; whole grains; fish; moderate alcohol consumption; lower intake of red and processed meat; and monounsaturated to saturated fatty acids[21]. The modified aMED score ranged from 0 to 9, a higher score denoting a higher adherence to the Mediterranean diet[21]. The DASH score, designed to help prevent or treat hypertension, was based on eight dietary factors, including intake of high fruits, vegetables, nuts and legumes, low-fat dairy products, whole grain intake, low sodium, sweetened beverages and processed and unprocessed red meats[23]. Each component was attributed a score between 0 and 5 based on intake distribution quintiles. The overall score ranged from eight (lowest adherence) to 40 (highest adherence). The MIND score included ten brain-healthy dietary factors, including leafy-green vegetables, other vegetables, berries, nuts, whole grains, fish, beans, poultry, wine (in limited amounts) and olive oil, and five less healthy factors, including butter and margarine, cheese, red meat, fast/fried foods, and pastries and sweets[22]. Points of 0, 0.5 or 1 were attributed to each and the total MIND score ranged from 0 to 15, a higher score indicating a higher adherence. The hPDI was designed to reflect adherence to a healthy plant-based diet[48]; it included 18 dietary factors and ranged from 18 (lowest adherence) to 90 (highest adherence). The PHDI was derived based on the adherence to the reference diet included in the EAT-Lancet report[49]. The reference diet was based on evidence for health outcomes and staying within planetary boundaries for greenhouse gas emissions and other environmental parameters[24]. The scoring criteria included 15 dietary factors. For each dietary factor, the score ranged from 0 to 10, except for non-soy legumes and soy foods, which contributed a maximum score of 5. The total PHDI score ranged from 0 (non-adherence) to 140 (perfect adherence). The EDIP was scored based on 18 dietary factors related to inflammation[50]. The EDIH included 18 dietary factors related to hyperinsulinemia[46]. Given that higher EDIH and EDIP scores denote higher hyperinsulinemia and inflammatory dietary patterns, respectively, the orientation of the scores were reversed to ease comparison with other dietary scores and were denoted as rEDIH and rEDIP. Figure 3 is a visual representation of the dietary patterns and their dietary factors.

Food items were also categorized according to the NOVA classification system[51]. The average daily energy intake from UPFs was calculated, and the percentage of total daily energy from UPFs was determined based on the average total energy intake.

Assessment of healthy aging

Based on the construct of 'successful aging' described by Rowe & Kahn[52] and previous reports[19,53–56], a healthy aging phenotype was defined as surviving to the age of 70 years without the presence of 11 major chronic diseases and with no impairment in cognitive function, physical function or mental health. Participants who did not meet the phenotype criteria or who died before 2016 were considered as usual agers. Those who died after 2016, but had a complete assessment of the phenotype were included in the analyses. Cognitive function was assessed using a validated Subjective Cognitive Decline questionnaire[57] in which reporting one or fewer of seven (NHS) or six (HPFS) cognitive concerns was considered as intact cognitive function. Physical function was assessed using the 36-item Short Form survey[58] subsection on physical limitations that includes ten questions. Participants who reported not being limited in climbing one flight of stairs, walking one block, walking more than a mile, vacuuming, moving a table, walking several blocks, bathing or dressing, and being a little or not limited in climbing several flights of stairs, running lifting, bending, kneeling stooping and lifting carrying groceries, were considered as having intact physical function. Mental health was evaluated using the 15-item Geriatric Depression Scale, which ranges from 0 to 15 with a lower score indicating fewer depressive symptoms[59]. Reporting 1 or fewer depressive symptom (median value of both cohorts) was considered as having intact mental health. The 11 major chronic diseases were selected as they are the primary causes of

mortality in the United States[60] or are considered to be highly debilitating. They were also those ascertained at baseline and throughout the follow-ups. Clinical diagnoses of the major chronic diseases were reported by participants or next of kin for the deceased and were then ascertained by a physician through medical records, pathology reports or supplemental questionnaire inquiries, which are highly valid in these cohorts[61]. In the NHS, cognitive function was assessed in 2014; the presence of chronic diseases, physical function and mental health were assessed in 2016. In the HPFS, all domains were assessed in 2016.

Assessment of covariates

Every 2 years, participants completed a questionnaire that queried on body weight, ancestry, smoking status, physical activity, multivitamin use ever, family history of chronic diseases, including myocardial infarction, type 2 diabetes, cancer and dementia, postmenopausal status and hormone use in women, marital status, living alone and history of depression (based on antidepressant medication use and self-report of depression). The questionnaires are available online at https://nurseshealthstudy.org/participants/questionnaires for the NHS and at https://www.hsph.harvard.edu/hpfs/hpfs-questionnaires/ for the HPFS. BMI was calculated by dividing the weight (kg) by the height (m²). SES was calculated as a composite score using the participant's geocoded address, combining US census household income, home value, college degree, ancestry, occupied housing units and unemployment, and whether families were receiving interest or dividends[62].

Statistical analysis

The follow-up duration was calculated from the date when the first FFQ was returned until the date of the participant's death or the date of assessment for healthy aging in 2016, whichever occurred first. The main analysis used the average of available dietary pattern scores between 1986 and 2010 as the exposure to capture long-term intake and allow a lag of 6 years between exposures and outcomes. The residual method was used to adjust dietary pattern scores for total energy intake, including energy from alcohol[63], and quintiles were calculated. Missing values for covariates were replaced with the cohort-specific median value. As outcomes are binary and measured at one time point, logistic regression models were used to estimate the ORs and 95% CIs of healthy aging and its individual domains according to quintiles of energy-adjusted dietary pattern scores, with age at baseline in 1986 as a covariate (base model). The multivariable-adjusted model was further adjusted for baseline-reported ancestry (European, Asian, African-American, Other), SES (composite score) and marital status (yes/no), ever used multivitamins (yes/no), ever lived alone (yes/no), family history of dementia (yes/no), myocardial infarction, cancer, and diabetes (yes/no), and medical history of depression (yes/no), diabetes and CVD (yes/no), smoking status in 2010 (never, former, current smoker: 1–14 cigarettes per day, 15–24 cigarettes per day and ≥25 cigarettes per day), postmenopausal status (yes/no) and menopausal hormone use (no, past, or current hormone use; women only), and mean (1986–2010) BMI (kg m⁻²), physical activity (MET-h week⁻¹) and alcohol intake (g per day) for DASH, hPDI and PHDI. An OR above 1 indicated a higher likelihood of healthy aging. Associations using the patterns as continuous variables, standardized according to their respective increment from the 10th to the 90th percentiles, were also examined. Analyses were performed in each cohort and in the pooled cohorts. The analyses in the pooled cohorts were further adjusted for cohort (sex). Absolute risks in both quintiles were calculated using the proportion of healthy agers in Q1 and the multivariable-adjusted OR comparing Q5 versus Q1. E values and the lower or upper bound were calculated for the ORs to assess the potential impact of unmeasured confounding on the observed associations. A higher E value denotes stronger evidence that unmeasured confounding would be required to fully explain away the observed association. Prespecified subgroup analyses were conducted according to cohort (sex), BMI (<25 versus

≥25 kg m⁻²), physical activity (above/below median), smoking (yes/no), SES (above/below median) and ancestry (European/non-European). Potential subgroup interactions were evaluated using interaction models, including the product of the subgroup and the exposure. As secondary analyses, the association of dietary patterns scores with healthy aging using an age cutoff of 75 years, and the association of UPF consumption with healthy aging (>70 years) were assessed. As a sensitivity analysis, we applied linear weights to dietary pattern scores across seven time points, ranging from 1986 to 2010, assigning the highest weight to the year closest to the healthy aging assessment (2010) and the lowest weight to 1986.

Intake in the individual food groups and nutrients that reflect the dietary pattern scores were also energy-adjusted and standardized according to their respective increment from the 10th to the 90th percentiles. The associations of energy-adjusted food group and nutrient intakes with healthy aging and its domains were examined using logistic regressions, accounting for the covariates described in the multivariable-adjusted model. Given that all dietary factors are also found in the pattern scores, the models were not adjusted for any measure of diet quality. P values were corrected for FDR using the Benjamini–Hochberg method; an FDR-corrected $P < 0.05$ was considered statistically significant.

Analyses were performed with SAS v.9.4 (SAS Institute) and R v.4.2.0. Statistical tests were two-sided and $P < 0.05$ was considered statistically significant.

Reporting summary

Further information on research design is available in the Nature Portfolio Reporting Summary linked to this article.

Data availability

Because of participant confidentiality and privacy concerns, data are available only upon written request. According to standard controlled access procedures, applications to use the NHS and HPFS resources will be reviewed by our External Collaborators Committee for scientific aims, evaluation of the fit of the data for the proposed methodology and verification that the proposed use meets the guidelines of the Ethics and Governance Framework and the consent that was provided by the participants. Investigators can expect initial responses within 4 weeks of request submission. Further information, including the procedures for obtaining and accessing data from the NHS and HPSF is described at https://www.nurseshealthstudy.org/researchers (nhsaccess@channing.harvard.edu) and https://hsph.harvard.edu/research/health-professionals/resources/for-external-collaborators/. The USDA and Harvard University food composition databases are publicly available at https://www.fns.usda.gov/usda-fis/usda-foods-database and https://hsph.harvard.edu/department/nutrition/nutrition-questionnaire-service-center/#nutrient-data.

Code availability

The analysis code is publicly available through GitHub (https://github.com/DrTessier/diets_healthyaging/).

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Author contributions

A.-J.T. and M.G.-F. had full access to all the study data and take responsibility for the integrity of the data and the accuracy of the data analysis. A.-J.T., M.G.-F. and F.B.H. designed the research. A.-J.T. conducted the analyses, prepared the tables and figures, and wrote the manuscript. All authors contributed to the interpretation of the results and critical revision of the manuscript for important intellectual content. All authors approved the final version of the manuscript. The corresponding author attests that all listed authors meet the authorship criteria and that no others meeting the criteria have been omitted.

Competing interests

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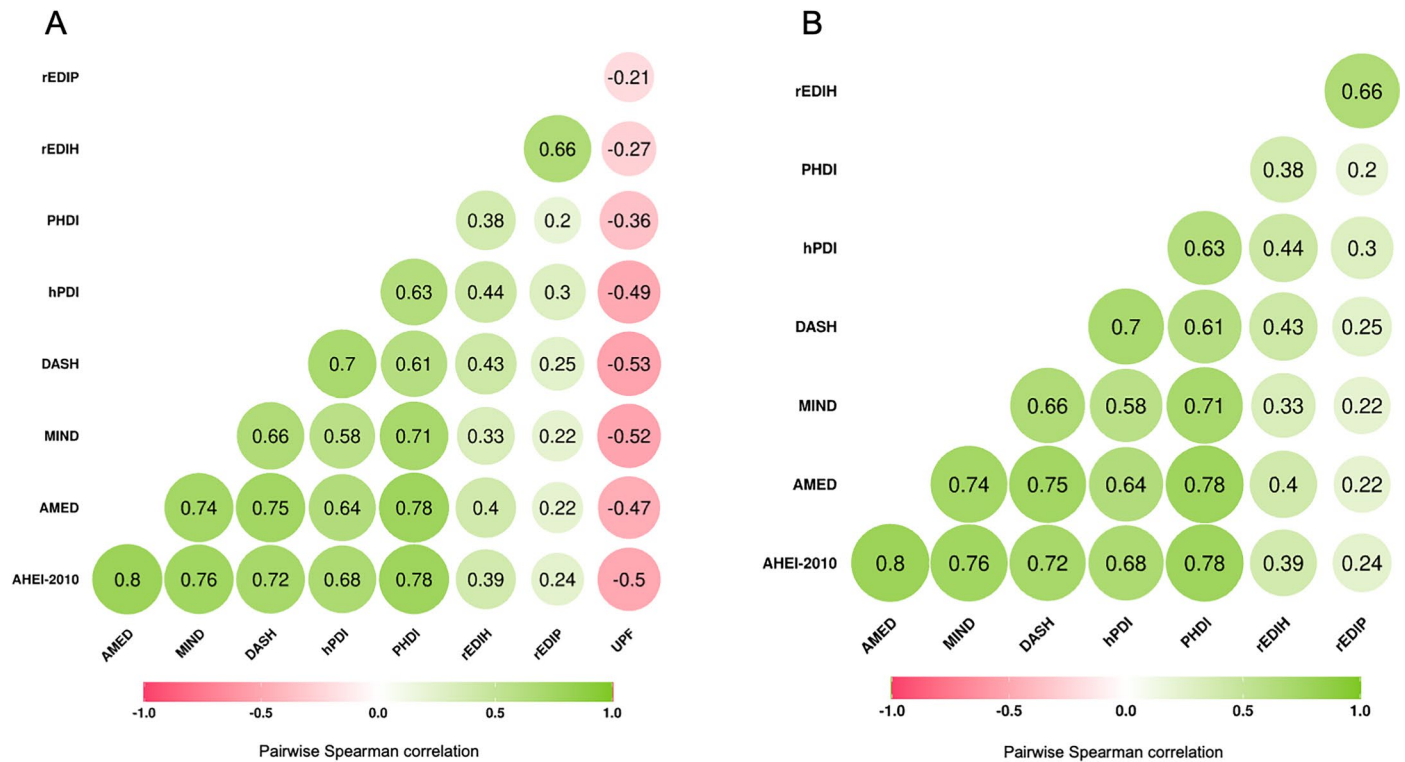
Extended Data Fig. 1 | Pairwise Spearman correlations between energy-adjusted average (1986-2010) dietary pattern scores. A. Pairwise Spearman correlations were applied in the pooled main dataset (n = 105,015). P values for all correlations are two-sided and <0.0001 (not adjusted for multiple comparisons); **B**. Pairwise Spearman correlations were applied in the pooled dataset excluded participants with missing UPF data (n = 104,635). P values for all correlations are two-sided and <0.0001 (not adjusted for multiple comparisons). AHEI,

alternative healthy eating index; AMED, alternative Mediterranean diet index; DASH, Dietary approaches to stop hypertension; MIND, Mediterranean-DASH intervention for neurodegenerative delay diet; hPDI, healthful plant-based diet index; PHDI, planetary health diet index; EDIH, empirical dietary index for hyperinsulinemia; EDIP, empirical dietary inflammatory pattern. The rEDIH and rEDIP are reversed scores to allow for comparison with other dietary scores.

Extended Data Table 1 | Age-standardized characteristics of the study population in the lowest and highest quintiles of energy-adjusted dietary pattern scores in the NHS between 1986 and 2010

Quintile	Q1 14,018	Q5 14,018	Q1 14,018	Q5 14,018	Q1 14,018	Q5 14,018	Q1 14,018	Q5 14,018
Dietary score	AHEI-2010		AMED		DASH		MIND	
Energy-adjusted score	41.5 (3.9)	67.9 (4.7)	2.4 (0.6)	6.3 (0.6)	18.3 (1.8)	29.3 (1.7)	6.0 (0.6)	9.5 (0.6)
Age, at baseline	53.0 (7.3)	52.2 (7.1)	52.3 (7.4)	53.2 (7.0)	51.2 (7.2)	54.4 (7.0)	54.0 (7.2)	52.0 (7.1)
Ancestry								
European	95.0	93.5	95.1	93.8	94.3	94.2	95.2	93.2
Asian	0.3	1.3	0.4	1.1	0.7	0.9	0.3	1.4
African	1.0	1.6	0.8	1.7	1.4	1.4	0.8	2.0
Other	3.7	3.5	3.8	3.4	3.6	3.6	3.7	3.5
SES score, at baseline	-0.9 (3.3)	1.0 (4.1)	-0.6 (3.4)	0.7 (4)	-0.6 (3.5)	0.6 (3.9)	-0.9 (3.3)	0.9 (4)
Alone, ever	30.7	32.6	31.7	31.4	29.8	35.0	34.4	29.8
History of depression, yes	21.4	18.2	22.3	17.4	21.0	17.9	22.1	17.8
History of cancer, yes	4.3	4.0	4.0	4.3	3.7	4.3	4.3	4.0
History of diabetes, yes	3.0	2.3	2.5	2.4	1.9	3.1	2.9	2.5
History of CVD, yes	4.8	3.5	4.2	3.8	3.8	4.4	4.8	3.7
Family history of dementia, yes	15.5	19.8	16.2	18.4	16.4	17.9	15.9	18.6
Multivitamin use, ever	81.1	92.8	82.1	91.9	81.0	92.0	82.6	91.7
BMI, kg/m2	26.6 (5.5)	25.3 (4.4)	26.7 (5.5)	25.3 (4.4)	26.5 (5.4)	25.3 (4.6)	26.6 (5.5)	25.4 (4.5)
Never smoker, %	67.5	52.8	62.0	58.4	59.0	63.1	65.4	57.1
Physical activity, MET task-h/wk	0.9 (1.4)	2.7 (2.7)	0.9 (1.5)	2.6 (2.7)	0.9 (1.5)	2.6 (2.7)	0.9 (1.5)	2.7 (2.7)
Alcohol intake, g/d	5.1 (11.1)	6.3 (7.1)	5.3 (10.9)	5.9 (7)	6.3 (10.7)	4.5 (7)	4 (8.7)	6.4 (8.1)
Energy intake, kcal	1726 (456)	1725 (449)	1714 (485)	1723 (396)	1728 (472)	1737 (420)	1724 (484)	1722 (433)
Dietary score	hPDI		PHDI		rEDIH		rEDIP	
Energy-adjusted score	47.0 (2.4)	62.5 (2.8)	66.4 (4.6)	92.9 (5.0)	-0.5 (0.1)	0.0 (0.1)	-0.3 (0.1)	0.4 (0.2)
Age, at baseline	52.2 (7.3)	53.4 (7.1)	53.1 (7.4)	52.2 (7.0)	51.4 (7.3)	53.1 (7.1)	52.6 (7.3)	52.0 (7.1)
Ancestry								
European	95.3	93.3	95.1	92.8	94.5	95.3	92.6	96.3
Asian	0.4	1.3	0.3	1.8	0.5	0.7	1.3	0.3
African	1.1	1.7	0.8	1.9	1.6	0.6	2.5	0.3
Other	3.3	3.7	3.7	3.6	3.4	3.4	3.7	3.1
SES score, at baseline	-0.3 (3.5)	0.4 (4)	-0.6 (3.4)	0.8 (4)	-0.6 (3.4)	0.8 (4)	-0.6 (3.5)	0.7 (3.9)
Alone, ever	31.7	32.3	31.9	31.3	28.8	33.1	29.7	31.3
History of depression, yes	19.9	18.0	21.5	18.1	23.0	17.5	23.3	17.5
History of cancer, yes	4.0	4.3	4.5	3.8	4.0	4.1	4.3	4.0
History of diabetes, yes	1.9	3.6	2.8	2.3	4.8	1.2	5.1	1.2
History of CVD, yes	4.0	4.3	4.7	3.4	5.1	3.2	5.8	2.6
Family history of dementia, yes	17.1	17.8	15.0	19.6	15.9	19.3	15.9	18.9
Multivitamin use, ever	83.7	90.6	81.2	92.9	82.9	90.6	83.7	89.5
BMI, kg/m2	26.7 (5.4)	25.3 (4.6)	26.4 (5.4)	25.3 (4.5)	28.3 (5.9)	24.2 (3.8)	28.1 (5.8)	24.5 (4)
Never smoker, %	62.6	59.3	66.5	53.7	65.8	53.2	67.4	51.2
Physical activity, MET task-h/wk	1.0 (1.6)	2.5 (2.8)	0.9 (1.6)	2.6 (2.7)	1.1 (1.7)	2.4 (2.6)	1.2 (1.8)	2.2 (2.5)
Alcohol intake, g/d	5 (8.7)	5.7 (9)	4.7 (9.1)	6.2 (8.6)	3.5 (7.5)	10.4 (11.7)	2.8 (6.7)	11.5 (12.2)
Energy intake, kcal	1731 (430)	1722 (464)	1714 (485)	1716 (434)	1781 (490)	1806 (434)	1769 (481)	1769 (449)

Sample size of *n*=70,091. Values are the mean (s.d.) for continuous variables and % for categorical variables. BMI, body mass index; AHEI, alternative healthy eating index; AMED, alternative Mediterranean diet index; DASH, Dietary approaches to stop hypertension; MIND, Mediterranean-DASH intervention for neurodegenerative delay diet; hPDI, healthful plant-based diet index; PHDI, planetary health diet index; EDIH, empirical dietary index for hyperinsulinemia; EDIP, empirical dietary inflammatory pattern; SES, socio-economic status; MET, metabolic equivalent of task. The EDIH and EDIP are reversed scores to allow for comparison with other dietary scores.

Extended Data Table 2 | Age-standardized characteristics of the study population in the lowest and highest quintiles of energy-adjusted dietary pattern scores in the HPFS between 1986 and 2010

Quintile	Q1 6,984	Q5 6,984	Q1 6,984	Q5 6,984	Q1 6,984	Q5 6,984	Q1 6,984	Q5 6,984
Dietary score	AHEI-2010		AMED		DASH		MIND	
Energy-adjusted score	41.9 (4.4)	69.9 (4.5)	1.9 (0.6)	6.2 (0.6)	18.1 (1.9)	30.1 (1.8)	6.0 (0.6)	9.8 (0.6)
Age, at baseline	54.5 (8.7)	54.5 (8.5)	53.2 (8.7)	55.4 (8.4)	52.3 (8.5)	56.7 (8.4)	55.3 (8.7)	53.8 (8.5)
Ancestry								
European	95.7	95.1	96.3	94.8	94.9	95.8	96.1	94.5
Asian	1.1	1.5	1.0	1.6	2.0	1.0	1.1	1.9
African	1.2	1.0	0.9	1.2	1.3	0.9	0.7	1.1
Other	2.0	2.4	1.7	2.4	1.8	2.3	2.1	2.5
SES score, at baseline	-0.7 (3.4)	0.7 (3.9)	-0.6 (3.4)	0.6 (3.9)	-0.6 (3.5)	0.5 (3.8)	-0.8 (3.4)	0.7 (3.8)
Alone, ever	20.7	20.3	21.7	18.9	22.0	18.9	21.6	18.9
History of depression, yes	4.1	3.4	4.5	3.1	4.5	2.8	4.1	3.2
History of cancer, yes	4.8	3.7	4.2	4.3	4.1	4.1	4.5	3.4
History of diabetes, yes	3.9	3.4	2.9	3.7	1.8	5.4	3.8	3.4
History of CVD, yes	6.3	8.1	5.3	9.8	4.9	10.6	6.2	8.9
Family history of dementia, yes	3.3	3.3	3.5	3.3	3.4	3.3	3.0	3.6
Multivitamin use, ever	72.4	88.7	75.4	86.3	74.3	85.4	73.0	88.2
BMI, kg/m^2	26.4 (3.9)	25.2 (3.3)	26.5 (3.9)	25.1 (3.3)	26.3 (3.8)	25.1 (3.4)	26.4 (4)	25.2 (3.2)
Never smoker, %	80.9	71.3	74.1	76.0	72.4	80.0	78.9	72.7
Physical activity, MET task-h/wk	2.1 (2.9)	5.1 (4.4)	2.3 (3.1)	4.9 (4.4)	2.3 (3)	4.8 (4.5)	2.2 (3.2)	5.1 (4.4)
Alcohol intake, g/d	12.9 (18.6)	10.7 (9.6)	12.9 (17.6)	10.9 (10.4)	13.7 (16.5)	9.1 (11.4)	10.7 (15.1)	11.6 (12.2)
Energy intake, kcal	1987 (528)	1990 (511)	2013 (554)	2012 (485)	2006 (543)	2008 (489)	1999 (555)	1994 (502)
Dietary score	hPDI		PHDI		rEDIH		rEDIP	
Energy-adjusted score	46.8 (2.5)	63.4 (3.1)	63.0 (5.5)	94.4 (5.2)	-0.7 (0.2)	-0.1 (0.1)	-0.4 (0.2)	0.4 (0.2)
Age, at baseline	53.1 (8.7)	55.6 (8.4)	54.0 (8.8)	54.4 (8.3)	53.3 (8.8)	54.6 (8.5)	55.0 (8.7)	53.1 (8.4)
Ancestry								
European	95.6	94.8	95.5	94.6	95.0	96.1	93.0	97.0
Asian	1.2	1.8	1.3	2.1	1.3	1.1	2.5	0.6
African	1.0	1.2	1.2	1.0	1.6	0.7	2.1	0.4
Other	2.2	2.3	2.0	2.3	2.0	2.2	2.4	2.0
SES score, at baseline	-0.1 (3.6)	0.1 (3.8)	-0.6 (3.5)	0.6 (3.8)	-0.8 (3.4)	0.7 (3.9)	-0.4 (3.6)	0.2 (3.7)
Alone, ever	20.1	19.3	20.6	19.7	19.8	20.4	20.1	20.7
History of depression, yes	4.3	3.3	4.0	3.4	4.5	3.4	4.3	3.4
History of cancer, yes	4.4	4.1	4.1	3.8	4.3	3.7	4.4	3.7
History of diabetes, yes	1.9	5.1	3.8	3.5	5.9	1.7	5.7	2.0
History of CVD, yes	5.0	9.5	5.8	8.3	6.7	6.8	8.4	5.2
Family history of dementia, yes	3.2	3.3	3.1	3.3	3.0	3.5	3.2	3.1
Multivitamin use, ever	76.0	85.1	73.0	88.5	74.9	85.7	77.6	83.1
BMI, kg/m^2	26.2 (3.7)	25.4 (3.6)	26.4 (4)	25.1 (3.1)	27.1 (4.2)	24.9 (3.1)	26.8 (4.1)	25.5 (3.2)
Never smoker, %	75.9	74.1	78.5	70.2	78.2	69.9	79.3	67.9
Physical activity, MET task-h/wk	2.6 (3.3)	4.7 (4.5)	2.4 (3.3)	5 (4.4)	2.5 (3.4)	4.7 (4.3)	2.9 (3.7)	4.1 (4.1)
Alcohol intake, g/d	10.1 (12.6)	12.3 (14.5)	10.5 (14.6)	12.1 (13.1)	8.8 (12.5)	17.2 (16.3)	6.5 (10.7)	21.4 (17.3)
Energy intake, kcal	2008 (502)	1999 (531)	1985 (592)	1982 (470)	2086 (574)	2105 (510)	2068 (572)	2062 (513)

Sample size of $n=34,924$. Values are the mean (s.d.) for continuous variables and % for categorical variables. BMI, body mass index; AHEI, alternative healthy eating index; AMED, alternative Mediterranean diet index; DASH, Dietary approaches to stop hypertension; MIND, Mediterranean-DASH intervention for neurodegenerative delay diet; hPDI, healthful plant-based diet index; PHDI, planetary health diet index; EDIH, empirical dietary index for hyperinsulinemia; EDIP, empirical dietary inflammatory pattern. The EDIH and EDIP are reversed scores to allow for comparison with other dietary scores.

Extended Data Table 3 | Associations of average dietary pattern scores (1986–2010) with healthy aging and its domains in the pooled cohorts

Outcome		Healthy aging	Healthy aging	Intact cognition	Intact physical function	Intact mental health	No chronic disease	Survived to 70 years
Cases Dietary score	Model	9,771 OR (95%CI) (Q5 vs. Q1)	9,771 OR (95%CI) (continuous)	29,543 OR (95%CI) (Q5 vs. Q1)	27,842 OR (95%CI) (Q5 vs. Q1)	27,842 OR (95%CI) (Q5 vs. Q1)	23,908 OR (95%CI) (Q5 vs. Q1)	39,769 OR (95%CI) (Q5 vs. Q1)
AHEI-2010	Age	3.06 (2.84, 3.30)	2.71 (2.56, 2.87)	2.46 (2.34, 2.57)	4.03 (3.82, 4.26)	3.27 (3.10, 3.44)	2.57 (2.44, 2.71)	3.38 (3.21, 3.55)
	MV	1.86 (1.71, 2.01)	1.71 (1.60, 1.82)	1.62 (1.54, 1.71)	2.30 (2.16, 2.44)	2.03 (1.92, 2.15)	1.64 (1.54, 1.74)	2.14 (2.02, 2.27)
AMED	Age	2.67 (2.48, 2.87)	2.43 (2.29, 2.58)	1.82 (1.74, 1.91)	2.91 (2.76, 3.07)	2.50 (2.37, 2.63)	2.06 (1.96, 2.17)	2.16 (2.05, 2.26)
	MV	1.70 (1.57, 1.84)	1.59 (1.49, 1.70)	1.35 (1.28, 1.42)	1.75 (1.65, 1.86)	1.67 (1.58, 1.77)	1.43 (1.35, 1.52)	1.53 (1.44, 1.62)
DASH	Age	2.62 (2.43, 2.81)	2.48 (2.34, 2.64)	1.85 (1.77, 1.94)	2.79 (2.64, 2.94)	2.42 (2.30, 2.55)	2.01 (1.91, 2.12)	2.10 (1.99, 2.20)
	MV	1.69 (1.56, 1.83)	1.65 (1.54, 1.76)	1.40 (1.33, 1.48)	1.73 (1.63, 1.84)	1.64 (1.55, 1.74)	1.43 (1.35, 1.51)	1.50 (1.41, 1.59)
MIND	Age	2.47 (2.29, 2.67)	2.36 (2.22, 2.50)	1.82 (1.74, 1.91)	2.93 (2.78, 3.09)	2.50 (2.37, 2.63)	1.91 (1.81, 2.01)	2.12 (2.02, 2.22)
	MV	1.60 (1.47, 1.73)	1.57 (1.47, 1.68)	1.40 (1.33, 1.48)	1.82 (1.72, 1.94)	1.75 (1.65, 1.85)	1.35 (1.28, 1.43)	1.59 (1.50, 1.69)
hPDI	Age	2.00 (1.87, 2.15)	1.88 (1.78, 1.99)	1.44 (1.38, 1.51)	2.18 (2.07, 2.29)	1.78 (1.69, 1.87)	1.64 (1.56, 1.72)	1.60 (1.52, 1.68)
	MV	1.45 (1.35, 1.57)	1.40 (1.32, 1.49)	1.21 (1.15, 1.28)	1.56 (1.47, 1.65)	1.37 (1.30, 1.45)	1.32 (1.25, 1.40)	1.33 (1.26, 1.41)
PHDI	Age	2.75 (2.55, 2.96)	2.44 (2.31, 2.59)	2.45 (2.34, 2.56)	3.73 (3.54, 3.93)	3.01 (2.86, 3.17)	2.43 (2.31, 2.57)	3.35 (3.19, 3.52)
	MV	1.68 (1.55, 1.82)	1.56 (1.47, 1.66)	1.65 (1.57, 1.74)	2.16 (2.04, 2.30)	1.89 (1.78, 2.00)	1.55 (1.47, 1.65)	2.17 (2.05, 2.30)
rEDIH	Age	3.20 (2.96, 3.46)	2.60 (2.45, 2.76)	2.15 (2.05, 2.26)	3.89 (3.68, 4.11)	2.79 (2.64, 2.95)	2.89 (2.73, 3.06)	2.87 (2.72, 3.02)
	MV	1.80 (1.64, 1.96)	1.53 (1.43, 1.63)	1.42 (1.34, 1.50)	1.78 (1.67, 1.90)	1.62 (1.52, 1.72)	1.75 (1.65, 1.87)	1.71 (1.61, 1.82)
rEDIP	Age	2.34 (2.17, 2.53)	1.84 (1.75, 1.94)	1.57 (1.50, 1.64)	2.45 (2.33, 2.58)	1.98 (1.88, 2.09)	2.20 (2.09, 2.32)	1.90 (1.81, 2.00)
	MV	1.58 (1.45, 1.72)	1.29 (1.22, 1.37)	1.14 (1.09, 1.21)	1.38 (1.30, 1.46)	1.34 (1.27, 1.42)	1.52 (1.43, 1.61)	1.29 (1.22, 1.37)

Sample size of n=105,015. The age-adjusted logistic regression models are adjusted for age at baseline (1986) and cohort (sex). The MV-adjusted logistic regression models are adjusted for age at baseline (1986), cohort (sex), BMI (kg/m^2), ancestry (European, Asian, African-American, other), smoking status (never, former, current smoker: 1–14 cigarettes per day, 15–24 cigarettes per day, and ≥25 cigarettes per day), alcohol intake (g/d), physical activity (metabolic equivalent task-hours/week), multivitamin use ever (yes/no), family history of myocardial infarction (yes/no), family history of type 2 diabetes, family history of cancer, family history of dementia (yes/no), postmenopausal status (yes/no) and menopausal hormone use (no, past, or current hormone use) (only women), socio-economic status at baseline, marital status (yes/no), living alone ever (yes/no), history of depression (yes/no). MV, multivariable; OR, odds ratio; CI, confidence interval; AHEI, alternative healthy eating index; AMED, alternative Mediterranean diet index; DASH, Dietary approaches to stop hypertension; MIND, Mediterranean-DASH intervention for neurodegenerative delay diet; hPDI, healthful plant-based diet index; PHDI, planetary health diet index; EDIH, empirical dietary index for hyperinsulinemia; EDIP, empirical dietary inflammatory pattern. The EDIH and EDIP are reversed scores to allow for comparison with other dietary scores.

Extended Data Table 4 | Absolute risks for Q1 and Q5 across all dietary pattern scores

Dietary pattern	Absolute risks, %	
	Q1	Q5
AHEI	5.3 (5.4, 5.3)	9.9 (9.2, 10.7)
AMED	6.1 (6.2, 6.1)	10.4 (9.7, 11.2)
DASH	7.3 (7.4, 7.2)	12.4 (11.5, 13.2)
MIND	5.1 (5.2, 5.1)	8.2 (7.6, 8.8)
hPDI	7.7 (7.8, 7.7)	11.2 (10.5, 12.0)
PHDI	5.6 (5.6, 5.5)	9.4 (8.7, 10.1)
rEDIH	5.3 (5.3, 5.2)	9.5 (8.7, 10.2)
rEDIP	5.3 (5.4, 5.3)	8.4 (7.8, 9.1)

The proportion of healthy agers in Q1 and the multivariable-adjusted OR comparing Q5 versus Q1 was used to calculate the absolute risks in both quintiles.

Extended Data Table 5 | Associations of average dietary pattern scores (1986–2010) with healthy aging using an age cutoff of 75 years

Outcome		Healthy aging	Healthy aging
Cases	Total 89,755	5,445	5,445
Dietary score	Model	OR (95%CI) (Q5 vs. Q1)	OR (95%CI) (continuous)
AHEI-2010	Age	4.36 (3.94, 4.83)	3.46 (3.21, 3.73)
	MV	2.24 (2.01, 2.50)	1.91 (1.76, 2.08)
AMED	Age	3.25 (2.95, 3.58)	2.89 (2.67, 3.12)
	MV	1.86 (1.67, 2.06)	1.71 (1.58, 1.86)
DASH	Age	3.16 (2.87, 3.48)	2.89 (2.68, 3.13)
	MV	1.84 (1.66, 2.04)	1.77 (1.62, 1.92)
MIND	Age	3.02 (2.73, 3.34)	2.74 (2.54, 2.96)
	MV	1.78 (1.60, 1.98)	1.70 (1.56, 1.85)
hPDI	Age	2.36 (2.15, 2.59)	2.18 (2.03, 2.34)
	MV	1.61 (1.46, 1.77)	1.53 (1.42, 1.66)
PHDI	Age	3.70 (3.35, 4.09)	3.12 (2.90, 3.36)
	MV	1.94 (1.74, 2.16)	1.77 (1.63, 1.91)
rEDIH	Age	4.23 (3.79, 4.72)	3.17 (2.94, 3.41)
	MV	2.03 (1.80, 2.30)	1.68 (1.54, 1.83)
rEDIP	Age	2.85 (2.57, 3.15)	2.04 (1.91, 2.17)
	MV	1.68 (1.50, 1.88)	1.34 (1.24, 1.44)

Sample size of $n = 89,755$. The age-adjusted logistic regression models are adjusted for age at baseline (1986) and cohort (sex). The MV-adjusted logistic regression models are adjusted for age at baseline (1986), cohort (sex), BMI (kg/m²), ancestry (European, Asian, African-American, other), smoking status (never, former, current smoker: 1–14 cigarettes per day, 15–24 cigarettes per day, and ≥25 cigarettes per day), alcohol intake (g/d), physical activity (metabolic equivalent task-hours/week), multivitamin use ever (yes/no), family history of myocardial infarction (yes/no), family history of type 2 diabetes, family history of cancer, family history of dementia (yes/no), postmenopausal status (yes/no) and menopausal hormone use (no, past, or current hormone use) (only women), socio-economic status at baseline, marital status (yes/no), living alone ever (yes/no), history of depression (yes/no), in the pooled cohorts. MV, multivariable; OR, odds ratio; CI, confidence interval; AHEI, alternative healthy eating index; AMED, alternative Mediterranean diet index; DASH, Dietary approaches to stop hypertension; MIND, Mediterranean-DASH intervention for neurodegenerative delay diet; hPDI, healthful plant-based diet index; PHDI, planetary health diet index; EDIH, empirical dietary index for hyperinsulinemia; EDIP, empirical dietary inflammatory pattern. The EDIH and EDIP are reversed scores to allow for comparison with other dietary scores.

Extended Data Table 6 | Associations of weighted average dietary pattern scores (1986–2010) with healthy aging

Outcome		Healthy aging	Healthy aging
Cases	Total 105,015	9,771	9,771
Dietary score	Model	OR (95%CI) (Q5 vs. Q1)	OR (95%CI) (continuous)
AHEI-2010	Age	3.22 (2.92, 3.54)	2.87 (2.66, 3.09)
	MV	1.97 (1.77, 2.19)	1.82 (1.67, 1.97)
AMED	Age	2.52 (2.30, 2.77)	2.34 (2.17, 2.53)
	MV	1.63 (1.48, 1.81)	1.54 (1.42, 1.67)
DASH	Age	2.59 (2.36, 2.84)	2.41 (2.23, 2.60)
	MV	1.67 (1.51, 1.85)	1.61 (1.48, 1.76)
MIND	Age	2.42 (2.20, 2.67)	2.30 (2.13, 2.49)
	MV	1.61 (1.45, 1.78)	1.56 (1.43, 1.69)
hPDI	Age	1.94 (1.77, 2.12)	1.86 (1.73, 2.00)
	MV	1.43 (1.30, 1.57)	1.41 (1.31, 1.52)
PHDI	Age	2.62 (2.38, 2.88)	2.41 (2.24, 2.60)
	MV	1.64 (1.48, 1.81)	1.56 (1.44, 1.68)
rEDIH	Age	3.06 (2.76, 3.38)	2.56 (2.37, 2.76)
	MV	1.79 (1.60, 2.01)	1.57 (1.44, 1.70)
rEDIP	Age	2.28 (2.07, 2.52)	1.72 (1.61, 1.83)
	MV	1.60 (1.43, 1.79)	1.26 (1.17, 1.35)

Sample size of n=105,015. The age-adjusted logistic regression models are adjusted for age at baseline (1986) and cohort (sex). The MV-adjusted logistic regression models are adjusted for age at baseline (1986), cohort (sex), BMI (kg/m^2), ancestry (European, Asian, African-American, other), smoking status (never, former, current smoker: 1–14 cigarettes per day, 15–24 cigarettes per day, and ≥25 cigarettes per day), alcohol intake (g/d), physical activity (metabolic equivalent task-hours/week), multivitamin use ever (yes/no), family history of myocardial infarction (yes/no), family history of type 2 diabetes, family history of cancer, family history of dementia (yes/no), postmenopausal status (yes/no) and menopausal hormone use (no, past, or current hormone use) (only women), socio-economic status at baseline, marital status (yes/no), living alone ever (yes/no), history of depression (yes/no), in the pooled cohorts. MV, multivariable; OR, odds ratio; CI, confidence interval; AHEI, alternative healthy eating index; AMED, alternative Mediterranean diet index; DASH, Dietary approaches to stop hypertension; MIND, Mediterranean-DASH intervention for neurodegenerative delay diet; hPDI, healthful plant-based diet index; PHDI, planetary health diet index; EDIH, empirical dietary index for hyperinsulinemia; EDIP, empirical dietary inflammatory pattern. The EDIH and EDIP are reversed scores to allow for comparison with other dietary scores. Linear weights were applied as follows: 1986=1, 1990=2, 1994=3, 1998=4, 2002=5, 2006=6, 2010=7.

Extended Data Table 7 | Associations of average ultraprocessed food consumption (1986–2010) with healthy aging and its domains in the pooled cohorts

Outcome		Healthy aging		Healthy aging	Intact cognition	Intact physical function	Intact mental health	No chronic disease	Survived to 70 years
Cases		9,768		9,768	35,541	29,526	27,828	23,898	39,757
Dietary score	Model	OR (95%CI) (Q5 vs. Q1)	E-values (Upper bound)	OR (95%CI) (continuous)	OR (95%CI) (Q5 vs. Q1)	OR (95%CI) (Q5 vs. Q1)	OR (95%CI) (Q5 vs. Q1)	OR (95%CI) (Q5 vs. Q1)	OR (95%CI) (Q5 vs. Q1)
UPF	Age	0.50 (0.47, 0.54)	3.41 (3.11)	0.54 (0.51, 0.57)	0.79 (0.75, 0.83)	0.54 (0.51, 0.57)	0.57 (0.54, 0.60)	0.69 (0.65, 0.73)	0.75 (0.72, 0.79)
	MV	0.68 (0.63, 0.73)	2.30 (2.08)	0.72 (0.67, 0.76)	0.89 (0.84, 0.94)	0.73 (0.69, 0.78)	0.71 (0.67, 0.75)	0.85 (0.80, 0.90)	0.83 (0.79, 0.88)

Sample size of n=104,635 without missing UPF intake. The age-adjusted logistic regression models are adjusted for age at baseline (1986) and cohort (sex). The MV-adjusted logistic regression models are adjusted for age at baseline (1986), cohort (sex), BMI (kg/m^2), ancestry (European, Asian, African-American, other), smoking status (never, former, current smoker: 1–14 cigarettes per day, 15–24 cigarettes per day, and ≥25 cigarettes per day), alcohol intake (g/d), physical activity (metabolic equivalent task-hours/week), multivitamin use ever (yes/no), family history of myocardial infarction (yes/no), family history of type 2 diabetes, family history of cancer, family history of dementia (yes/no), postmenopausal status (yes/no) and menopausal hormone use (no, past, or current hormone use) (only women), socio-economic status at baseline, marital status (yes/no), living alone ever (yes/no), history of depression (yes/no), in the pooled cohorts. MV, multivariable; OR, odds ratio; CI, confidence interval; UPF, ultraprocessed foods (nova 4); Q1: lowest UPF intake; Q5: highest UPF intake. UPF intake as % of total energy was used.

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Our web collection on statistics for biologists contains articles on many of the points above.

Software and code

Policy information about availability of computer code

Data collection	No software was used for data collection.
Data analysis	Main analyses were performed using SAS version 9.4 and analyses for individual dietary factors were performed using R versions 4.2.0.The analysis programs are publicly available at https://github.com/DrTessier/diets_healthyaging.

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by the participants. Investigators can expect initial responses within 4 weeks of request submission. Further information including the procedures for obtaining and accessing data from the Nurses' Health Studies and Health Professionals' Follow-up Study is described at https://www.nurseshealthstudy.org/researchers (email: nhsaccess@channing.harvard.edu) and https://sites.sph.harvard.edu/hpfs/for-collaborators.The Harvard University Food Composition tables are publicly available at https://hsph.harvard.edu/department/nutrition/nutrition-questionnaire-service-center/#nutrient-data.

Research involving human participants, their data, or biological material

Policy information about studies with [human participants or human data](). See also policy information about [sex, gender (identity/presentation), and sexual orientation]() and [race, ethnicity and racism]().

Reporting on sex and gender	Both sexes (self-reported) are included in this study. Detailed participants' characteristics by sex are shown in Extended Data Table 1 and 2. We included sex as a covariate in our main analyses. Additionally, we conducted subgroup analyses by sex and effect estimate are reported in Figure 2. The results were consistent in both groups.
Reporting on race, ethnicity, or other socially relevant groupings	Reported in Table 1.
Population characteristics	he study included 70,091 women from the Nurses' Health Study and 34,924 men from the Health Professionals Follow-up Study free of 11 chronic diseases at baseline and with detailed dietary assessment. A detailed description of the population characteristics can be found in the Results and Methods sections as well as in Table 1 and Extended Data Tables 1 and 2 of the manuscript.
Recruitment	The Nurses health studies (NHS) and NHSII include registered women nurses. The Health Professionals Follow-up study (HPFS) includes men health professionals (veterinarians, dentists, pharmacists, optometrists, osteopath, physicians, and podiatrists). Questionnaires were sent to participants in these cohorts to collect and update their lifestyle and medical history every two years. Participants provided data on their dietary intake during the preceding year using an extensively validated semi-quantitative food frequency questionnaire every four years. The follow-up rates were approximately 90% in all cohorts.
Ethics oversight	This is an observational study. The study protocol was approved by the Institutional Review Board (IRBs) of the Brigham and Women's Hospital, Harvard T.H. Chan School of Public Health, and participating registries (IRB Protocol number: 2001P001945/BWH and 10372. The IRBs allowed participants' completion of questionnaires to be considered as implied consent for participation in these studies of health professionals. Written informed consent was required for biomarkers collection and for medical record acquisition. The study was performed in accordance with the Declaration of Helsinki.

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Life sciences study design

All studies must disclose on these points even when the disclosure is negative.

Sample size	The study population is preexisting. We documented 9,771 cases of healthy agers, allowing us to detect the major findings of the present study with statistical power of >90% from a post hoc analysis
Data exclusions	We excluded participants who had not returned a food frequency questionnaire between 1986-2010, those with implausible energy intake, those with one or more of the 11 chronic diseases, those with missing healthy aging phenotype in 2016.
Replication	The validity and reproducibility of questionnaires and outcome ascertainment have been reported previously and described in the Methods. Moderate correlations were observed for foods, nutrients, and dietary patterns comparing the estimates from food frequency questionnaires with those from multiple one-week diet records. Participants who reported a new diagnosis of major chronic disease were asked for permission to obtain their medical records and pathological reported. The Subjective Cognitive Decline (SCD), Short-Form 36 and the Geriatric Depression Scale have all shown good validity at measuring self-perceived cognitive decline, physical limitations, and depressive symptoms, respectively. Deaths were identified through the next-of-kin or portal office when questionnaires were mailed and through searches of the National Death Index. Death ascertainment using National Death Index was reported to have a high sensitivity (98%) and specificity (100%).Replication of these analyses was not applicable and therefore not conducted.
Randomization	Not applicable. This study is an observational study without an intervention.
Blinding	Not applicable. This study is an observational study without an intervention.

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☒ ☐	Animals and other organisms
☒ ☐	Clinical data
☒ ☐	Dual use research of concern
☒ ☐	Plants

Methods

n/a	Involved in the study
☒ ☐	ChIP-seq
☒ ☐	Flow cytometry
☒ ☐	MRI-based neuroimaging

Plants

Seed stocks	NA
Novel plant genotypes	NA
Authentication	NA