Supplemental material

Assessment of modifiable risk factors

BMI. Body weight and height were asked in biennial questionnaires from 1984 to 2016 in the NHS and from 1986 to 2016 in the HPFS, and BMI was calculated as weight (kg) over height (m) squared. The correlation between measured and self-reported weight was 0.97 for both NHS and HPFS participants.[1] We have 17 and 16 repeated measures of BMI in the NHS and HPFS, respectively.

Smoking. Participants self-reported their smoking status (past, current, never smoker) and the number of cigarettes smoked (1-4, 5-14, 15-24, 25-34, 35-44, and ≥45 cigarettes/day) in biennial questionnaires from 1984 to 2016 in the NHS and from 1986 to 2016 in the HPFS. We categorized smoking status into 13 groups, namely never, former (categorized into 1-4, 5-14, 15-24, 25-34, 35-44, ≥45 cigarettes/day), current (categorized in to 1-4, 5-14, 15-24, 25-34, 35-44, ≥45 cigarettes/day), and assigned numbers 0-12 for the 13 groups. We have 17 and 16 repeated measures of smoking in the NHS and HPFS, respectively.

Alcohol intake. In 1984, a 116-item food frequency questionnaire (FFQ) was administered to the NHS participants to obtain information on usual intake of food and beverages. Starting in 1986, an expanded 131-item FFQ was administered every 4 years to update diet from the NHS and the HPFS participants. In FFQs, participants were asked how often (from "never or less than once per month" to "6 or more times per day") on average they consumed a standard portion size of each food item during the previous year. The FFQ has shown good validity and reproducibility, and the results have been described in detail elsewhere.[2-5] Questions about the consumption of alcoholic

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beverages (including beer, wine, and liquor) were included in each questionnaire. Alcohol intake was assessed until 2010 in the NHS and 2014 in the HPFS, and we have 8 repeated measures in both cohorts.

Diet quality: The Alternative Health Eating Index (AHEI). In each 4-year cycle of diet assessment via an extensively validated food frequency questionnaire, food items were combined into food groups, and a dietary pattern score AHEI-2010was derived to reflect diet quality.[6] In our analysis, scoring for the AHEI-2010 was based on intake levels of 10 components, excluding alcohol, which were chosen on the basis of their association with chronic disease and mortality risk in observational and interventional studies.[6] The score emphasized higher intakes of fruit, vegetables, whole grains, long-chain omega-3 fats, nuts and legumes, and polyunsaturated fatty acids and lower intakes of sugar-sweetened beverages, red and processed meat, *trans* fat, and sodium. Each component was scored from 0 (unhealthy) to 10 (healthiest), and the total score ranged from 0 (non-adherence) to 100 (perfect adherence). We have 8 and 6 repeated measures of diet in the NHS and HPFS, respectively.

Physical activity. Physical activity was assessed by previously validated questionnaires.[7] Beginning in 1986 participants from both cohorts self-reported amount of time spent per week on each of the following physical activities: walking; jogging; running; bicycling; calisthenics, aerobics, aerobic dance, or rowing machine use; lap swimming; playing tennis; and playing squash or racquet ball. From this information, weekly energy expenditure in metabolic equivalent task-hours (MET-hours) was calculated.[8] The reproducibility and validity of the physical activity questionnaire has been described elsewhere.[7] The correlation for physical activity between two repeated questionnaires administered two years apart was 0.59, and correlation between physical activity reported in diaries and that reported on questionnaire was 0.62. Physical activity was assessed 11 times in the NHS, and 7 times in the HPFS.

Smoothing mixture model (SMM)

We used SMM to identify patterns of each risk factor, which adopted a modified expectation-maximization (EM) algorithm to delineate trajectories with smoothing functions of age.[9] Initially, we divided participants into $\boldsymbol{k}$ groups according to the mean value of a risk factor across follow-up period. The group assignment and estimation of the smooth trajectories for each group were achieved by iterating the expectation step (E step) and maximization step (M step). In M step, for individual $\boldsymbol{i}$ that was classified into the group $\boldsymbol{m}$, the model was $\boldsymbol{E}(\boldsymbol{Y}_{\boldsymbol{i}}) = \boldsymbol{f}_{\boldsymbol{m}}(\boldsymbol{t}_{\boldsymbol{i}}) + \boldsymbol{b}_{\boldsymbol{mi}}$, where the vector $\boldsymbol{Y}_{\boldsymbol{i}}$ was the multiple repeated measurements of the risk factor over time $\boldsymbol{t}_{\boldsymbol{i}}$ for individual $\boldsymbol{i}$, $\boldsymbol{f}_{\boldsymbol{m}}(.)$ was a non-parametric penalized smoothing function of age, and $\boldsymbol{b}_{\boldsymbol{mi}}$ was random effect of individual $\boldsymbol{i}$. Then we obtained mean predicted value $\widehat{\boldsymbol{Y}}_{\boldsymbol{i}(\mathbf{1})}, \widehat{\boldsymbol{Y}}_{\boldsymbol{i}(\mathbf{2})}, \ldots, \widehat{\boldsymbol{Y}}_{\boldsymbol{i}(\boldsymbol{k})}$ estimated from the model fitted in the *1*st, *2*nd, …, $\boldsymbol{k}$th groups, respectively. In the E step, we obtained the log likelihood contributions of individual $\boldsymbol{i}$'s trajectory of responses belonging to the *1*st, *2*nd, …, $\boldsymbol{k}$th groups, and reassigned individual $\boldsymbol{i}$ to the group with the largest log likelihood. The E and M steps were iterated until the model converged, which was determined when the sum of the largest log likelihood for all individuals remained the same. The R script of the SMM is available in Github (https://github.com/mingding-hsph/Smoothing-mixture-model).

Total, between-person, and within-person sum of squares

Total sum of squares: We first calculated the difference between each value and the grant mean, which was the mean of all values from all participants. Then we summed the squared differences across all participants.

Between-person sum of squares: For each participant, we first computed the difference between its group mean and the grand mean. Then we summed the squared differences across all participants.

Within-person sum of squares: For each participant, we first computed the difference between each value and its group mean. Then we summed the squared differences across all participants.

Total sum of squares would be equal to the sum of between-person sum of squares and within-person sum of squares.

Joint membership of trajectories of risk factors and trajectories of change in risk factors

First, we identified trajectories of risk factors during follow-up and classified participants into three groups (high, medium, low) using SMM. Within each group, we obtained the mean predicted value of risk factor with age (fixed effects) and the predicted value of risk factor with age for each participant (random effects) from the output of SMM. We plotted the mean and 95% CI of predicted trajectories of each group and predicted trajectories of individuals within each group using the 'ggplot' command in R 3.5.0. The identification of trajectories of risk factors was conducted in the NHS and the HPFS, separately.

Second, we reclassified these participants using SMM from a different dimension—trajectories of change in risk factors from baseline. The participants were classified into three groups: increase, stable, and decrease. Within each group, we obtained the mean predicted value of change in risk factor (fixed effects) and the predicted value of change in risk factor for each participant (random effects) from the output of SMM. We plotted the mean and 95% CI of predicted trajectories of each group and predicted trajectories of individuals within each group using the 'ggplot' command in R 3.5.0. The identification of trajectories of risk factors was conducted in the NHS and the HPFS, separately.

Finally, based on the group memberships of trajectories of risk factors and trajectories of change in risk factors, we jointly classified participants into nine groups: high–stable, high–increase, high–decrease, medium–stable, medium–increase, medium–decrease, low–stable, low–increase, and low–decrease. After obtaining the joint group membership, we pooled the data of the NHS and the HFPS. Within each joint group, we calculated mean value of risk factor with age and used 'loess.smooth' function in R to obtain the trajectories of risk factors with age. The trajectories of risk factors based on joint group memberships were plotted using 'plot' command in R 3.5.0.

Group-based trajectory analysis

Proposed by Nagin *et al*, group-based trajectory analysis is a widely used method to classify participants within a population with heterogeneous longitudinal trajectories.[10] It allows different sets of parameter values for mixture components corresponding to different unobserved subgroups of individuals, and captures latent trajectory classes with different growth curves by using an expectation-maximization (EM) algorithm. Group-based trajectory analysis assumes individuals within groups are homogenous and uses polynomials to generate flexible trajectories.[11] We modeled trajectories with cubic polynomials, fitted group-based trajectory model using "proc traj" command using SAS version 9.2 for UNIX (SAS Institute, Cary, NC), and plotted the trajectories using "trajplot" command.[12]

Table S1. Time (year) at assessment of modifiable risk factors in the Nurses' Health Study (NHS) and the Health Professionals Follow-up Study (HPFS).

	Time at assessment of risk factors																
	84	**86**	**88**	**90**	**92**	**94**	**96**	**98**	**00**	**02**	**04**	**06**	**08**	**10**	**12**	**14**	**16**
BMI, smoking																	
NHS	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
HPFS		X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Diet quality																	
NHS	X	X		X		X		X		X		X		X			
HPFS		X		X		X		X		X		X					
Physical activity																	
NHS		X	X		X	X	X	X	X		X		X		X	X	
HPFS		X		X		X		X		X		X	X				
Alcohol intake																	
NHS	X	X		X		X		X		X		X		X		X	
HPFS		X		X		X		X		X		X		X			

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Table S2. Variance components of body mass index (BMI), smoking, alcohol intake, diet quality, and physical activity in the Nurses' Health Study and the Health Professionals Follow-up Study.

	NHS				HPFS			
Risk factors	Between person sum of squares (SS)	Within person SS	Total SS	Proportion of between person SS over total SS, %	Between person sum of squares (SS)	Within person SS	Total SS	Proportion of between person SS over total SS, %
BMI	10650346	1533622	12183968	87	2381276	275831	2657107	90
Smoking	22907934	9006215	31914149	72	6508684	2263251	8771935	74
Alcohol intake	8218491	2793784	11012275	75	9266668	2681234	11947902	78
AHEI	15671920	9071161	24743080	63	8416905	2650293	11067198	76
Physical activity	27163279	28920211	56083489	48	26252022	18104344	44356366	59

Figure S1. A flow diagram of sample selection in the Nurses' Health Study (NHS).

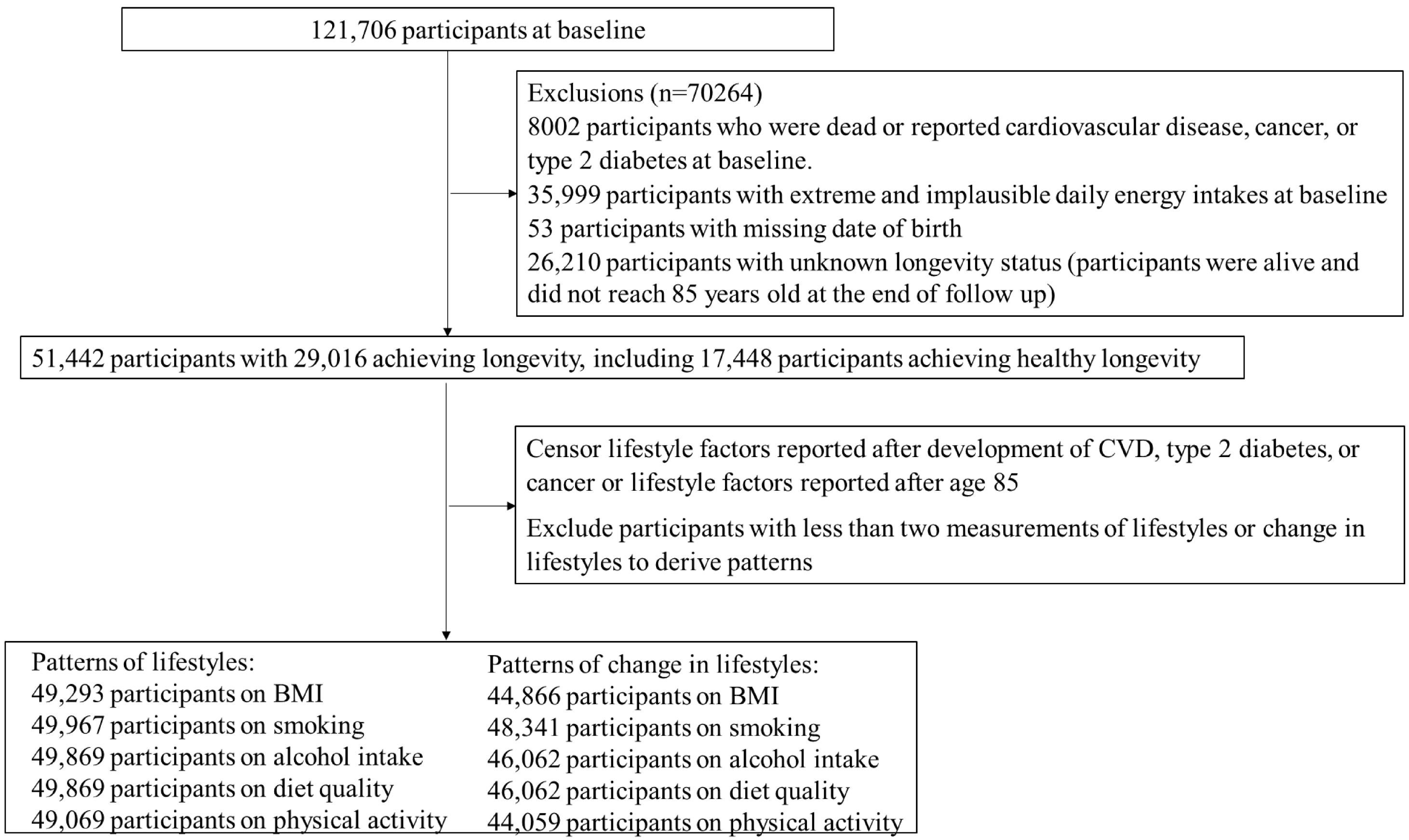

Figure S2. A flow diagram of sample selection in the Health Professionals Follow-up Study (HPFS).

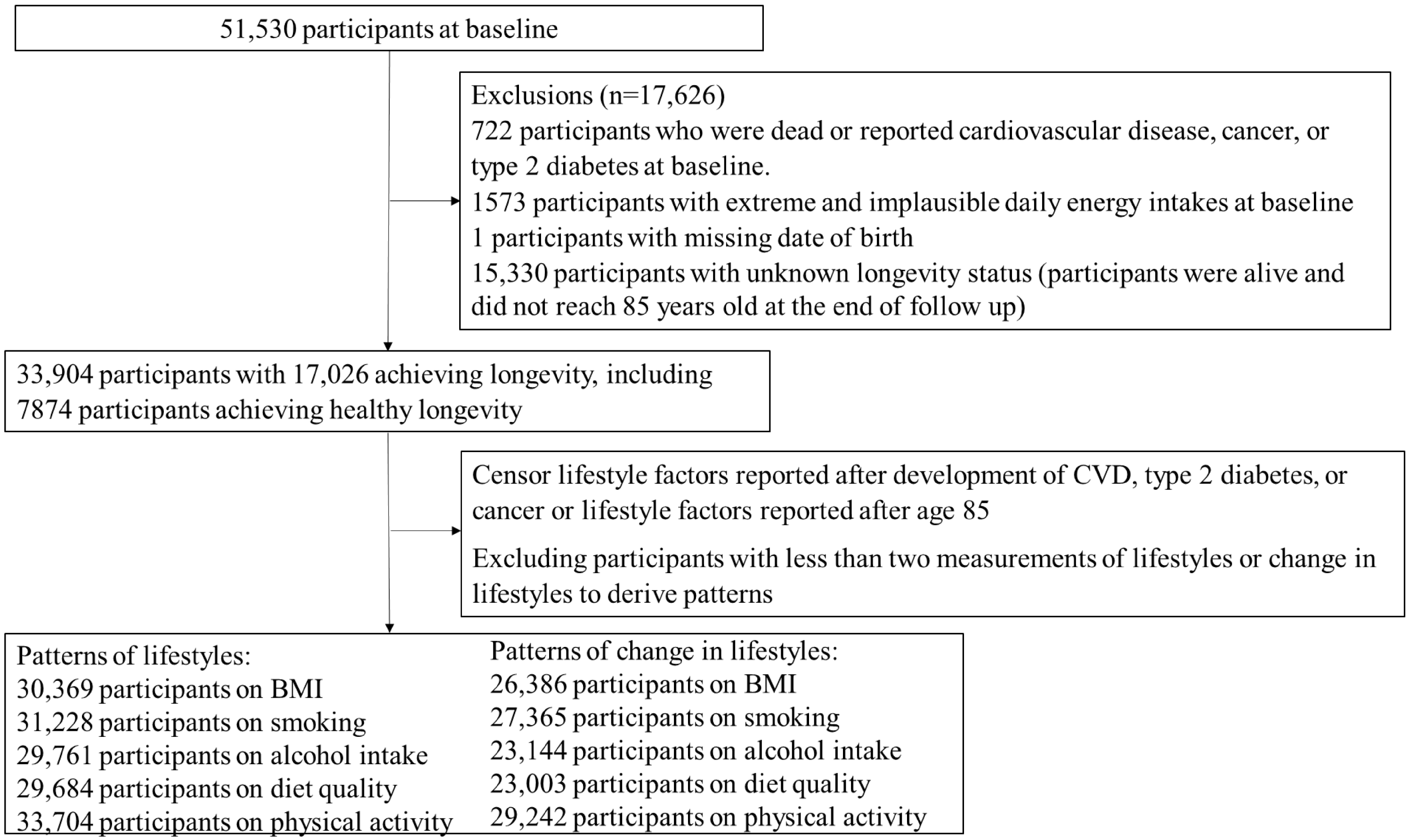

Table S3. Baseline characteristics of participants by trajectories of modifiable risk factors including body mass index (BMI), smoking, alcohol intake, diet quality, and physical activity in the Nurses' Health Study (NHS, women) and the Health Professionals Follow-up Study (HPFS, men).

	BMI				Smoking			
NHS (1984)	Low (n=23,856)	Medium (n=19658)	High (n=5810)	P value	Low (n=39,773)	Medium (n=6739)	High (n=3487)	P value
Age	54.79 (5.18)	54.08 (5.34)	52.15 (5.88)	<0.001	54.36 (5.29)	53.11 (5.78)	54.50 (5.66)	<0.001
BMI (kg/m^2)	21.96 (1.95)	26.44 (2.61)	34.06 (4.73)	<0.001	25.43 (4.76)	24.09 (4.13)	24.47 (4.38)	<0.001
Alcohol intake (g)	8.73 (12.71)	6.706 (11.348)	4.09 (9.078)	<0.001	6.49 (10.68)	9.814 (13.879)	13.08 (17.94)	<0.001
Physical activity (MET-h/week)	15.79 (21.82)	44.36 (10.09)	10.15 (15.55)	<0.001	14.66 (20.42)	42.13 (9.71)	9.91 (20.78)	<0.001
AHEI	44.33 (10.52)	13.06 (19.63)	43.53 (10.1)	<0.001	44.94 (10.36)	12.29 (19.71)	40.49 (9.37)	<0.001
Current smoker, %	29	24	20	<0.001	8	97	99	<0.001
Caucasian, %	98	98	97	<0.001	98	98	99	<0.001
Menopausal status, %	70	69	68	<0.001	68	74	75	<0.001
Postmenopausal hormone use, %[§]	21	17	11	<0.001	19	16	14	<0.001
Family history of cancer, %	43	43	42	0.78	43	40	39	0.43
Family history of cardiovascular disease, %	35	36	37	0.004	36	36	37	<0.001
Family history of diabetes, %	20	25	30	<0.001	23	21	20	<0.001
Multivitamin use, %	40	38	35	<0.001	39	34	34	<0.001
HPFS (1986)	Low (n=14,213)	Medium (n=13213)	High (n=2947)		Low (n=28,242)	Medium (n=2086)	High (n=904)	
Age	60.59 (7.67)	58.74 (7.73)	55.05 (7.91)	<0.001	59.40 (7.87)	57.67 (8.01)	60.11 (8.48)	<0.001
BMI (kg/m^2)	22.83 (3.52)	26.2 (4.16)	31.34 (6.77)	<0.001	25.03 (5.10)	24.61 (5.59)	24.42 (5.81)	<0.001
Alcohol intake (g)	11.98 (15.76)	12.48 (16.71)	10.7 (16.17)	0.42	11.37 (15.48)	17.16 (19.6)	22.1 (24.69)	<0.001

Physical activity (MET-h/week)	22.59 (28.17)	47.12 (10.61)	12.82 (20.19)	<0.001	20.28 (27.16)	43.62 (10.49)	11.15 (17.50)	<0.001
AHEI	48.56 (11.10)	18.41 (26.45)	46.24 (10.58)	<0.001	48.26 (10.83)	15.45 (21.25)	41.39 (9.90)	<0.001
Current smoker, %	11	10	10	0.20	3	82	98	<0.001
Caucasian, %	91	91	91	0.01	91	90	93	0.58
Family history of cancer, %	9	9	11	0.06	9	10	9	0.87
Family history of cardiovascular disease, %	35	35	35	0.50	35	33	34	0.04
Family history of diabetes, %	15	16	16	0.004	15	13	12	<0.001
Multivitamin use, %	37	33	30	<0.001	35	27	35	<0.001

-continued

	AHEI				Physical activity			
NHS (1984)	Low (n=16,152)	Medium (n=22395)	High (n=11,355)	P value	Low (n=32,110)	Medium (n=14251)	High (n=2739)	P value
Age	53.47 (5.64)	54.33 (5.28)	55.04 (5.06)	<0.001	54.29 (5.43)	54.17 (5.24)	53.41 (5.41)	<0.001
BMI (kg/m^2)	25.50 (5.00)	25.27 (4.64)	24.66 (4.32)	<0.001	25.66 (4.92)	24.33 (3.94)	23.67 (3.83)	<0.001
Alcohol intake (g)	7.87 (13.07)	7.447 (11.73)	6.57 (10.31)	<0.001	7.24 (12.18)	7.601 (11.291)	8.04 (11.70)	<0.001
Physical activity (MET-h/week)	9.98 (14.23)	44.83 (6.67)	19.62 (26.38)	<0.001	7.35 (8.62)	46.2 (10.38)	51.81 (51.80)	<0.001
AHEI	35.19 (6.31)	14.08 (20.04)	55.96 (8.06)	<0.001	43.03 (10.01)	21.72 (18.25)	48.82 (10.81)	<0.001
Current smoker, %	33	25	17	<0.001	28	22	21	<0.001
Caucasian, %	99	98	97	<0.001	98	98	98	0.03
Menopausal status, %	70	70	69	<0.001	70	69	70	0.09
Postmenopausal hormone use, %[§]	16	19	21	<0.001	18	19	19	<0.001
Family history of cancer, %	43	43	43	0.24	43	44	43	0.02

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Family history of cardiovascular disease, %	36	36	36	0.26	36	35	36	0.52
Family history of diabetes, %	24	23	23	0.23	23	23	21	0.12
Multivitamin use, %	34	40	45	<0.001	37	42	44	<0.001
HPFS (1986)	Low (n=8978)	Medium (n=13082)	High (n=7628)		Low (n=22,244)	Medium (n=9625)	High (n=1839)	
Age	58.20 (7.88)	59.47 (7.69)	60.61 (7.62)	<0.001	60.01 (8.05)	58.75 (7.76)	57.84 (7.63)	<0.001
BMI (kg/m^2)	25.41 (5.17)	25.06 (5)	24.46 (4.90)	<0.001	25.23 (5.54)	24.62 (4.7)	24.38 (4.37)	<0.001
Alcohol intake (g)	14.23 (18.55)	12.07 (15.64)	9.60 (13.42)	<0.001	11.83 (16.55)	12.47 (15.89)	12.35 (15.83)	0.003
Physical activity (MET-h/week)	15.5 (22.85)	48.31 (6.24)	25.59 (29.67)	<0.001	9.60 (10.20)	49.49 (10.75)	73.03 (65.82)	<0.001
AHEI	36.84 (6.41)	19.54 (26.73)	59.96 (7.43)	<0.001	46.77 (10.83)	32.45 (22.39)	50.68 (11.22)	<0.001
Current smoker, %	16	9	4	<0.001	13	8	7	<0.001
Caucasian, %	92	91	91	<0.001	91	91	91	0.06
Family history of cancer, %	9	9	10	0.01	9	9	9	1.00
Family history of cardiovascular disease, %	33	35	39	<0.001	36	34	35	0.04
Family history of diabetes, %	15	16	16	0.01	15	15	15	0.56
Multivitamin use, %	32	35	40	<0.001	32	35	36	<0.001

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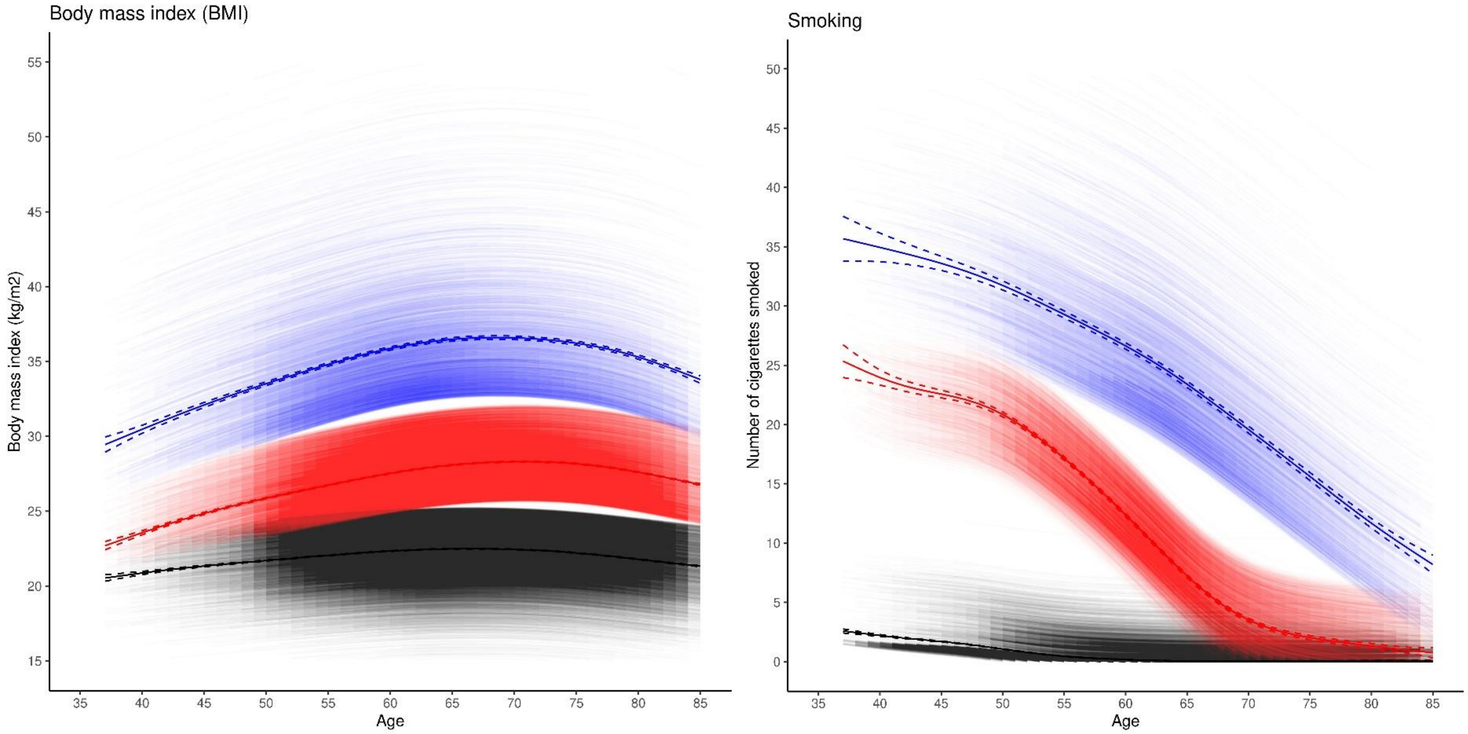
	Alcohol intake			
NHS (1984)	Low (n=36,728)	Medium (n=10025)	High (n=3149)	P value
Age	54.23 (5.41)	54.2 (5.29)	54.02 (5.32)	<0.001
BMI (kg/m^2)	25.69 (4.96)	23.91 (3.54)	23.81 (3.70)	<0.001
Alcohol intake (g)	2.46 (3.84)	16.27 (10.82)	36.39 (17.98)	<0.001
Physical activity (MET-h/week)	13.28 (19.50)	44.63 (10.01)	14.42 (19.91)	<0.001
AHEI	44.27 (10.45)	16.52 (23.68)	42.76 (9.74)	<0.001
Current smoker, %	23	32	45	<0.001
Caucasian, %	97	99	99	<0.001
Menopausal status, %	69	70	71	0.15
Postmenopausal hormone use, %[§]	18	20	19	<0.001
Family history of cancer, %	43	43	42	0.28
Family history of cardiovascular disease, %	36	36	36	0.60
Family history of diabetes, %	25	20	17	<0.001
Multivitamin use, %	39	40	38	0.72
HPFS (1986)	Low (n=18,786)	Medium (n=8050)	High (n=2929)	
Age	59.54 (7.88)	58.94 (7.55)	59.4 (7.79)	<0.001
BMI (kg/m^2)	25.08 (5.18)	24.86 (4.69)	25.03 (5.03)	0.05
Alcohol intake (g)	3.65 (4.72)	19.37 (11.24)	46.14 (19.99)	<0.001

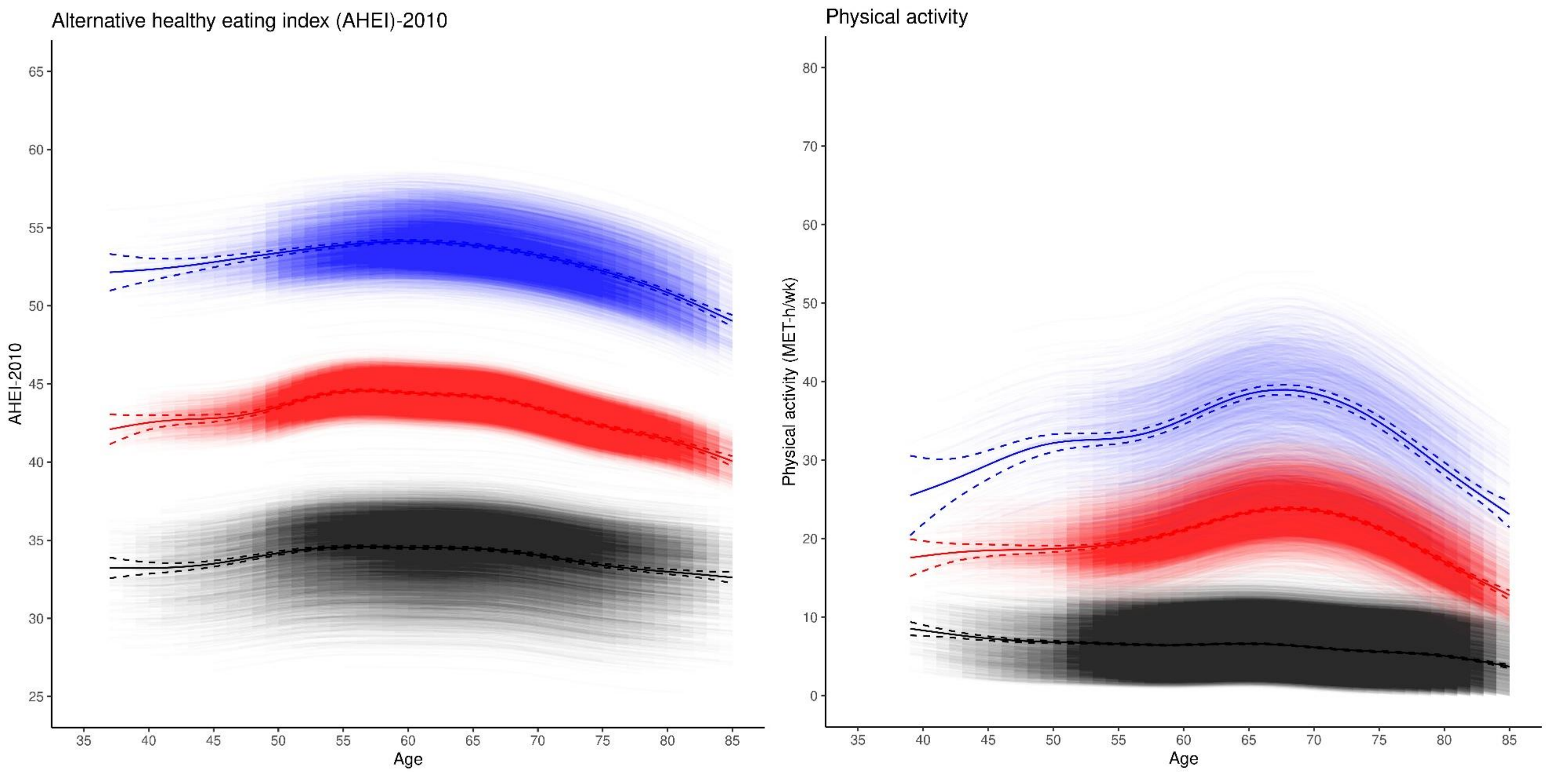
Physical activity (MET-h/week)	48.31 (11.05)	47.98 (10.56)	44.46 (10.37)	<0.001
AHEI	18.94 (26.18)	21.83 (27.33)	19.48 (27.07)	<0.001
Current smoker, %	8	11	21	<0.001
Caucasian, %	91	92	93	<0.001
Family history of cancer, %	10	9	10	0.54
Family history of cardiovascular disease, %	35	35	37	0.30
Family history of diabetes, %	17	14	15	<0.001
Multivitamin use, %	35	35	37	0.21

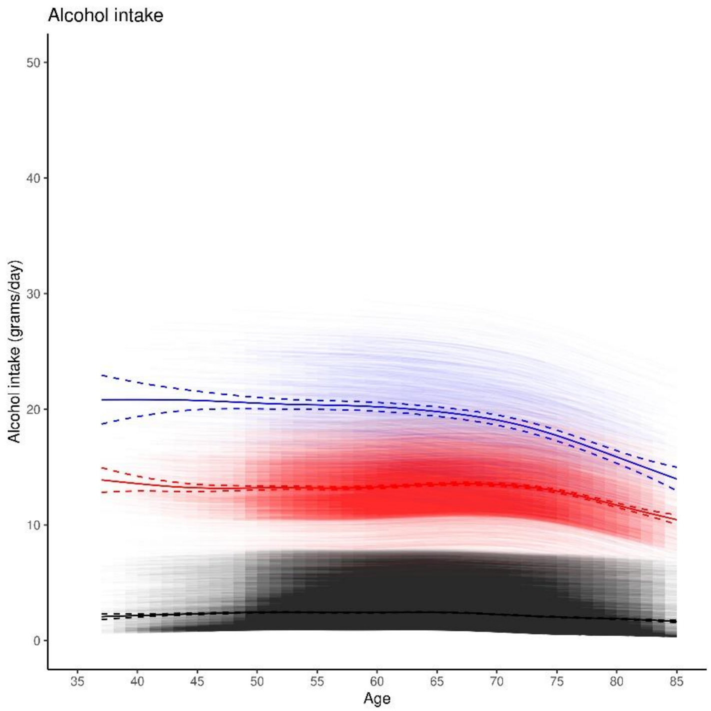
MET-h/week: metabolic equivalent hours per week; AHEI: Alternate healthy eating index
For continuous variables, data are mean values and standard deviations.
§Percentage of current postmenopausal hormone use among total women.

P values were obtained using linear regression for continuous variables and logistic regression for categorical variables.

Figure S3. Plots of patterns of modifiable risk factors with 95% confidence interval in the Nurses' Health Study.




Alternative healthy eating index (AHEI)-2010
AHEI-2010
Age
Physical activity
Physical activity (MET-h/wk)
Age

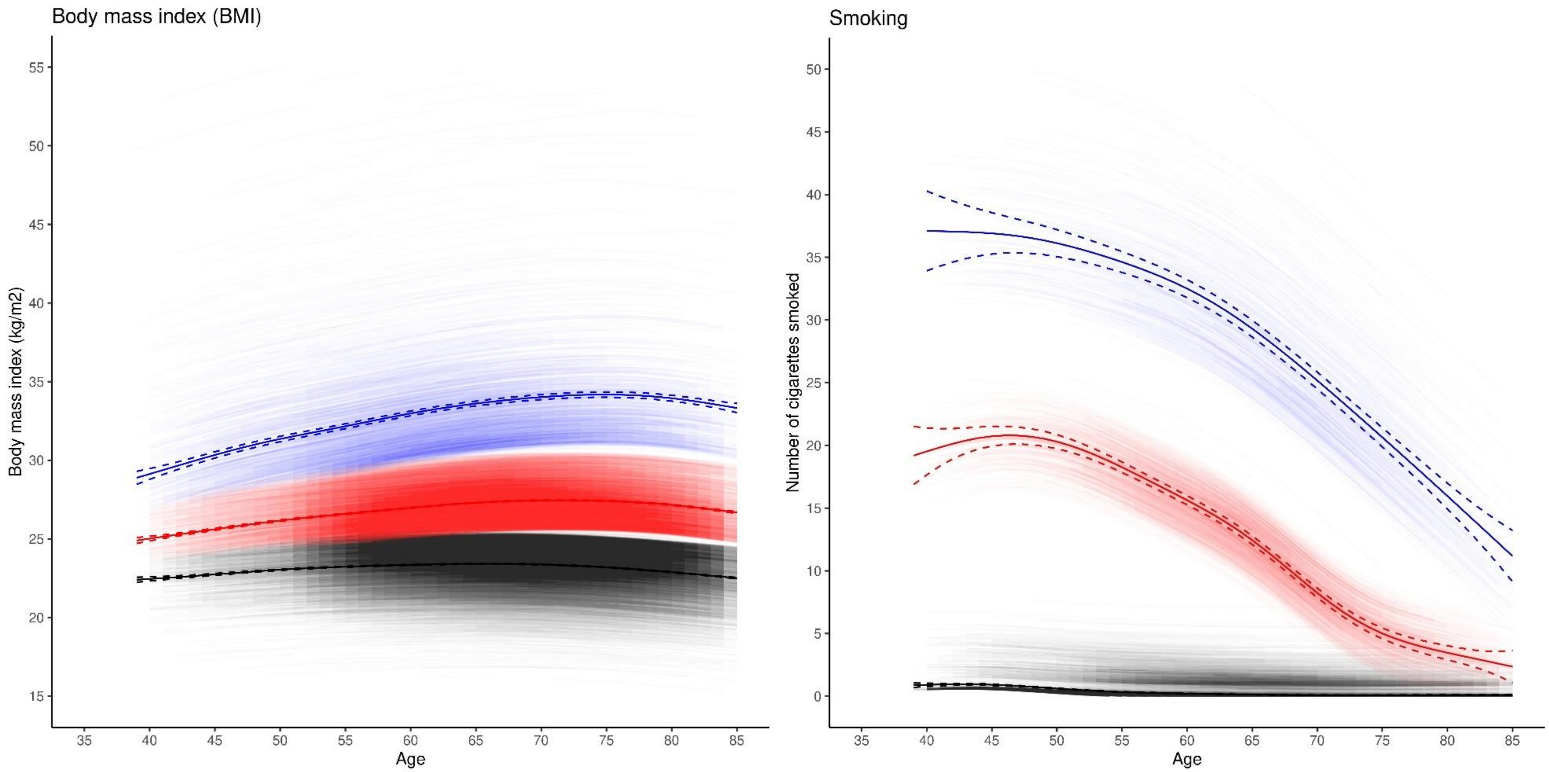


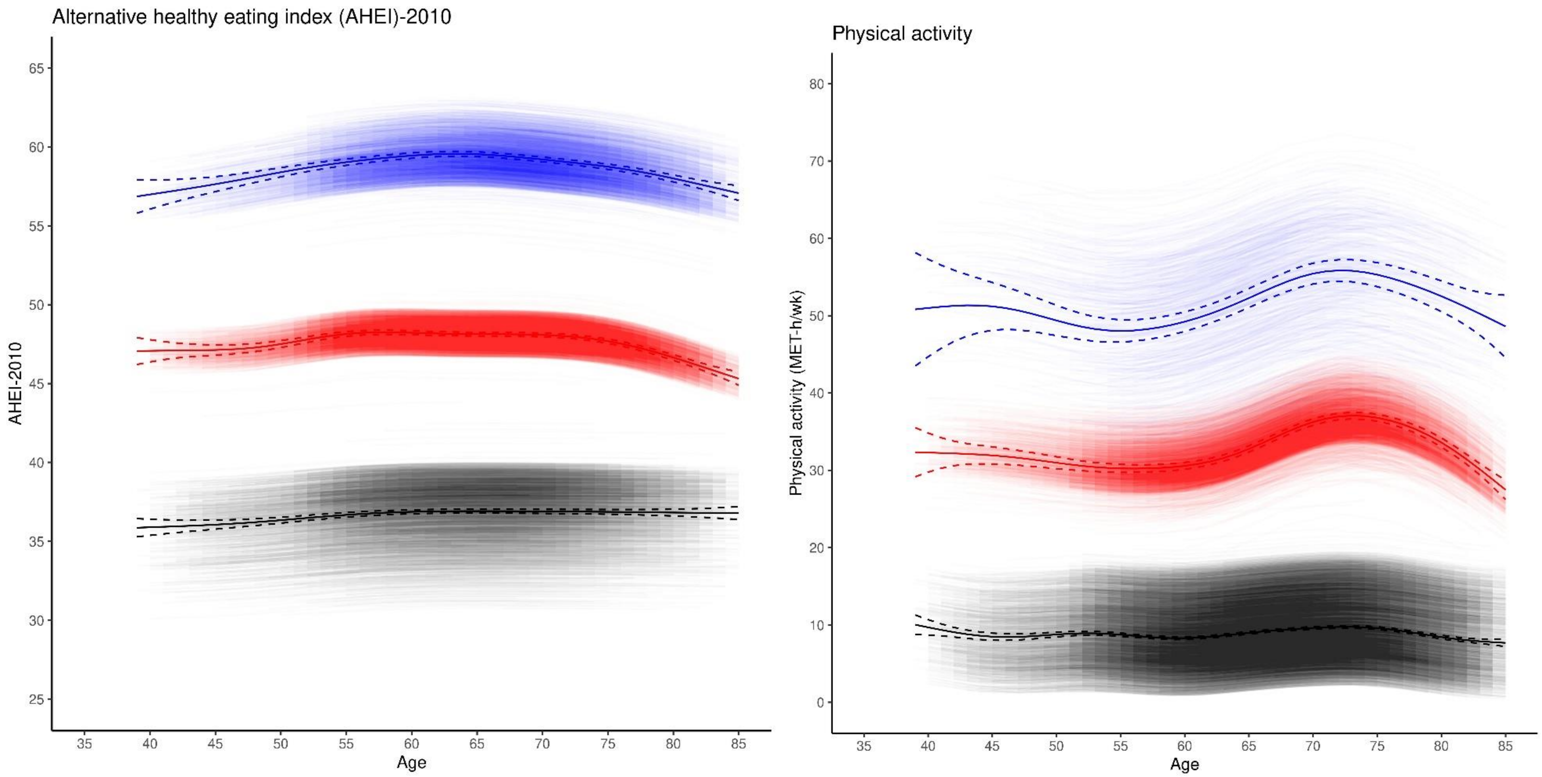
Solid line: the mean of predicted trajectories of each group; Dash line: 95% confidence interval (CI) of predicted trajectories of each group.

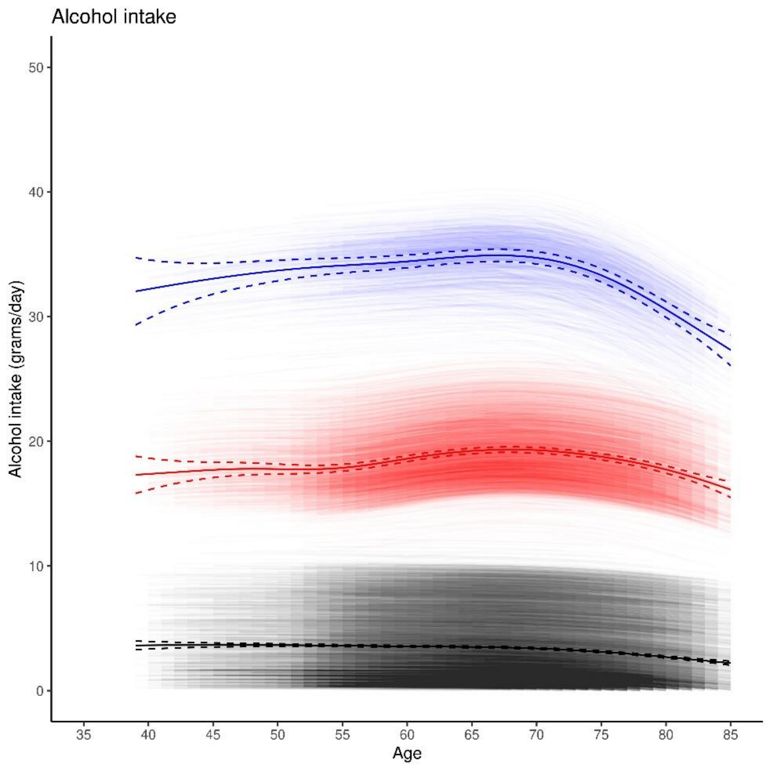
For AHEI-2010, physical activity, and alcohol intake, we classified trajectories using standardized values and mapped the standardized values to real values using the inverse cumulative distribution function when plotting the trajectories.

We identified patterns of risk factors using smoothing mixture models (SMM). We obtained the mean and 95% CI of predicted trajectories of each group and predicted trajectories of each participant within each group.

Figure S4. Plots of patterns of modifiable risk factors with 95% confidence interval in the Health Professionals Follow-up Study.




Alternative healthy eating index (AHEI)-2010
AHEI-2010
65
60
55
50
45
40
35
30
25
35 40 45 50 55 60 65 70 75 80 85
Age
Physical activity
Physical activity (MET-h/wk)
80
70
60
50
40
30
20
10
0
35 40 45 50 55 60 65 70 75 80 85
Age

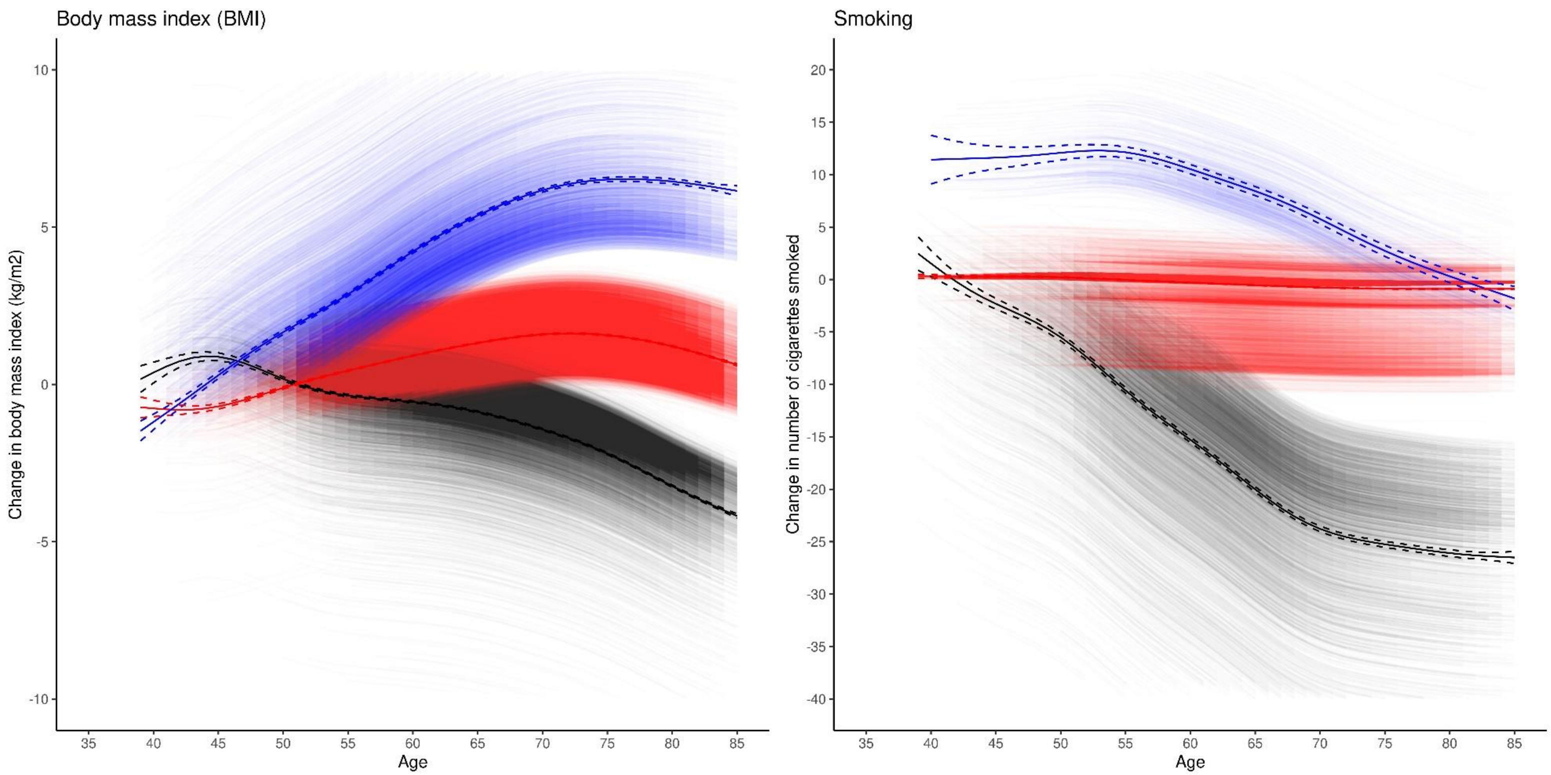


Solid line: the mean of predicted trajectories of each group; Dash line: 95% confidence interval (CI) of predicted trajectories of each group.

For AHEI-2010, physical activity, and alcohol intake, we classified trajectories using standardized values and mapped the standardized values to real values using the inverse cumulative distribution function when plotting the trajectories.

We identified patterns of risk factors using smoothing mixture models (SMM). We obtained the mean and 95% CI of predicted trajectories of each group and predicted trajectories of each participant within each group.

Figure S5. Plots of patterns of change in modifiable risk factors from baseline with 95% confidence interval in the NHS.



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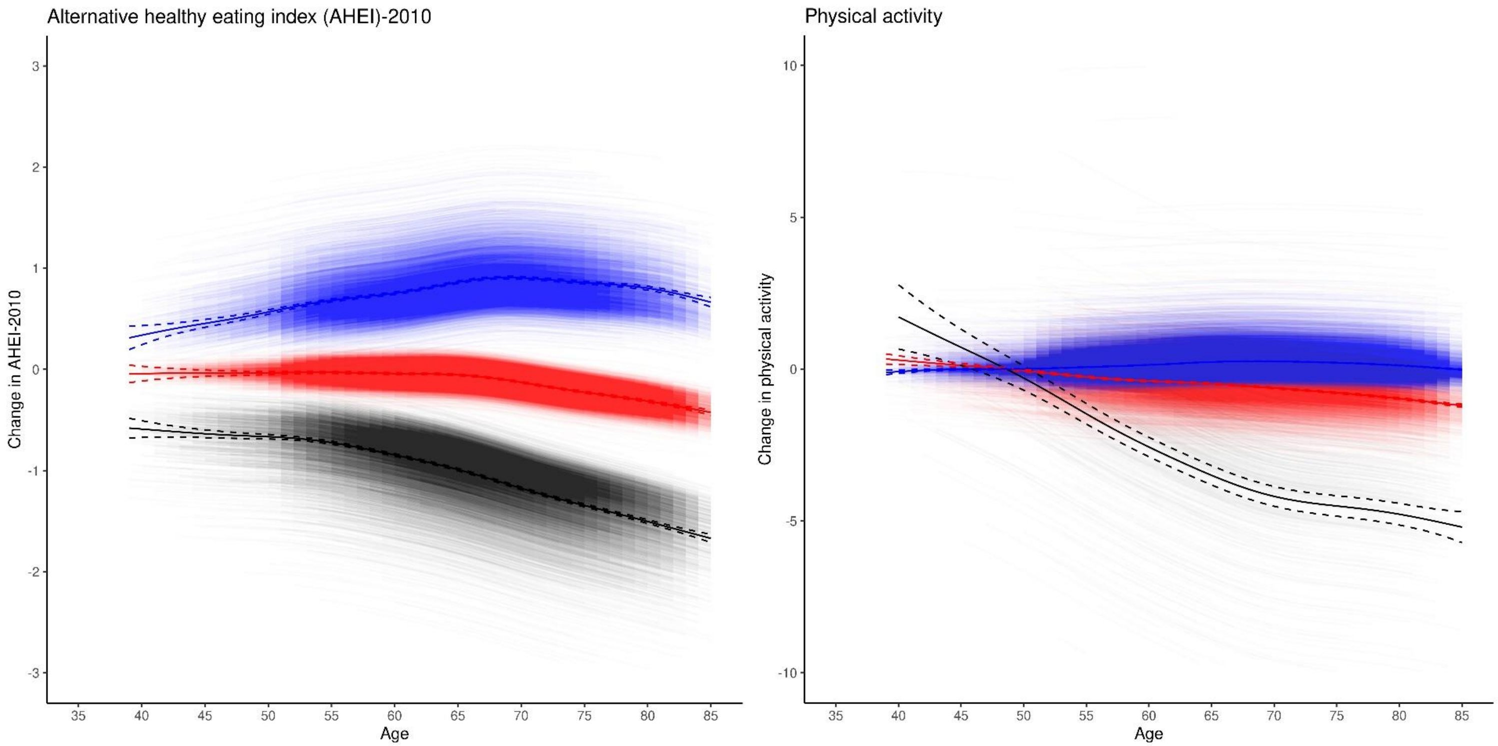
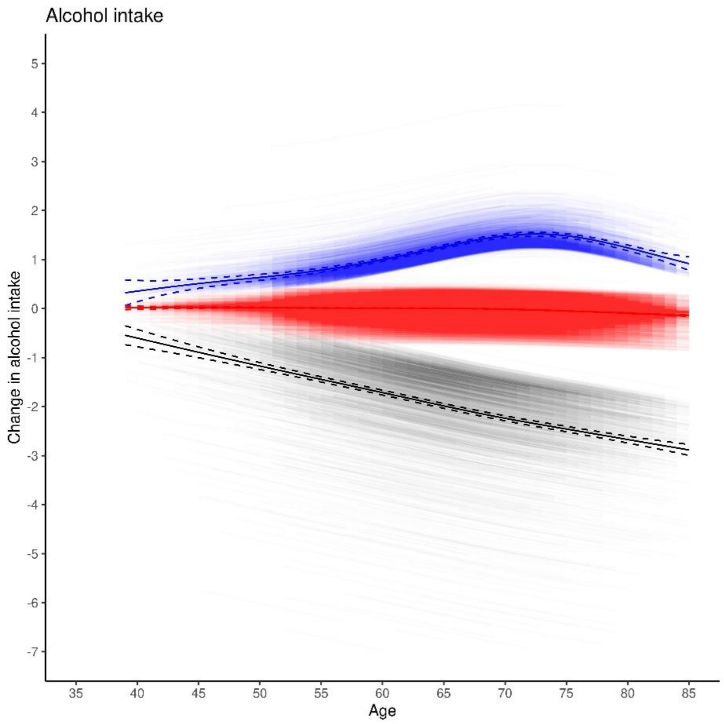

Alternative healthy eating index (AHEI)-2010
Change in AHEI-2010
Age
Physical activity
Change in physical activity
Age

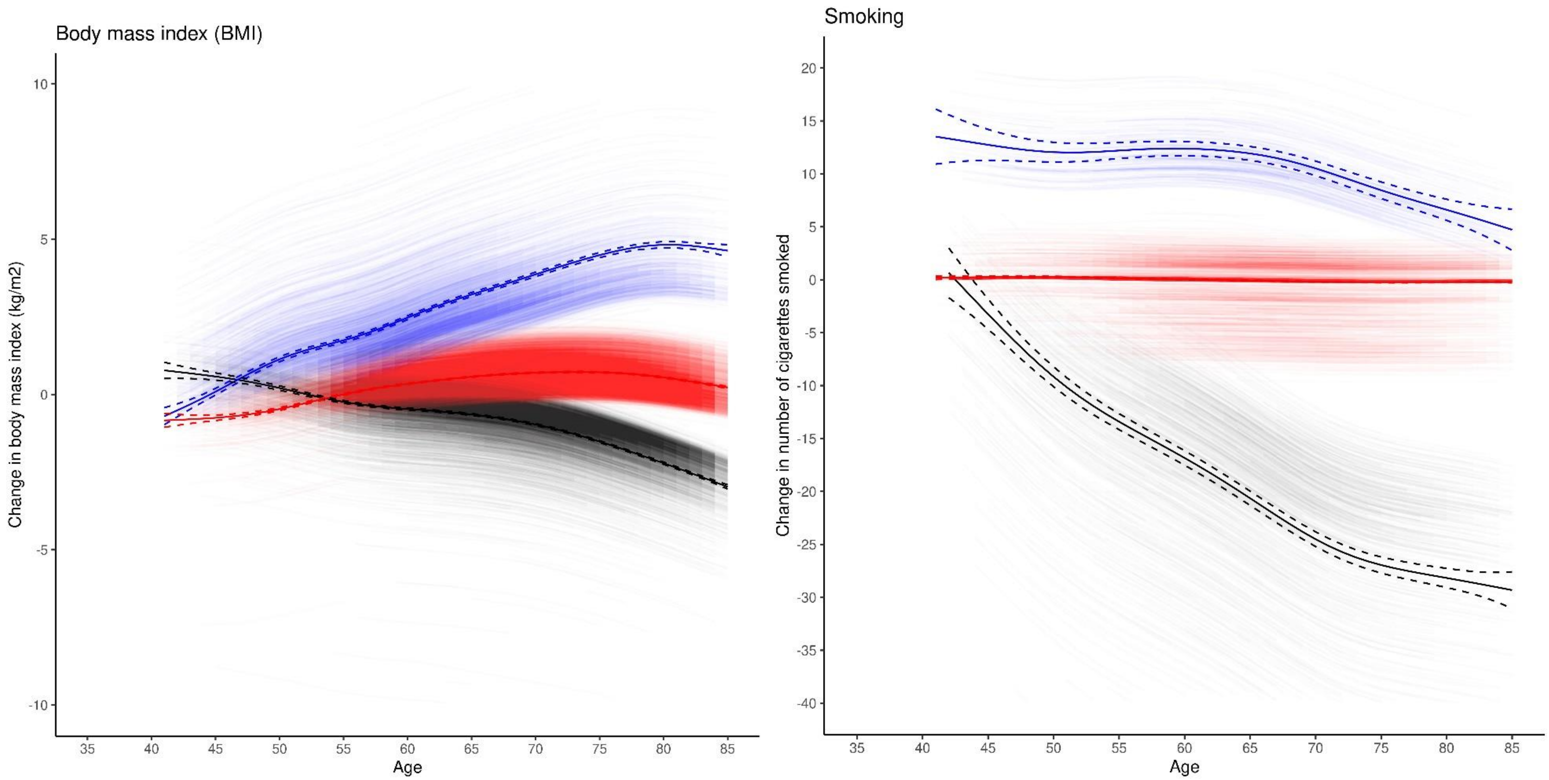


Solid line: the mean of predicted trajectories of each group; Dash line: 95% confidence interval (CI) of predicted trajectories of each group.

For change in AHEI-2010, physical activity, and alcohol intake, we plotted the trajectories in the scale of standardized values.

We identified patterns of risk factors using smoothing mixture models (SMM). We obtained the mean and 95% CI of predicted trajectories of each group and predicted trajectories of each participant within each group.

Figure S6. Plots of patterns of change in modifiable risk factors from baseline with 95% confidence interval in the Health Professionals Follow-up Study.



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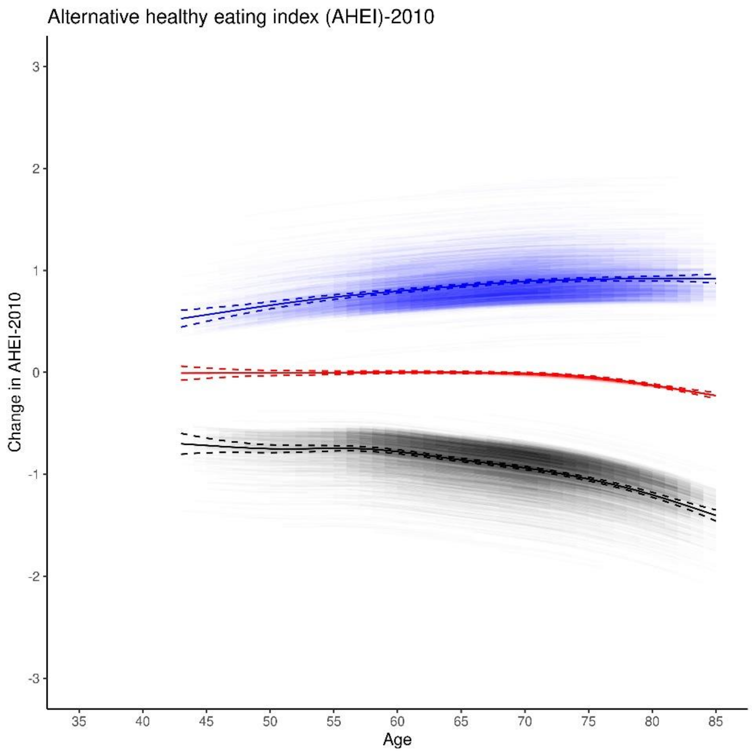

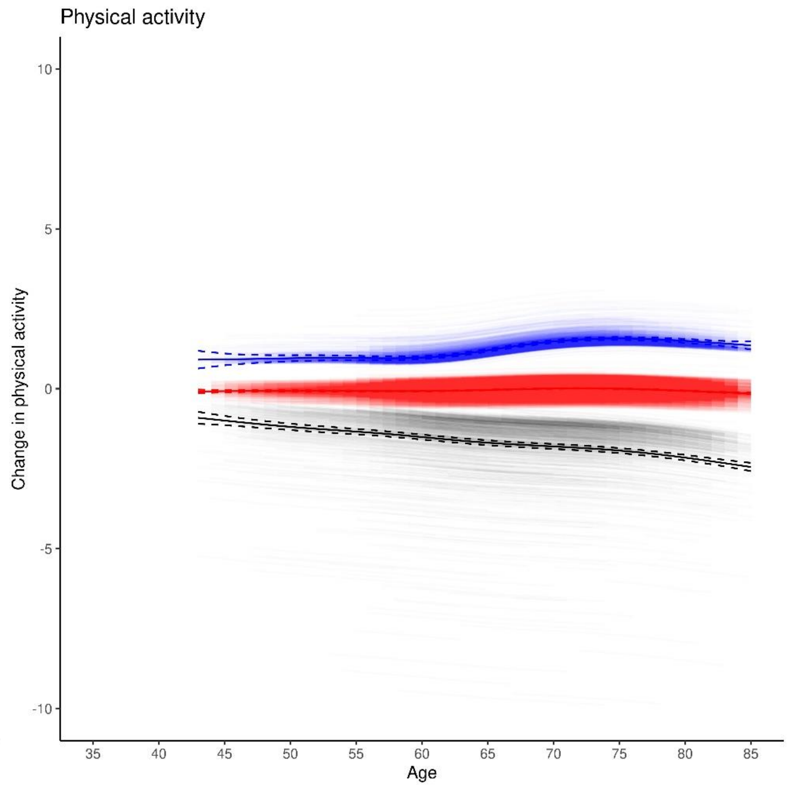

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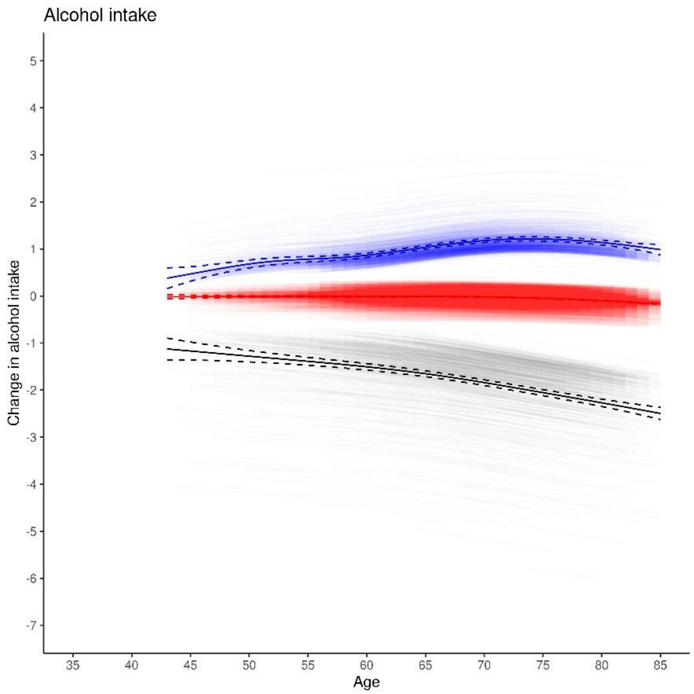
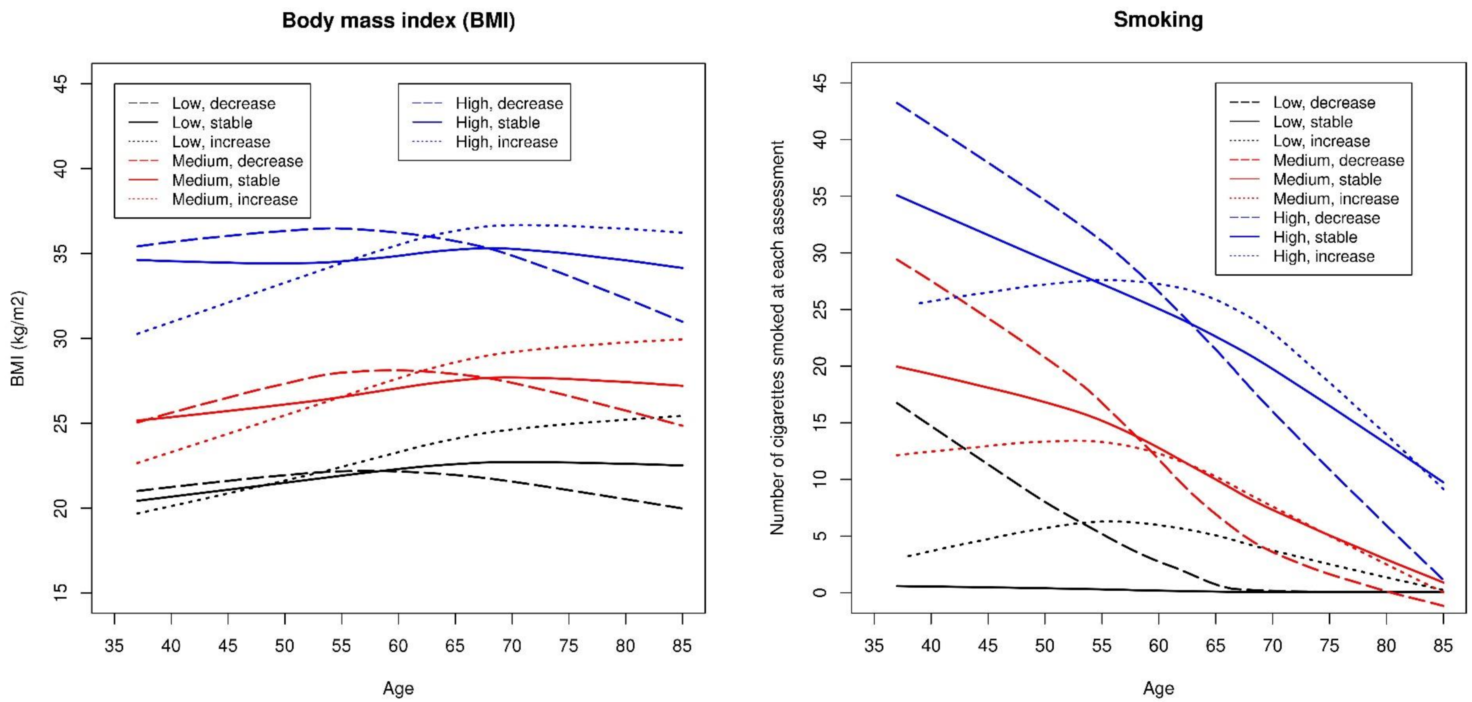


Solid line: the mean of predicted trajectories of each group; Dash line: 95% confidence interval (CI) of predicted trajectories of each group.

For change in AHEI-2010, physical activity, and alcohol intake, we plotted the trajectories in the scale of standardized values.

We identified patterns of risk factors using smoothing mixture models (SMM). We obtained the mean and 95% CI of predicted trajectories of each group and predicted trajectories of each participant within each group.

Figure S7. Plots of joint patterns of modifiable risk factors and change in the factor from baseline in the Nurses' Health Study (women).



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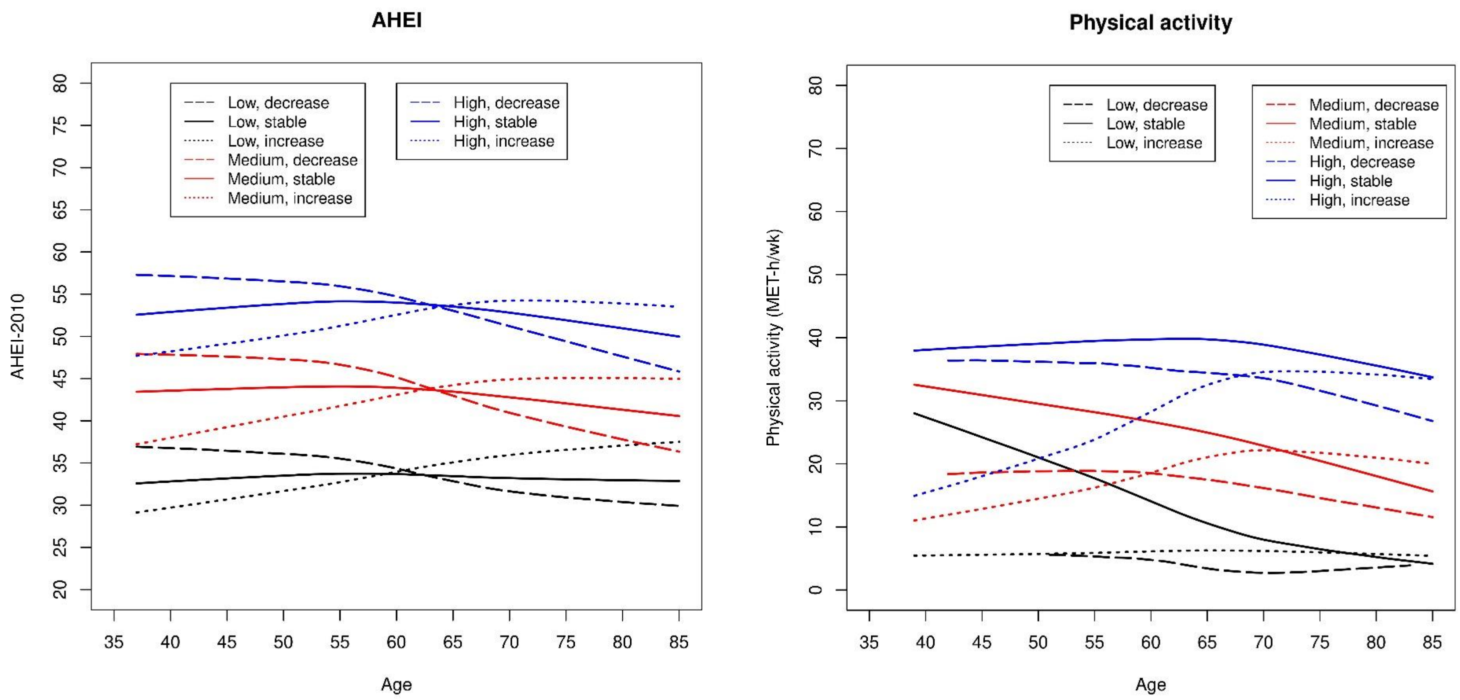
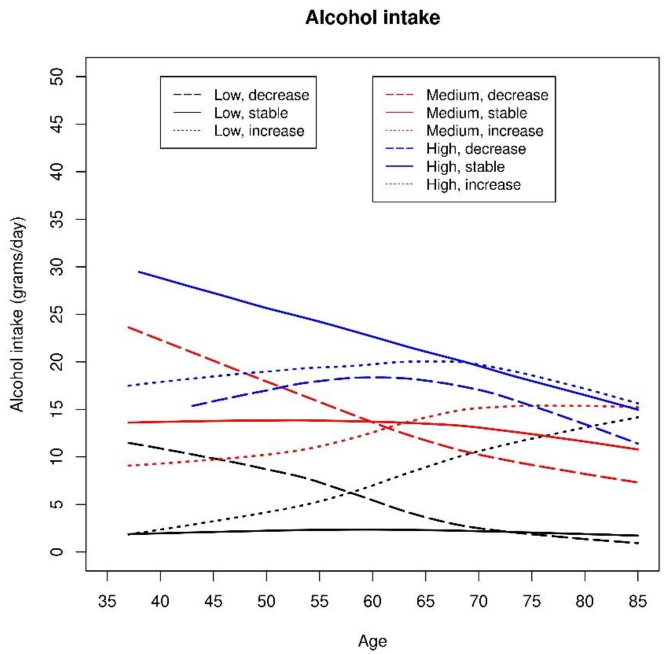

AHEI
AHEI-2010
Age
Low, decrease
Low, stable
Low, increase
Medium, decrease
Medium, stable
Medium, increase
High, decrease
High, stable
High, increase
Physical activity
Physical activity (MET-h/wk)
Age
Low, decrease
Low, stable
Low, increase
Medium, decrease
Medium, stable
Medium, increase
High, decrease
High, stable
High, increase



We identified patterns of risk factor and patterns of change in the risk factor using smoothing mixture models, classified participants according to joint group membership, and plotted the mean values of the risk factor with age within each category using loess.smooth function in R.

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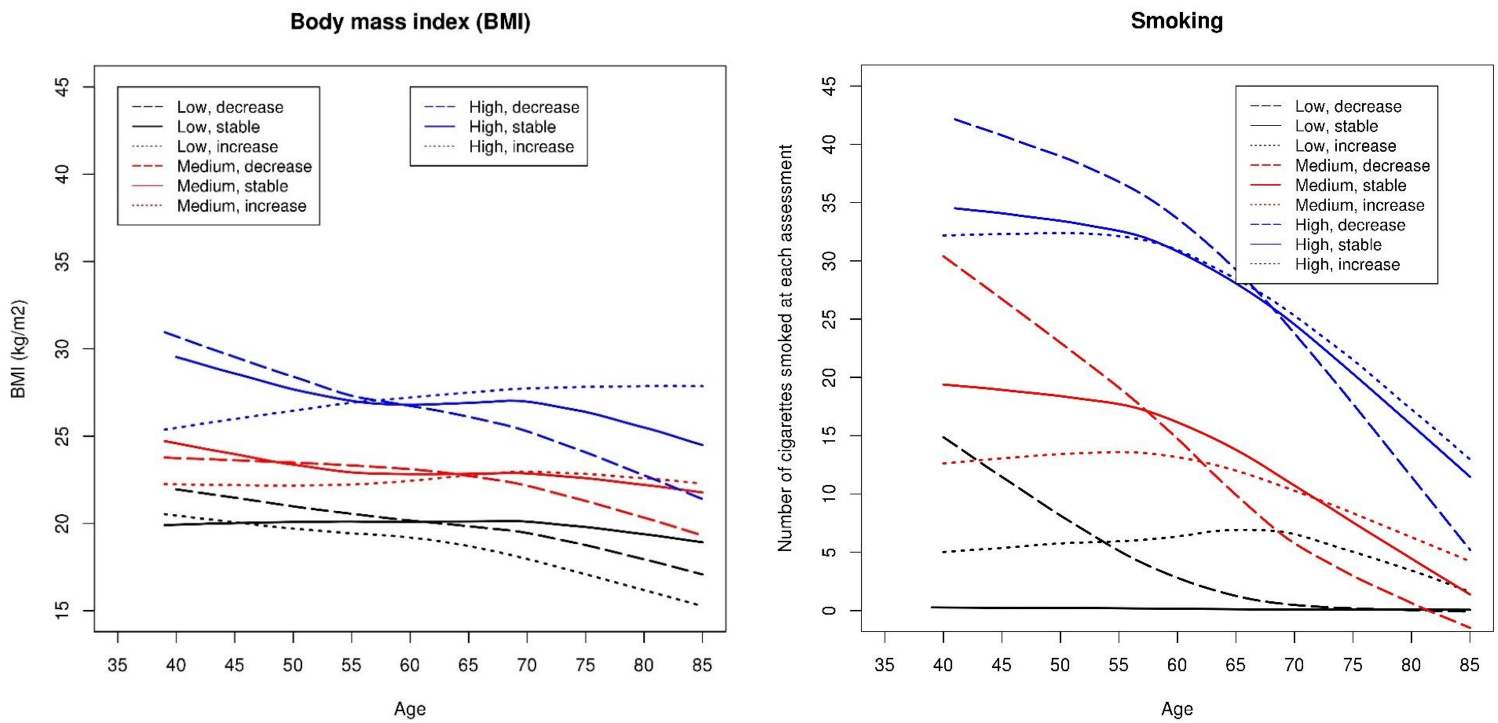
Figure S8. Plots of joint patterns of modifiable risk factors and change in the factor from baseline in the Health Professionals Follow-up Study (men).



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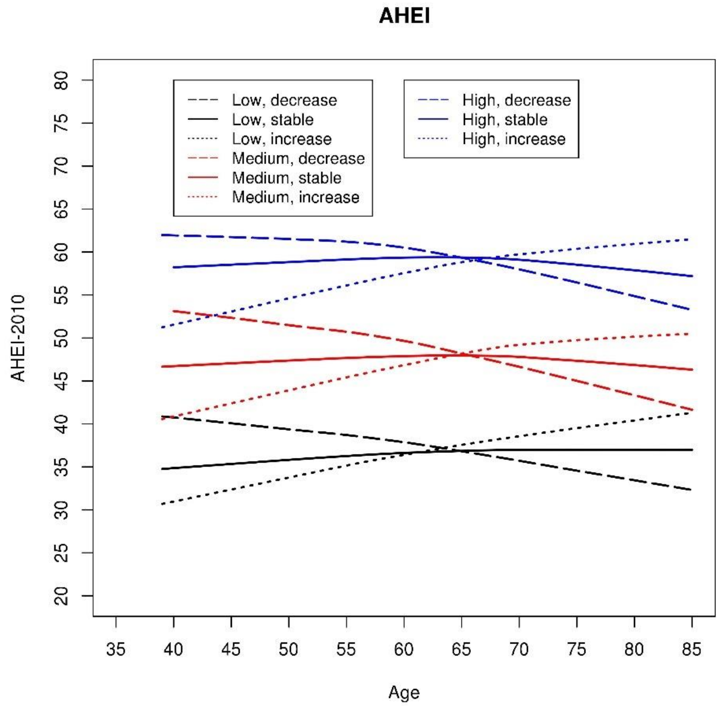

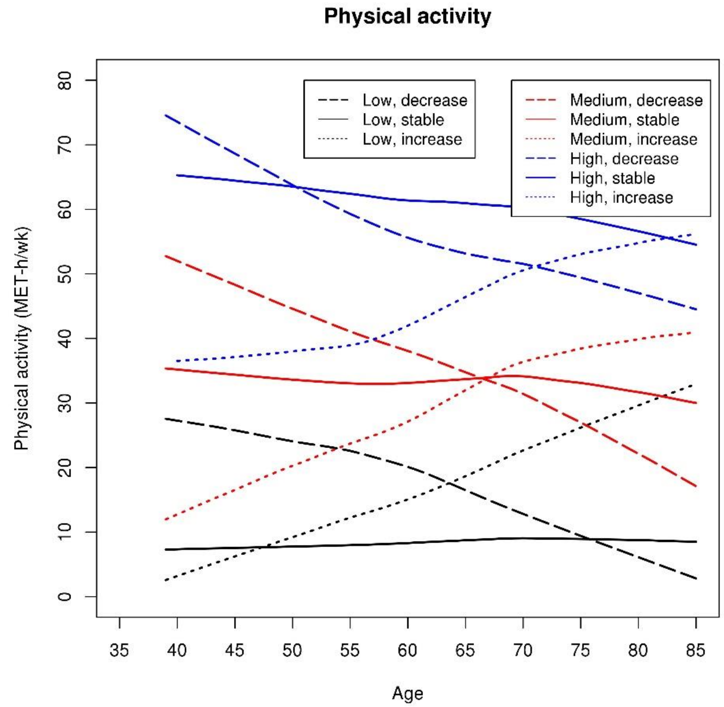

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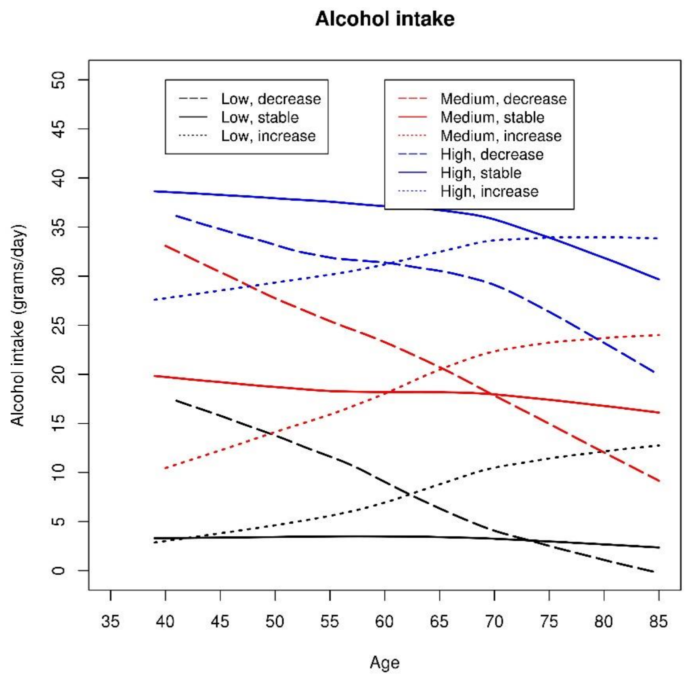

We identified patterns of risk factor and patterns of change in the risk factor using smoothing mixture models, classified participants according to joint group membership, and plotted the mean values of the risk factor with age within each category using loess.smooth function in R.

Table S4. Associations of trajectories of modifiable risk factors and trajectories of change in the factors with odds ratios (OR) of achieving longevity in the Nurses' Health Study (women) and the Health Professionals Follow-up Study (men).

Risk factors	**Medium**	**Low**	**High**	**Change in risk factors**	**No change**	**Increase**	**Decrease**
BMI				BMI			
NHS				*NHS*			
Cases/Participants	11739/19645	14106/23841	2544/5807	Cases/Participants	15870/23961	2972/6555	7493/14350
Model 1	1.00	0.98 (0.94, 1.01)	0.53 (0.49, 0.56)	Model 3	1.00	0.47 (0.44, 0.50)	0.55 (0.53, 0.58)
Model 2	1.00	0.96 (0.92, 1.01)	0.58 (0.54, 0.62)	Model 4	1.00	0.77 (0.71, 0.82)	0.55 (0.52, 0.58)
HPFS				*HPFS*			
Cases/Participants	6916/13212	7999/14210	1047/2947	Cases/Participants	9225/14734	1099/3254	4122/8398
Model 1	1.00	1.17 (1.12, 1.23)	0.50 (0.46, 0.54)	Model 3	1.00	0.35 (0.32, 0.38)	0.57 (0.54, 0.60)
Model 2	1.00	1.04 (0.98, 1.09)	0.62 (0.57, 0.68)	Model 4	1.00	0.63 (0.57, 0.69)	0.59 (0.56, 0.63)
Smoking				Smoking			
NHS				*NHS*			
Cases/Participants	2497/6731	25206/39752	889/3484	Cases/Participants	25781/41782	322/932	2004/5627
Model 1	1.00	2.94 (2.79, 3.10)	0.58 (0.53, 0.64)	Model 3	1.00	0.55 (0.48, 0.64)	1.28 (1.16, 1.42)
Model 2	1.00	2.80 (2.63, 2.98)	0.54 (0.48, 0.60)	Model 4	1.00	0.72 (0.60, 0.85)	1.24 (1.10, 1.39)
HPFS				*HPFS*			
Cases/Participants	608/2086	15431/28238	206/904	Cases/Participants	14144/25505	205/715	332/1145
Model 1	1.00	2.93 (2.66, 3.23)	0.72 (0.60, 0.86)	Model 3	1.00	0.36 (0.29, 0.44)	1.59 (1.28, 1.98)
Model 2	1.00	2.68 (2.41, 2.97)	0.61 (0.51, 0.75)	Model 4	1.00	0.49 (0.39, 0.60)	1.50 (1.19, 1.89)
AHEI				AHEI			
NHS				*NHS*			
Cases/Participants	13237/22388	8102/16135	7316/11346	Cases/Participants	13321/21554	7696/12937	6536/11571
Model 1	1.00	0.70 (0.67, 0.73)	1.25 (1.20, 1.32)	Model 3	1.00	1.02 (0.97, 1.08)	0.67 (0.64, 0.71)
Model 2	1.00	0.83 (0.79, 0.87)	1.06 (1.01, 1.12)	Model 4	1.00	1.07 (1.00, 1.13)	0.82 (0.77, 0.87)
HPFS				*HPFS*			
Cases/Participants	7202/13082	4293/8976	4492/7626	Cases/Participants	6697/10899	3415/6146	3418/5958
Model 1	1.00	0.75 (0.71, 0.79)	1.17 (1.11, 1.24)	Model 3	1.00	0.98 (0.91, 1.05)	0.64 (0.59, 0.69)
Model 2	1.00	0.88 (0.83, 0.93)	1.02 (0.96, 1.09)	Model 4	1.00	0.97 (0.89, 1.05)	0.78 (0.71, 0.84)

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Physical activity				Physical activity			
NHS				*NHS*			
Cases/Participants	9126/14243	17522/32088	1671/2738	Cases/Participants	4811/7763	20513/35799	279/497
Model 1	1.00	0.67 (0.65, 0.70)	0.88 (0.81, 0.96)	Model 3	1.00	1.12 (1.04, 1.22)	0.55 (0.43, 0.71)
Model 2	1.00	0.75 (0.72, 0.79)	0.90 (0.82, 0.99)	Model 4	1.00	1.10 (1.01, 1.19)	0.81 (0.62, 1.05)
HPFS				*HPFS*			
Cases/Participants	5474/9624	10549/22241	958/1839	Cases/Participants	12051/22581	2542/4588	980/2073
Model 1	1.00	0.68 (0.65, 0.72)	0.82 (0.75, 0.91)	Model 3	1.00	0.94 (0.86, 1.02)	0.52 (0.46, 0.58)
Model 2	1.00	0.65 (0.62, 0.69)	0.88 (0.79, 0.98)	Model 4	1.00	1.03 (0.94, 1.13)	0.64 (0.56, 0.73)
Alcohol intake				Alcohol intake			
NHS				*NHS*			
Cases/Participants	5862/10019	21292/36703	1501/3147	Cases/Participants	24113/39576	2192/3881	1248/2605
Model 1	1.00	0.98 (0.94, 1.02)	0.65 (0.60, 0.70)	Model 3	1.00	0.83 (0.76, 0.90)	0.63 (0.57, 0.71)
Model 2	1.00	0.99 (0.93, 1.04)	0.78 (0.71, 0.85)	Model 4	1.00	1.06 (0.97, 1.17)	0.82 (0.72, 0.93)
HPFS				*HPFS*			
Cases/Participants	4556/8049	10110/18783	1371/2929	Cases/Participants	11403/18922	1488/2721	725/1501
Model 1	1.00	0.89 (0.85, 0.94)	0.67 (0.62, 0.73)	Model 3	1.00	0.72 (0.66, 0.79)	0.67 (0.58, 0.77)
Model 2	1.00	0.84 (0.79, 0.89)	0.74 (0.68, 0.81)	Model 4	1.00	0.95 (0.85, 1.05)	0.77 (0.66, 0.90)

Model 1 is univariate analysis.

Model 2 adjusted for baseline age (continuous), race (White, Black, Asian, and other), family histories of cancer (yes, no), myocardial infarction (yes, no), and type 2 diabetes (yes, no), multivitamin use (yes, no), menopausal status (yes, no, women only), postmenopausal hormone use (yes, no, women only), cohort, education (registered nurse, bachelor degree, master degree and higher, women only), social economic status (annual family income [quartiles] for women and work status [disabled, retired, part-time, full-time] for men), aspirin use (yes, no), use of antihypertensive medications (yes, no), and use of cholesterol lowering medications (yes, no), and the other four risk factors at baseline as continuous variables.

Model 3 adjusted for all variables included in model 1, as well as group membership of trajectories of the risk factor (categorical).

Model 4 adjusted for all variables included in model 2, as well as group membership of trajectories of the risk factor (categorical).

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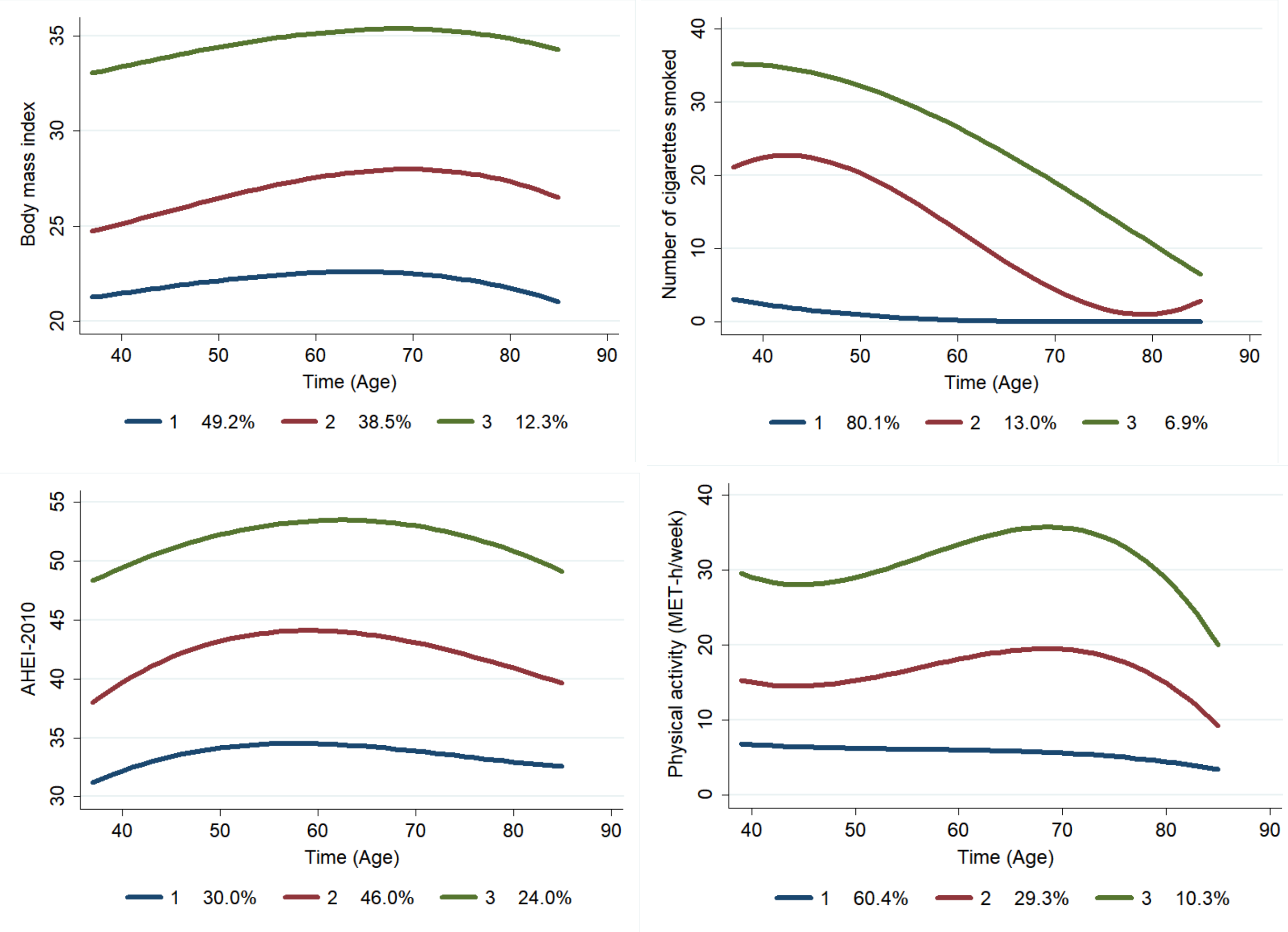
Table S5. Assignment of score (1-9) to each risk factor based on the joint patterns.

Joint patterns	BMI	Smoking	AHEI	Physical activity	Alcohol intake
Low, decrease	3	2	9	9	6
Low, stable	1	1	8	8	4
Low, increase	5	3	7	7	3
Medium, decrease	4	4	6	5	5
Medium, stable	2	5	5	3	1
Medium, increase	6	6	4	2	2
High, decrease	8	7	3	6	8
High, stable	7	8	2	4	7
High, increase	9	9	1	1	9

Figure S9. Plots of patterns of modifiable risk factors with 95% confidence interval in the Nurses' Health Study using group-based trajectory analysis.



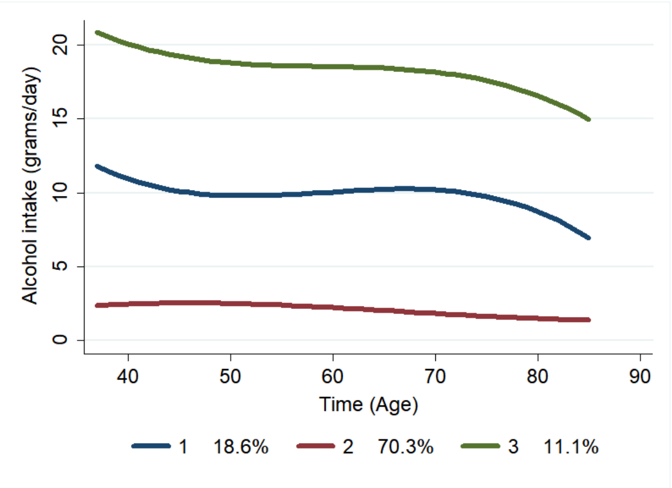
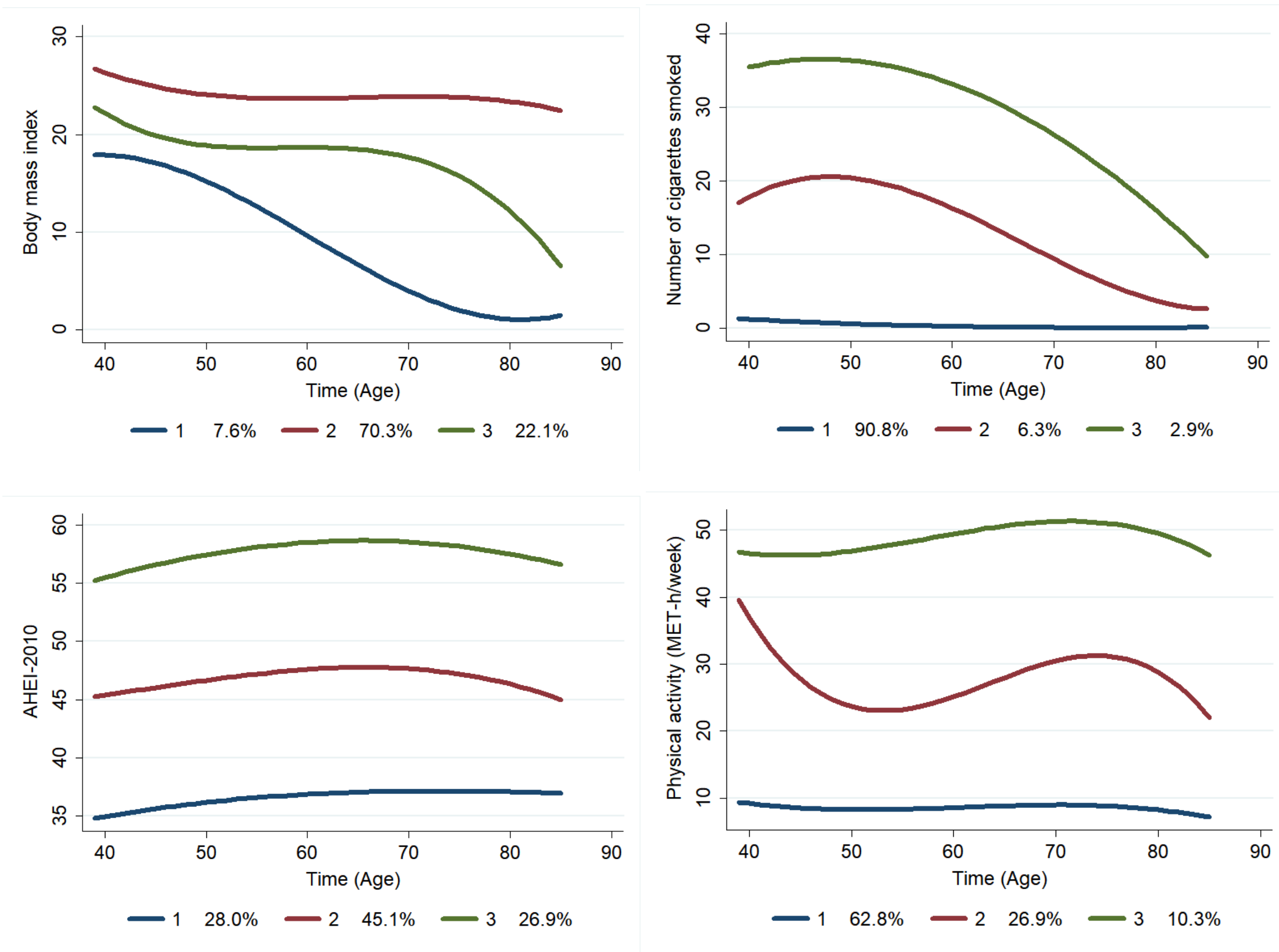

Alcohol intake (grams/day)
0
5
10
15
20
40
50
60
70
80
90
Time (Age)
1 18.6%
2 70.3%
3 11.1%

Figure S10. Plots of patterns of modifiable risk factors with 95% confidence interval in the Health Professionals Follow-up Study using group-based trajectory analysis.



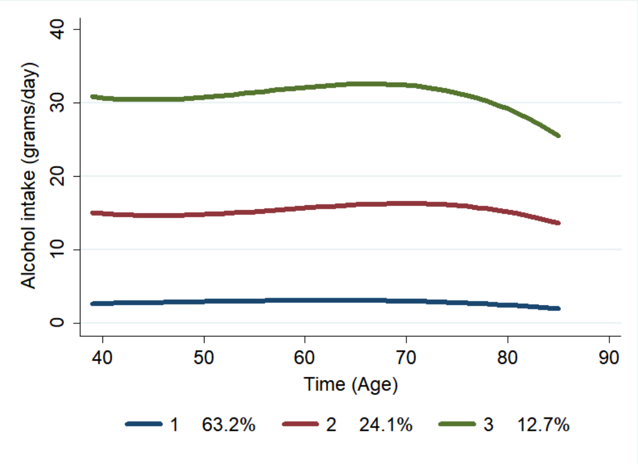


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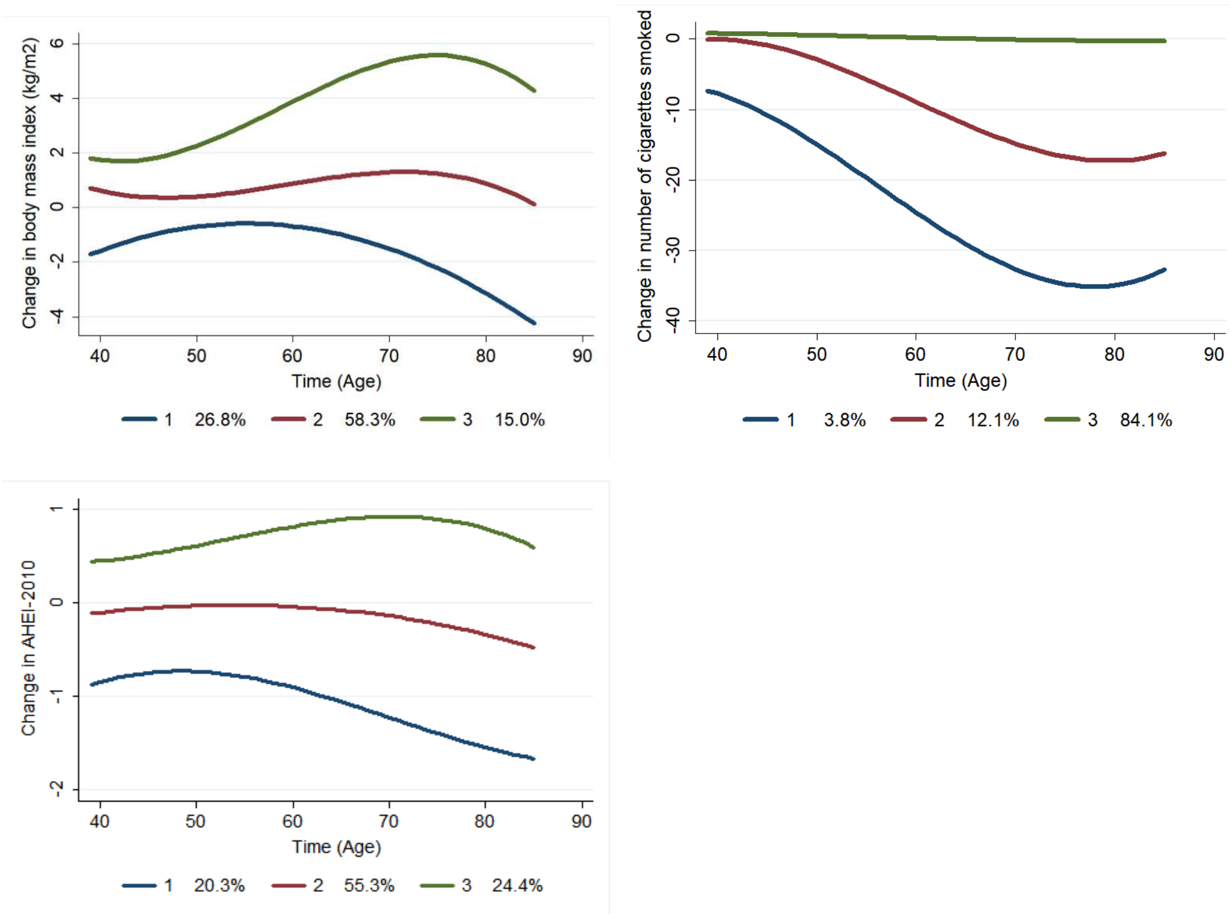
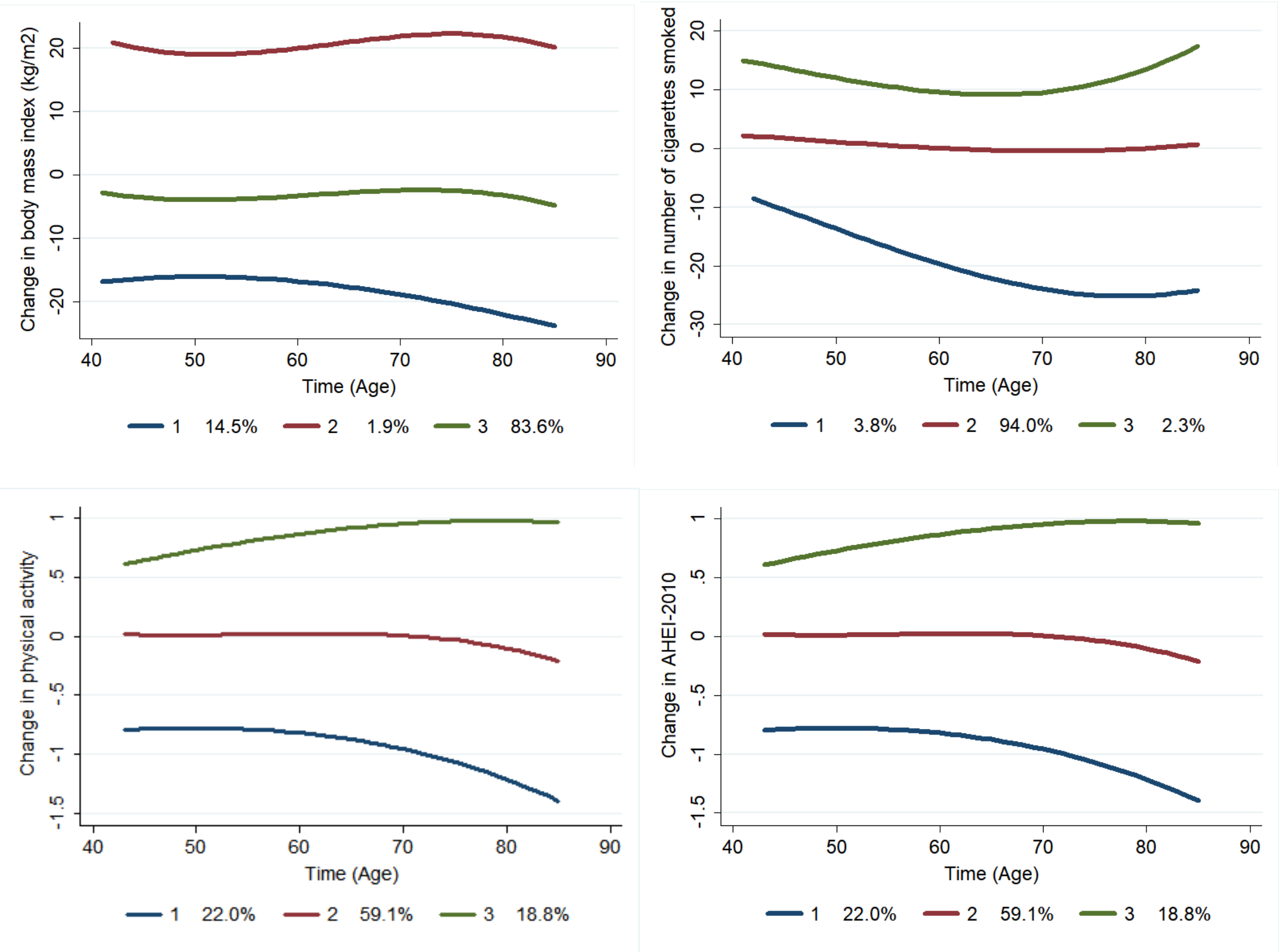
Figure S11. Plots of patterns of change in modifiable risk factors from baseline with 95% confidence interval in the Nurses' Health Study using group-based trajectory analysis.



Note: We did not obtain valid model output for change in alcohol intake and physical activity due to the ERROR "Floating Point Zero Divide".

Figure S12. Plots of patterns of change in modifiable risk factors from baseline with 95% confidence interval in the Health Professionals Follow-up Study using group-based trajectory analysis.



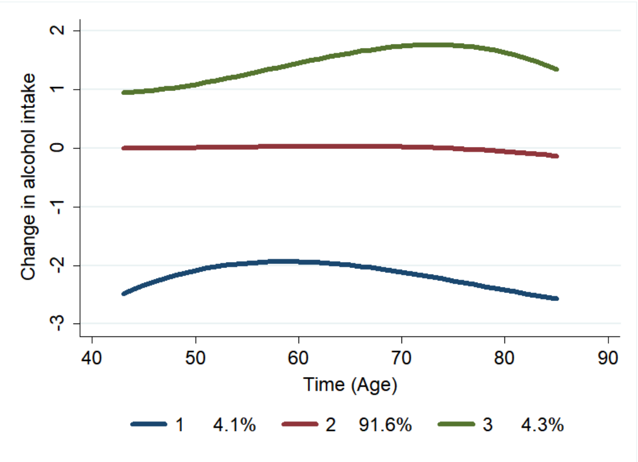

Change in alcohol intake
-3
-2
-1
0
1
2
40
50
60
70
80
90
Time (Age)
1 4.1%
2 91.6%
3 4.3%

Table S6. Comparison of classification of trajectories of risk factors and change in risk factors using smoothing mixture model and group-based trajectory model by pooling the Nurses' Health Study and the Health Professionals Follow-up Study.

Classification of trajectories of risk factors						Classification of trajectories of change in risk factors					
		Group-based trajectory model			Spearman correlation			Group-based trajectory model			Spearman correlation
BMI		Low	Medium	High		**BMI**		Decrease	Stable	Increase	
	Low	22636	704	137			Decrease	21580	10371	170	
Smoothing mixture model	Medium	13714	29666	2718		Smoothing mixture model	Stable	564	18256	1628	
	High	1719	2501	5902	0.65		Increase	614	10086	8014	0.7
Smoking		Low	Medium	High		**Smoking**		Decrease	Stable	Increase	
	Low	63550	10	3			Decrease	63562	6127	8	
Smoothing mixture model	Medium	159	4460	4382		Smoothing mixture model	Stable	2381	556	694	
	High	4306	4355	6	0.79		Increase	1371	96	946	0.27
AHEI-2010		Low	Medium	High		**AHEI-2010**		Decrease	Stable	Increase	
	Low	22231	488	2			Decrease	17578	16946	152	
Smoothing mixture model	Medium	2898	33359	1225		Smoothing mixture model	Stable	144	15508	12644	
	High	1	1630	17756	0.93		Increase	0	12	6113	0.75
Physical activity		Low	Medium	High		**Physical activity**		Decrease	Stable	Increase	
	Low	27647	7072	461			Decrease	2039	11870	0	
Smoothing mixture model	Medium	26705	9990	640		Smoothing mixture model	Stable	34	10713	3778	
	High	2	6814	3477	0.4		Increase	0	1	811	0.51
Alcohol intake		Low	Medium	High		**Alcohol intake**		Decrease	Stable	Increase	
	Low	49826	564	1373			Decrease	7	2131	1971	
Smoothing mixture model	Medium	5687	11844	579		Smoothing mixture model	Stable	1494	16793	162	
	High	1	5667	4126	0.8		Increase	0	2	588	0.32

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Table S7. Stratified analysis by age at baseline on associations of joint patterns of modifiable risk factors and change in the factor from baseline with odds ratios (OR) of achieving longevity by pooling the Nurses' Health Study and the Health Professionals Follow-up Study.

	Age at baseline<65 years		Age at baseline≥65 years		
	Probability of achieving longevity*	Odds ratio of achieving longevity#	Probability of achieving longevity*	Odds ratio of achieving longevity#	P for interaction&
BMI					
High, decrease	0.40 (0.37, 0.43)	0.37 (0.33, 0.42)	0.42 (0.32, 0.53)	0.28 (0.18, 0.45)	
High, increase	0.53 (0.50, 0.55)	0.62 (0.55, 0.70)	0.78 (0.59, 0.90)	1.37 (0.57, 3.30)	
High, stable	0.52 (0.49, 0.54)	0.60 (0.54, 0.67)	0.60 (0.52, 0.67)	0.57 (0.41, 0.80)	
Low, decrease	0.51 (0.50, 0.52)	0.58 (0.55, 0.62)	0.61 (0.58, 0.65)	0.61 (0.53, 0.72)	
Low, increase	0.58 (0.53, 0.62)	0.77 (0.64, 0.92)	0.72 (0.42, 0.90)	0.99 (0.28, 3.56)	
Low, stable	0.67 (0.65, 0.68)	1.11 (1.05, 1.18)	0.71 (0.68, 0.74)	0.95 (0.82, 1.10)	
Medium, decrease	0.51 (0.49, 0.52)	0.58 (0.54, 0.62)	0.58 (0.54, 0.62)	0.53 (0.44, 0.64)	
Medium, increase	0.64 (0.62, 0.66)	0.98 (0.90, 1.08)	0.64 (0.51, 0.75)	0.67 (0.39, 1.16)	
Medium, stable	0.64 (0.63, 0.65)	Ref	0.72 (0.69, 0.75)	Ref	<0.001
Smoking					
High, decrease	0.24 (0.21, 0.27)	0.59 (0.49, 0.70)	0.35 (0.23, 0.48)	0.44 (0.22, 0.86)	
High, increase	0.26 (0.21, 0.31)	0.64 (0.49, 0.84)	0.32 (0.17, 0.52)	0.39 (0.15, 0.97)	
High, stable	0.25 (0.23, 0.28)	0.63 (0.54, 0.72)	0.40 (0.32, 0.49)	0.55 (0.34, 0.92)	
Low, decrease	0.49 (0.45, 0.53)	1.75 (1.46, 2.10)	0.50 (0.28, 0.73)	NA	
Low, increase	0.38 (0.31, 0.46)	1.15 (0.83, 1.61)	0.68 (0.66, 0.71)	0.83 (0.30, 2.33)	
Low, stable	0.64 (0.63, 0.65)	3.25 (2.96, 3.57)	0.48 (0.39, 0.57)	1.78 (1.23, 2.57)	
Medium, decrease	0.38 (0.36, 0.40)	1.12 (0.99, 1.26)	0.52 (0.42, 0.62)	0.76 (0.46, 1.27)	
Medium, increase	0.39 (0.35, 0.44)	1.21 (0.98, 1.49)	0.48 (0.42, 0.53)	0.91 (0.53, 1.55)	
Medium, stable	0.35 (0.33, 0.37)	Ref	0.55 (0.45, 0.64)	Ref	<0.001
AHEI					
High, decrease	0.49 (0.35, 0.63)	0.88 (0.81, 0.96)	0.75 (0.70, 0.79)	0.87 (0.67, 1.13)	
High, increase	0.48 (0.34, 0.62)	1.13 (1.03, 1.23)	0.74 (0.69, 0.79)	0.85 (0.66, 1.09)	
High, stable	0.47 (0.33, 0.61)	1.04 (0.96, 1.12)	0.78 (0.75, 0.82)	1.06 (0.85, 1.33)	
Low, decrease	0.49 (0.35, 0.63)	0.72 (0.66, 0.78)	0.69 (0.62, 0.74)	0.65 (0.49, 0.86)	

Low, increase	0.45 (0.32, 0.59)	0.80 (0.73, 0.87)	0.73 (0.67, 0.78)	0.80 (0.60, 1.06)	
Low, stable	0.43 (0.30, 0.57)	0.84 (0.79, 0.90)	0.74 (0.70, 0.78)	0.84 (0.68, 1.04)	
Medium, decrease	0.54 (0.40, 0.68)	0.88 (0.82, 0.95)	0.70 (0.66, 0.75)	0.70 (0.56, 0.88)	
Medium, increase	0.50 (0.37, 0.64)	0.97 (0.91, 1.04)	0.73 (0.69, 0.77)	0.80 (0.64, 1.01)	
Medium, stable	0.51 (0.37, 0.65)	Ref	0.77 (0.74, 0.80)	Ref	<0.001
Physical activity					
High, decrease	0.45 (0.31, 0.58)	0.74 (0.61, 0.90)	0.74 (0.61, 0.84)	1.17 (0.62, 2.18)	
High, increase	0.43 (0.31, 0.57)	1.08 (0.93, 1.25)	0.72 (0.65, 0.79)	1.06 (0.73, 1.54)	
High, stable	0.38 (0.26, 0.51)	0.92 (0.81, 1.06)	0.77 (0.65, 0.86)	1.38 (0.75, 2.56)	
Low, decrease	0.49 (0.35, 0.63)	0.66 (0.52, 0.82)	0.56 (0.47, 0.64)	0.51 (0.35, 0.73)	
Low, increase	0.41 (0.29, 0.55)	0.75 (0.70, 0.80)	0.59 (0.50, 0.68)	0.59 (0.40, 0.86)	
Low, stable	0.37 (0.25, 0.51)	0.75 (0.70, 0.81)	0.61 (0.59, 0.64)	0.63 (0.55, 0.73)	
Medium, decrease	0.50 (0.36, 0.64)	0.84 (0.71, 0.99)	0.64 (0.57, 0.71)	0.73 (0.53, 1.00)	
Medium, increase	0.46 (0.33, 0.59)	1.08 (1.00, 1.16)	0.75 (0.70, 0.78)	1.19 (0.94, 1.50)	
Medium, stable	0.46 (0.33, 0.60)	Ref	0.71 (0.68, 0.75)	Ref	<0.001
Alcohol intake					
High, decrease	0.53 (0.38, 0.66)	0.62 (0.52, 0.74)	0.70 (0.61, 0.78)	0.71 (0.46, 1.10)	
High, increase	0.51 (0.37, 0.65)	0.80 (0.70, 0.91)	0.75 (0.66, 0.82)	0.88 (0.56, 1.38)	
High, stable	0.45 (0.31, 0.59)	0.72 (0.64, 0.81)	0.76 (0.70, 0.81)	0.93 (0.68, 1.27)	
Low, decrease	0.59 (0.44, 0.72)	0.65 (0.52, 0.81)	0.75 (0.50, 0.90)	0.88 (0.30, 2.60)	
Low, increase	0.53 (0.39, 0.67)	1.18 (0.95, 1.45)	0.75 (0.63, 0.85)	0.92 (0.50, 1.67)	
Low, stable	0.51 (0.37, 0.65)	0.95 (0.89, 1.00)	0.74 (0.71, 0.77)	0.86 (0.72, 1.02)	
Medium, decrease	0.56 (0.41, 0.70)	0.77 (0.68, 0.87)	0.71 (0.64, 0.77)	0.74 (0.52, 1.04)	
Medium, increase	0.48 (0.34, 0.62)	1.02 (0.92, 1.14)	0.73 (0.67, 0.79)	0.81 (0.58, 1.13)	
Medium, stable	0.47 (0.33, 0.62)	Ref	0.77 (0.73, 0.80)	Ref	<0.001

*Logistic model adjusted for baseline age (continuous), race (White, Black, Asian, and other), family histories of cancer (yes, no), myocardial infarction (yes, no), and type 2 diabetes (yes, no), multivitamin use (yes, no), menopausal status (yes, no, women only), postmenopausal hormone use (yes, no, women only), cohort, education (registered nurse, bachelor degree, master degree and higher, women only), social economic status (annual family income [quartiles] for women and work status [disabled, retired, part-time, full-time] for men), aspirin use (yes, no), use of antihypertensive medications (yes, no), use of cholesterol lowering medications (yes, no), and the other four risk factors at baseline as continuous variables.

#Predicted odds of longevity was obtained using 'estimate' statement under 'proc logistic' command in SAS, assuming mean values of continuous covariates and median values of categorical covariates.

&We included interaction terms of age (<65, ≥65 years) and joint pattens of lifestyle factors (9 categories) into the model (18 categories of interaction terms). P for interaction was obtained using likelihood ratio test comparing models with and without interaction terms.

Table S8. Percentage (%) of missing of risk factors at each assessment in the Nurses' Health Study (NHS) and the Health Professionals Follow-up Study (HPFS).

	Time at assessment of risk factors																
	84	**86**	**88**	**90**	**92**	**94**	**96**	**98**	**00**	**02**	**04**	**06**	**08**	**10**	**12**	**14**	**16**
BMI																	
NHS	6	10	14	3	6	1	2	2	3	7	6	8	8	9	11	12	14
HPFS		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Smoking																	
NHS			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
HPFS	0	4	2	1	2	2	2	2	3	2	3	3	4	6	8	3	3
Diet quality																	
NHS	0	14		12		9		10		10		9		11			
HPFS		0		23		20		19		17		18					
Physical activity																	
NHS		9	4		2	1	1	1	0		0		0		10	9	
HPFS		1		0		0		0		0		0	0				
Alcohol intake																	
NHS	0	14		12		9		10		10		9		11			
HPFS		0		23		20		19		17		18		24			

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Table S9. Total number of assessments of risk factors during follow-up period in the Nurses' Health Study (NHS) (n=51442).

BMI			Smoking			Physical activity			Alcohol intake			Diet quality		
Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants[#] (%)	Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants[#] (%)	Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants[#] (%)	Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants[#] (%)	Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants[#] (%)
0	0	0	0	0	0	0	2	5	1	3	6	1	3	6
1	1	4	1	1	3	1	1	4	2	5	9	2	5	9
2	1	4	2	1	3	2	3	7	3	6	9	3	6	9
3	2	4	3	1	4	3	2	4	4	7	11	4	7	11
4	2	4	4	2	4	4	2	5	5	10	12	5	10	12
5	2	4	5	2	4	5	3	6	6	13	13	6	13	13
6	3	5	6	2	5	6	5	7	7	19	17	7	19	17
7	3	5	7	3	5	7	8	11	8	38	22	8	38	22
8	4	6	8	3	6	8	12	14						
9	5	6	9	4	6	9	16	16						
10	6	7	10	4	6	10	11	8						
11	7	8	11	6	6	11	34	14						
12	8	9	12	6	8									
13	9	9	13	7	9									
14	10	8	14	8	8									
15	12	7	15	9	7									
16	13	6	16	10	6									
17	13	5	17	30	10									

[#]We censored risk factors reported after diagnosis of CVD, type 2 diabetes, or cancer, and risk factors reported after age 85.

Table S10. Total number of assessments of risk factors during follow-up period in the Health Professionals Follow-up Study (HPFS) (n=33904).

BMI			Smoking			Physical activity			Alcohol intake			Diet quality		
Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants# (%)	Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants# (%)	Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants# (%)	Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants# (%)	Number of assessments	Percentage of participants in original data (%)	Percentage of participants after censoring participants# (%)
1	2	7	1	2	7	1	6	15	1	12	23	0	0	8
2	3	8	2	3	8	2	8	17	2	11	19	1	12	13
3	4	9	3	4	9	3	9	16	3	11	16	2	11	12
4	4	8	4	5	8	4	11	15	4	12	14	3	12	13
5	4	8	5	4	8	5	12	12	5	14	11	4	14	16
6	5	8	6	5	8	6	10	7	6	15	9	5	18	24
7	5	8	7	5	8	7	45	17	7	24	9	6	33	15
8	6	7	8	6	7									
9	6	7	9	6	6									
10	6	6	10	6	6									
11	6	5	11	7	5									
12	7	4	12	7	4									
13	7	4	13	8	4									
14	8	3	14	8	3									
15	7	3	15	9	3									
16	19	5	16	14	4									

#We censored risk factors reported after diagnosis of CVD, type 2 diabetes, or cancer, and risk factors reported after age 85.

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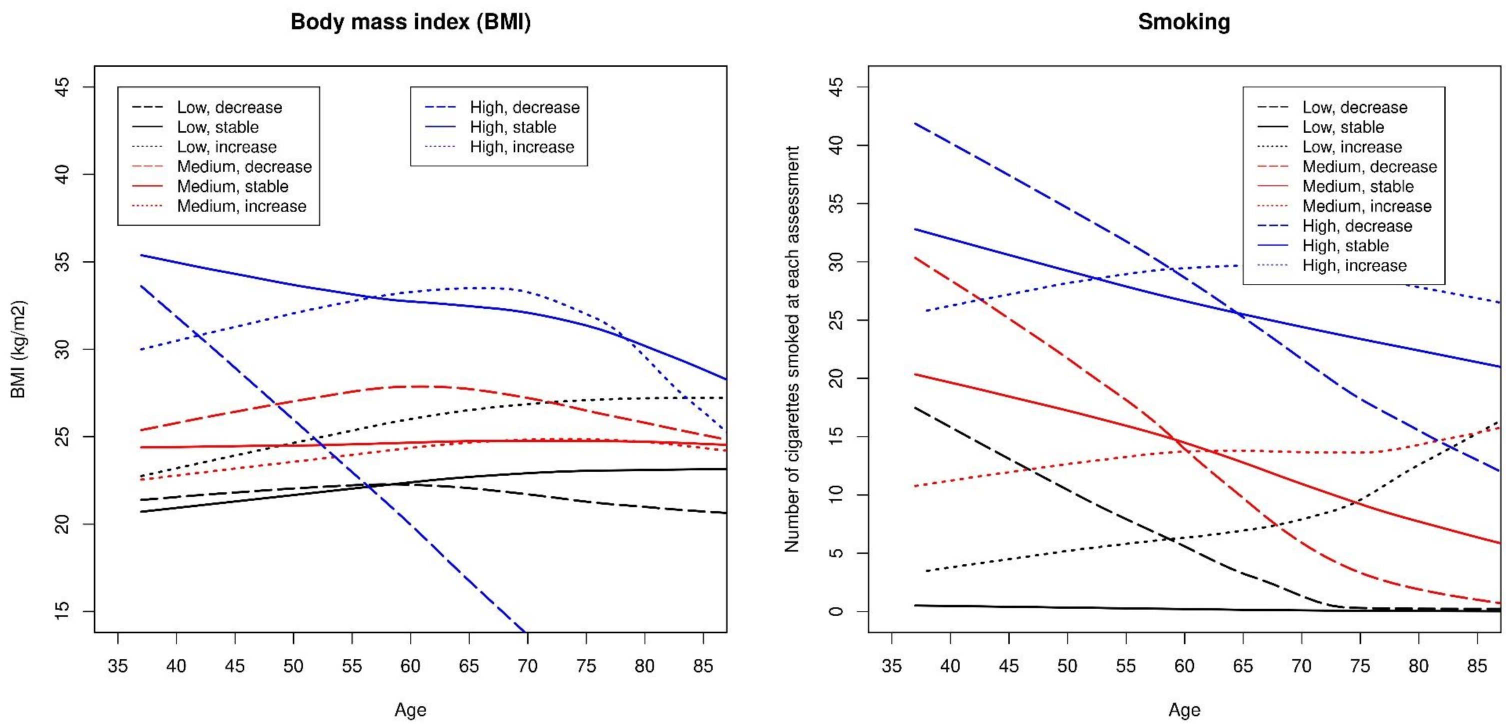
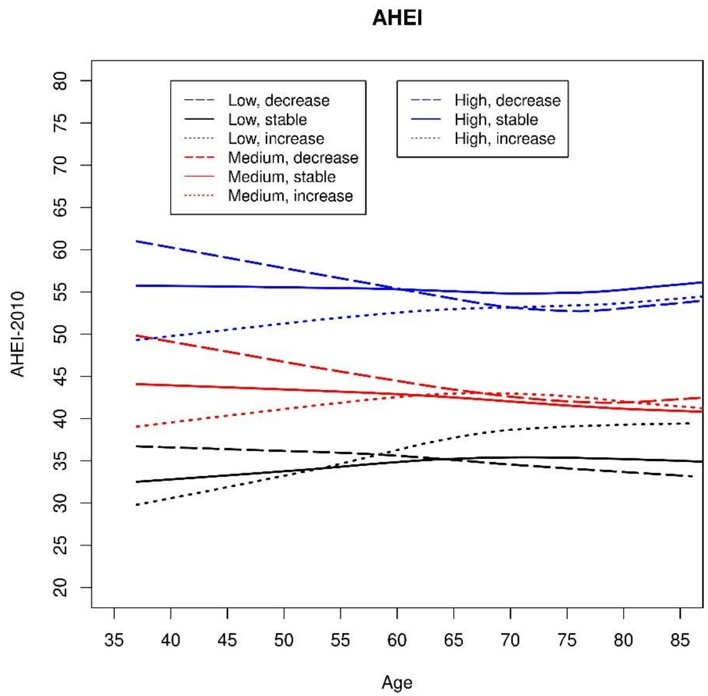
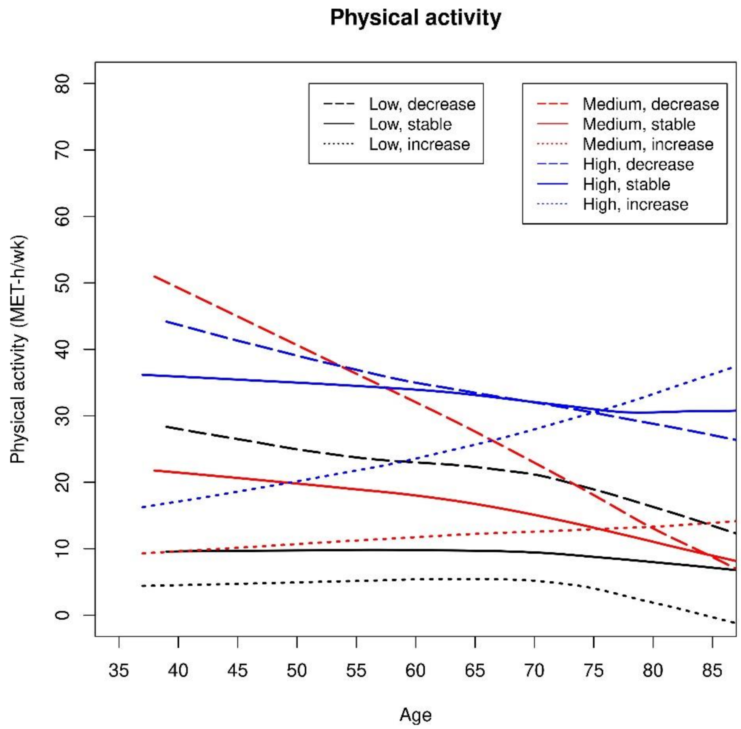
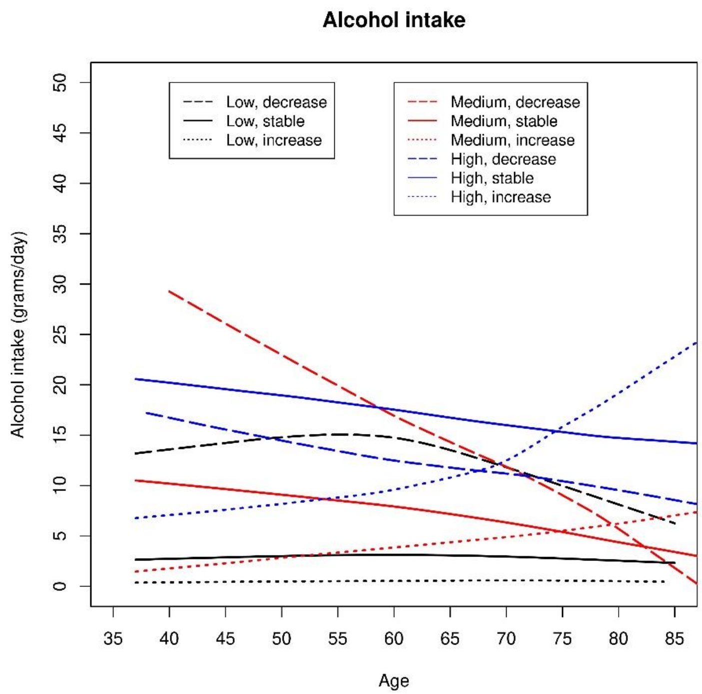
Figure S13. Plots of joint patterns of risk factors after missing data imputation by pooling the Nurses' Health Study and the Health Professionals Follow-up Study.




AHEI
AHEI-2010
Age
Low, decrease
Low, stable
Low, increase
Medium, decrease
Medium, stable
Medium, increase
High, decrease
High, stable
High, increase


Physical activity
Physical activity (MET-h/wk)
Age
Low, decrease
Low, stable
Low, increase
Medium, decrease
Medium, stable
Medium, increase
High, decrease
High, stable
High, increase



We identified patterns of risk factor and patterns of change in risk factor using smoothing mixture models, classified participants according to joint group membership, and plotted trajectories of risk factor within each category.

Table S11. Associations of patterns of risk factors and patterns of change in risk factors after missing data imputation with odds ratios (OR) of achieving longevity by pooling the Nurses' Health Study and the Health Professionals Follow-up Study.

Risk factors	Medium	Low	High	Change in risk factors	No change	Increase	Decrease
BMI				BMI			
Model 1	1.00	0.82 (0.80, 0.84)	0.53 (0.51, 0.55)	Model 3	1.00	0.61 (0.59, 0.63)	0.55 (0.53, 0.57)
Model 2	1.00	0.86 (0.83, 0.89)	0.58 (0.56, 0.61)	Model 4	1.00	0.83 (0.80, 0.86)	0.58 (0.55, 0.60)
Smoking				Smoking			
Model 1	1.00	3.00 (2.87, 3.15)	0.49 (0.44, 0.53)	Model 3	1.00	0.40 (0.35, 0.46)	1.14 (1.04, 1.25)
Model 2	1.00	2.89 (2.74, 3.05)	0.50 (0.45, 0.55)	Model 4	1.00	0.54 (0.46, 0.62)	1.11 (1.00, 1.23)
Diet quality (AHEI)				Diet quality (AHEI)			
Model 1	1.00	0.74 (0.71, 0.76)	1.21 (1.16, 1.25)	Model 3	1.00	1.19 (1.14, 1.24)	0.87 (0.83, 0.90)
Model 2	1.00	0.90 (0.86, 0.93)	1.05 (1.01, 1.10)	Model 4	1.00	1.10 (1.05, 1.15)	0.91 (0.87, 0.95)
Physical activity				Physical activity			
Model 1	1.00	0.60 (0.58, 0.62)	1.14 (1.10, 1.19)	Model 3	1.00	0.97 (0.93, 1.01)	0.75 (0.69, 0.82)
Model 2	1.00	0.66 (0.63, 0.69)	1.22 (1.17, 1.28)	Model 4	1.00	1.01 (0.97, 1.06)	0.83 (0.76, 0.91)
Alcohol intake				Alcohol intake			
Model 1	1.00	0.69 (0.67, 0.71)	0.95 (0.91, 0.98)	Model 3	1.00	0.95 (0.90, 0.99)	0.59 (0.55, 0.64)
Model 2	1.00	0.89 (0.85, 0.93)	0.95 (0.91, 1.00)	Model 4	1.00	0.94 (0.89, 1.00)	0.74 (0.68, 0.81)

Model 1 is univariate analysis.

Model 2 adjusted for baseline age (continuous), race (White, Black, Asian, and other), family histories of cancer (yes, no), myocardial infarction (yes, no), and type 2 diabetes (yes, no), multivitamin use (yes, no), menopausal status (yes, no, women only), postmenopausal hormone use (yes, no, women only), cohort, education (registered nurse, bachelor degree, master degree and higher, women only), social economic status (annual family income [quartiles] for women and work status [disabled, retired, part-time, full-time] for men), and the other four risk factors at baseline as continuous variables.

Model 3 is model 1 additionally adjusting for the risk factor at baseline (continuous) and the risk factor patterns (categorical).

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Model 4 is model 2 additionally adjusting for the risk factor at baseline (continuous) and the risk factor patterns (categorical).
Figure S14. Kaplan–Meier plot of survival during follow up in the Nurses' Health Study and the Health Professionals Follow-up Study.

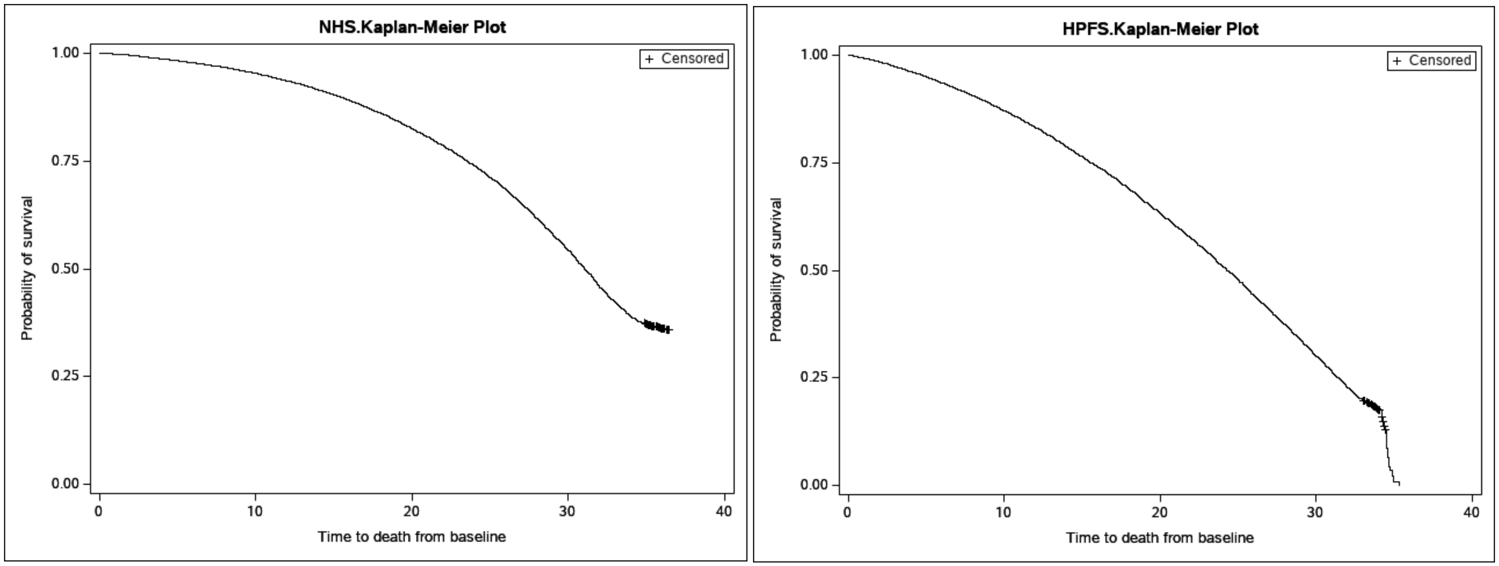
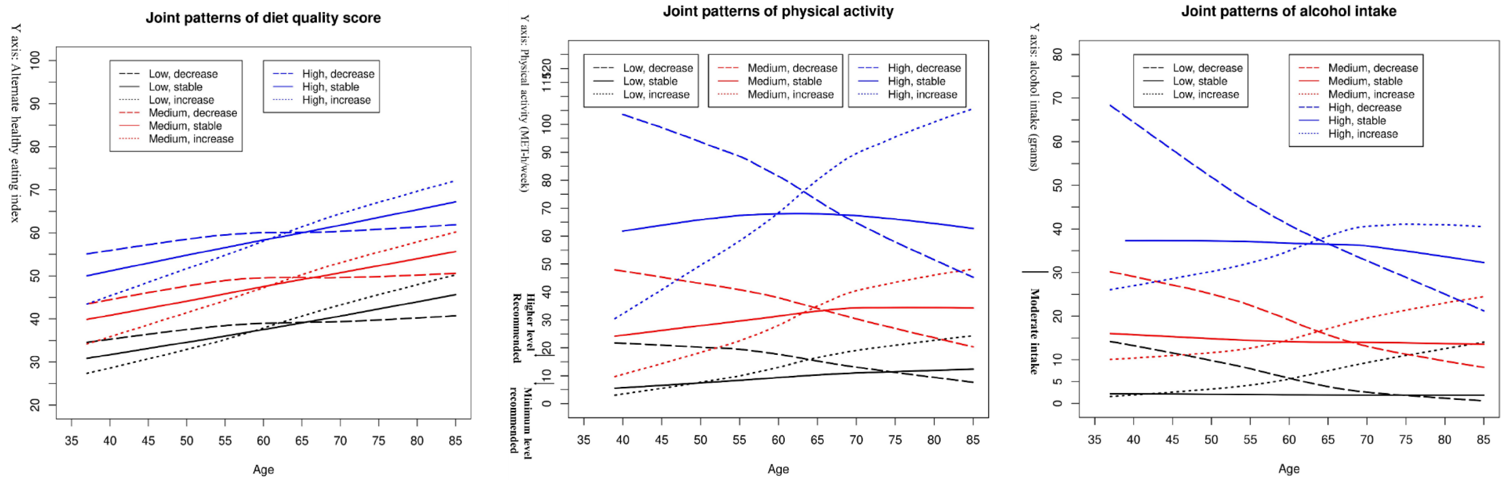


Figure S15. Plots of joint patterns of diet quality, physical activity, alcohol intake using unstandardized data by pooling the Nurses' Health Study and the Health Professionals Follow-up Study.



We identified patterns of risk factor and patterns of change in risk factor using smoothing mixture models, classified participants according to joint group membership, and plotted trajectories of risk factor within each category.

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Table S12. Associations of patterns of risk factor and patterns of change in risk factor using unstandardized data with odds ratios (OR) of achieving longevity by pooling the Nurses' Health Study and the Health Professionals Follow-up Study.

Patterns of risk factor	Medium	Low	High	Patterns of change in risk factor	No change	Increase	Decrease
Diet quality (AHEI)				Diet quality (AHEI)			
Cases/Participants	18346/30941	11619/21937	10588/17285	Cases/Participants	19432/32253	9678/17909	11443/19908
Model 1	1.00	0.77 (0.75, 0.80)	1.09 (1.04, 1.13)	Model 3	1.00	0.85 (0.82, 0.89)	0.78 (0.75, 0.81)
Model 2	1.00	0.76 (0.73, 0.79)	1.11 (1.06, 1.16)	Model 4	1.00	0.99 (0.94, 1.03)	0.81 (0.77, 0.85)
Physical activity				Physical activity			
Cases/Participants	12878/20467	25323/45630	2352/4065	Cases/Participants	28694/49364	7120/11862	2592/5084
Model 1	1.00	0.73 (0.71, 0.76)	0.81 (0.76, 0.87)	Model 3	1.00	0.96 (0.91, 1.01)	0.55 (0.51, 0.59)
Model 2	1.00	0.72 (0.70, 0.75)	0.86 (0.80, 0.93)	Model 4	1.00	1.06 (1.00, 1.12)	0.68 (0.63, 0.73)
Alcohol intake				Alcohol intake			
Cases/Participants	9896/16869	29757/51438	2736/5614	Cases/Participants	32657/52517	3609/6342	1929/3928
Model 1	1.00	0.97 (0.93, 1.00)	0.67 (0.63, 0.71)	Model 3	1.00	0.75 (0.71, 0.80)	0.62 (0.57, 0.68)
Model 2	1.00	0.86 (0.83, 0.90)	0.77 (0.72, 0.83)	Model 4	1.00	1.08 (1.01, 1.16)	0.74 (0.67, 0.82)

Model 1 is univariate analysis.

Model 2 adjusted for baseline age (continuous), race (White, Black, Asian, and other), family histories of cancer (yes, no), myocardial infarction (yes, no), and type 2 diabetes (yes, no), multivitamin use (yes, no), menopausal status (yes, no, women only), postmenopausal hormone use (yes, no, women only), cohort, education (registered nurse, bachelor degree, master degree and higher, women only), social economic status (annual family income [quartiles] for women and work status [disabled, retired, part-time, full-time] for men), and the other four risk factors at baseline as continuous variables.

Model 3 is model 1 additionally adjusting for the risk factor at baseline (continuous) and the risk factor patterns (categorical).

Model 4 is model 2 additionally adjusting for the risk factor at baseline (continuous) and the risk factor patterns (categorical).

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Table S13. Comparison between participants who were excluded due to unknown longevity status (i.e. who were alive and did not reach 85) and the main study population.

	NHS (1984)		**HPFS (1986)**	
	Main population (n=51442)	Participants with unknown longevity status (n=26210)	Main population (n=33904)	Participants with unknown longevity status (n=15330)
Age	54.21 (5.41)	42.86 (3.14)	59.52 (8.04)	44.36 (3.19)
BMI (kg/m^2)	25.23 (4.72)	24.37 (4.46)	25.01 (5.27)	24.73 (4.52)
Alcohol intake (g)	7.37 (11.92)	6.16 (9.91)	12.04 (16.33)	9.86 (13.30)
Physical activity (MET-h/week)	13.99 (20.42)	14.51 (22.09)	19.53 (26.59)	23.65 (32.28)
AHEI	44.22 (10.32)	41.41 (9.83)	47.77 (10.92)	45.43 (10.62)
Current smoker, %	26	21	11	8
Caucasian, %	98	98	91	91
Menopausal status, %	69	8	NA	NA
Postmenopausal hormone use, %[§]	18	6	NA	NA
Family history of cancer, %	42	36	9	7
Family history of cardiovascular disease, %	36	31	35	29
Family history of diabetes, %	23	21	15	11
Multivitamin use, %	38	36	33	29

Table S14. Associations of patterns of risk factor and patterns of change in risk factor with odds ratios (OR) of mortality further including participants that were excluded due to unknown longevity status by pooling the Nurses' Health Study and the Health Professionals Follow-up Study.

Risk factors	Medium	Low	High	Change in risk factors	No change	Increase	Decrease
BMI				BMI			
Cases/Participants	22904/49215	27025/57979	7162/15198	Cases/Participants	20558/47718	12797/33165	18365/33377
Model 1	1.00	1.03 (1.00, 1.05)	1.02 (0.98, 1.06)	Model 3	1.00	0.58 (0.56, 0.60)	1.96 (1.90, 2.02)
Model 2	1.00	1.00 (0.96, 1.03)	1.75 (1.67, 1.84)	Model 4	1.00	0.99 (0.95, 1.04)	1.46 (1.40, 1.51)
Smoking				Smoking			
Cases/Participants	6810/11682	44749/103633	5338/6891	Cases/Participants	45508/103297	1625/2497	4975/9767
Model 1	1.00	0.48 (0.46, 0.50)	2.57 (2.40, 2.75)	Model 3	1.00	0.85 (0.77, 0.93)	0.72 (0.66, 0.77)
Model 2	1.00	0.36 (0.34, 0.38)	1.94 (1.78, 2.12)	Model 4	1.00	1.72 (1.52, 1.95)	0.70 (0.64, 0.78)
AHEI				AHEI			
Cases/Participants	24478/53366	17631/37512	13415/28677	Cases/Participants	23075/50907	9992/27788	13114/28040
Model 1	1.00	1.05 (1.02, 1.08)	1.02 (0.99, 1.05)	Model 3	1.00	0.81 (0.78, 0.84)	0.88 (0.85, 0.92)
Model 2	1.00	1.16 (1.12, 1.20)	0.94 (0.90, 0.98)	Model 4	1.00	0.95 (0.91, 1.00)	1.18 (1.13, 1.24)
Physical activity				Physical activity			
Cases/Participants	14685/36412	41241/80802	2611/6630	Cases/Participants	41088/82399	7812/22674	2244/5689
Model 1	1.00	1.57 (1.53, 1.61)	0.95 (0.90, 1.00)	Model 3	1.00	0.59 (0.57, 0.62)	0.78 (0.73, 0.84)
Model 2	1.00	1.28 (1.24, 1.32)	1.11 (1.04, 1.19)	Model 4	1.00	0.83 (0.80, 0.87)	1.46 (1.34, 1.59)
Alcohol intake				Alcohol intake			
Cases/Participants	12489/27992	38183/82791	4903/8992	Cases/Participants	39277/89581	3932/11527	3057/5985
Model 1	1.00	1.13 (1.10, 1.16)	1.47 (1.40, 1.54)	Model 3	1.00	0.64 (0.61, 0.68)	0.85 (0.79, 0.92)
Model 2	1.00	1.06 (1.02, 1.10)	1.26 (1.18, 1.34)	Model 4	1.00	1.08 (1.01, 1.16)	1.18 (1.07, 1.30)

Model 1 is univariate analysis.
Model 2 adjusted for baseline age (continuous), race (White, Black, Asian, and other), family histories of cancer (yes, no), myocardial infarction (yes, no), and type 2 diabetes (yes, no), multivitamin use (yes, no), menopausal status (yes, no, women only), postmenopausal hormone use (yes, no, women only), cohort, education (registered nurse, bachelor degree, master degree and higher, women only), social economic status (annual family income [quartiles] for women and work status [disabled, retired, part-time, full-time] for men), and the other four risk factors at baseline as continuous variables.
Model 3 is model 1 additionally adjusting for the risk factor at baseline (continuous) and the risk factor patterns (categorical).
Model 4 is model 2 additionally adjusting for the risk factor at baseline (continuous) and the risk factor patterns (categorical).

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Table S15. Associations of patterns of risk factor and patterns of change in risk factor with odds ratios (OR) of achieving longevity excluding participants who were below 51 years in the Nurses' Health Study and 49 years in the Health Professionals Follow-up Study.

Risk factors	Medium	Low	High	Change in risk factors	No change	Increase	Decrease
BMI				BMI			
Cases/Participants	15705/25184	18926/30518	2798/5445	Cases/Participants	21392/31101	2649/4466	10253/18634
Model 1	1.00	0.98 (0.94, 1.01)	0.63 (0.59, 0.67)	Model 3	1.00	0.72 (0.67, 0.77)	0.56 (0.54, 0.58)
Model 2	1.00	0.98 (0.94, 1.02)	0.63 (0.59, 0.67)	Model 4	1.00	0.86 (0.80, 0.93)	0.58 (0.56, 0.61)
Smoking				Smoking			
Cases/Participants	2444/5914	34509/53258	920/3234	Cases/Participants	33808/52513	459/1180	1646/3964
Model 1	1.00	2.83 (2.68, 2.99)	0.55 (0.50, 0.60)	Model 3	1.00	0.62 (0.54, 0.72)	1.49 (1.33, 1.66)
Model 2	1.00	2.72 (2.56, 2.90)	0.56 (0.51, 0.62)	Model 4	1.00	0.65 (0.56, 0.75)	1.44 (1.27, 1.63)
AHEI				AHEI			
Cases/Participants	17186/27420	10249/18220	10222/15511	Cases/Participants	17103/25685	8804/13309	8435/13404
Model 1	1.00	0.76 (0.74, 0.79)	1.16 (1.11, 1.21)	Model 3	1.00	1.05 (1.00, 1.11)	0.76 (0.72, 0.80)
Model 2	1.00	0.85 (0.82, 0.89)	1.04 (0.99, 1.08)	Model 4	1.00	1.02 (0.96, 1.07)	0.83 (0.79, 0.88)
Physical activity				Physical activity			
Cases/Participants	12260/18333	23968/42431	2158/3356	Cases/Participants	15724/25967	18036/28641	1188/2029
Model 1	1.00	0.64 (0.62, 0.67)	0.89 (0.83, 0.97)	Model 3	1.00	1.04 (0.99, 1.10)	0.65 (0.58, 0.73)
Model 2	1.00	0.71 (0.69, 0.74)	0.88 (0.81, 0.96)	Model 4	1.00	1.07 (1.01, 1.13)	0.72 (0.64, 0.81)
Alcohol intake				Alcohol intake			
Cases/Participants	8913/14124	26300/42269	2494/4816	Cases/Participants	29828/44981	2978/4621	1622/2908
Model 1	1.00	0.94 (0.91, 0.98)	0.63 (0.59, 0.67)	Model 3	1.00	0.93 (0.86, 1.00)	0.77 (0.69, 0.85)
Model 2	1.00	0.92 (0.88, 0.96)	0.74 (0.69, 0.80)	Model 4	1.00	1.00 (0.92, 1.09)	0.83 (0.75, 0.93)

Model 1 is univariate analysis.
Model 2 adjusted for baseline age (continuous), race (White, Black, Asian, and other), family histories of cancer (yes, no), myocardial infarction (yes, no), and type 2 diabetes (yes, no), multivitamin use (yes, no), menopausal status (yes, no, women only), postmenopausal hormone use (yes, no, women only), cohort, education (registered nurse, bachelor degree, master degree and higher, women only), social economic status (annual family income [quartiles] for women and work status [disabled, retired, part-time, full-time] for men), and the other four risk factors at baseline as continuous variables.
Model 3 is model 1 additionally adjusting for the risk factor at baseline (continuous) and the risk factor patterns (categorical).
Model 4 is model 2 additionally adjusting for the risk factor at baseline (continuous) and the risk factor patterns (categorical).

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