

Supplementary Material

Associations of healthy lifestyle and socioeconomic status with mortality and incident cardiovascular disease: two prospective cohort studies

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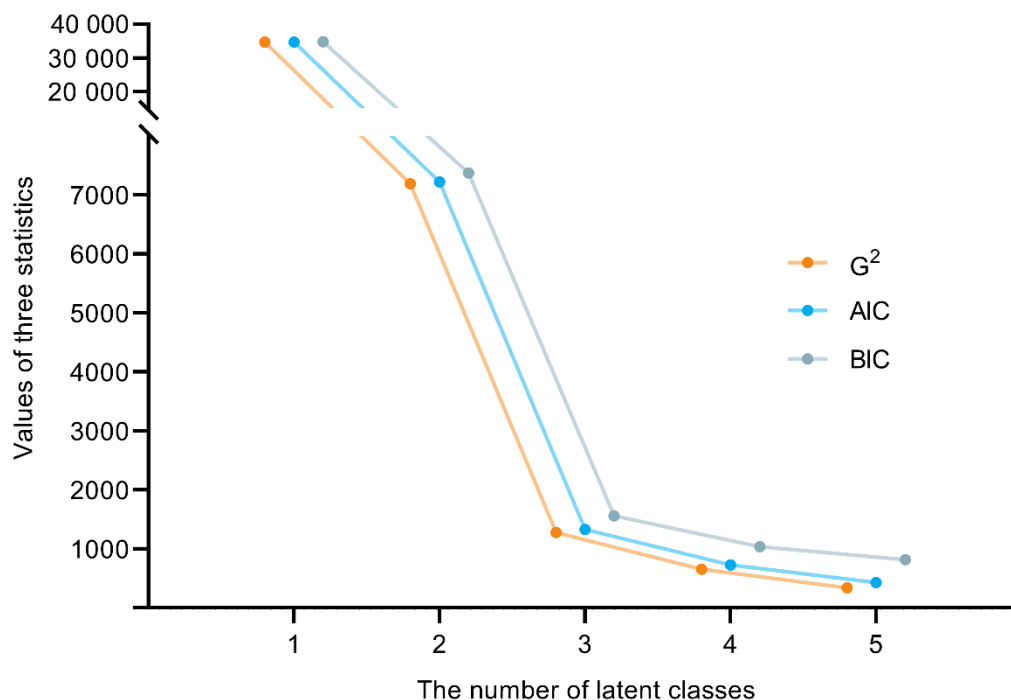
Supplementary method

Assessment of socioeconomic status using latent class analysis

Family income level, occupation, education level, and health insurance reflect different aspects of socioeconomic status (SES), thus we used these four parameters to generate an overall SES parameter in the US National Health and Nutrition Examination Survey (NHANES). There were three levels for each parameter, i.e., the family income-to-poverty ratio of ≥ 4 , >1 to <4 , and ≤ 1 for family income level; upper socioeconomic index, lower socioeconomic index, and unemployment for occupation; college or above, high school or equivalent, and less than high school for education level; and private health insurance, public health insurance only, and no health insurance for health insurance. Latent class analyses with different numbers of latent classes were conducted to select a reasonable model. The maximum absolute deviation between the parameter estimates in two successive iterations of the estimation procedure was set to 0.000001, which meant iteration would terminate when the difference between the parameter estimates in two successive iterations was less than 0.000001. Akaike information criterion (AIC), Bayesian information criterion (BIC), and likelihood ratio statistic G^2 were used for the model selection. The mean posterior probability, which reflected the uncertainty of posterior classification, was also used for the model selection, and a value of 0.7 or more indicated an acceptable uncertainty. Item-response probability was a posterior probability and was used for defining latent classes.

Since the model with six latent classes failed to converge, we only reported information on models with five or fewer latent classes. The following figure shows that G^2 statistics, AIC, and BIC all continued to go down as more latent classes were added. However, the decrease leveled off after the three-latent-class solution.

Figure for supplementary method. G^2 statistics, AIC, and BIC in models with different numbers of latent classes in the US NHANES



We additionally examined the mean posterior probabilities to facilitate the model selection. The following table shows the mean posterior probabilities, the prevalence of latent classes, and item-response probabilities in models with three to five latent classes. All mean posterior probabilities from the three-latent-class solution were all ≥ 0.77 ; mean posterior probabilities of latent classes 2 and 4 from the four-latent-class solution were

respectively 0.68 and 0.64 which were less than 0.70; and the mean posterior probabilities of four latent classes from the five-latent-class solution were less than 0.70. Thus, the three-latent-class solution was the best in terms of the uncertainty of posterior classification.

Table for supplementary method. Mean posterior probabilities, prevalence of latent classes, and item-response probabilities in models with three to five latent classes in the US NHANES*

Item†	Latent class 1	Latent class 2	Latent class 3	Latent class 4	Latent class 5
Three-latent-class solution					
MeanPP	0.86	0.77	0.85	NA	NA
Prevalence	0.35	0.43	0.23	NA	NA
Income 1	0.70	0.23	0.01	NA	NA
Income 2	0.28	0.73	0.50	NA	NA
Income 3	0.02	0.05	0.49	NA	NA
Occupation 1	0.58	0.06	0.02	NA	NA
Occupation 2	0.34	0.83	0.52	NA	NA
Occupation 3	0.08	0.12	0.45	NA	NA
Education 1	0.92	0.38	0.26	NA	NA
Education 2	0.07	0.42	0.26	NA	NA
Education 3	0.00	0.20	0.48	NA	NA
Insurance 1	0.92	0.79	0.13	NA	NA
Insurance 2	0.04	0.07	0.43	NA	NA
Insurance 3	0.04	0.13	0.44	NA	NA
Four-latent-class solution					
MeanPP	0.85	0.68	0.76	0.64	NA
Prevalence	0.35	0.31	0.12	0.22	NA
Income 1	0.70	0.29	0.02	0.02	NA
Income 2	0.28	0.70	0.40	0.71	NA
Income 3	0.02	0.01	0.58	0.27	NA
Occupation 1	0.59	0.04	0.00	0.07	NA
Occupation 2	0.33	0.85	0.37	0.74	NA
Occupation 3	0.08	0.11	0.63	0.19	NA
Education 1	0.92	0.37	0.21	0.37	NA
Education 2	0.08	0.46	0.27	0.28	NA
Education 3	0.01	0.17	0.51	0.35	NA
Insurance 1	0.92	0.86	0.07	0.40	NA
Insurance 2	0.04	0.08	0.60	0.14	NA
Insurance 3	0.04	0.05	0.33	0.45	NA
Five-latent-class solution					
MeanPP	0.83	0.67	0.66	0.65	0.67
Prevalence	0.32	0.31	0.07	0.16	0.15
Income 1	0.73	0.28	0.02	0.15	0.00
Income 2	0.26	0.71	0.34	0.66	0.63
Income 3	0.01	0.01	0.64	0.19	0.37
Occupation 1	0.60	0.04	0.00	0.17	0.01

Item†	Latent class 1	Latent class 2	Latent class 3	Latent class 4	Latent class 5
Occupation 2	0.33	0.85	0.23	0.62	0.75
Occupation 3	0.07	0.11	0.77	0.21	0.24
Education 1	0.92	0.35	0.22	0.71	0.11
Education 2	0.07	0.47	0.28	0.21	0.31
Education 3	0.01	0.19	0.50	0.08	0.59
Insurance 1	0.95	0.89	0.04	0.43	0.28
Insurance 2	0.03	0.06	0.69	0.19	0.23
Insurance 3	0.02	0.04	0.27	0.38	0.48

meanPP=mean posterior probability; NA=not available.

* The maximal item-response probabilities for each latent class were marked in bold.

† Prevalence indicated the prevalence of each latent class. Income 1 to 3 respectively referred to the family income-to-poverty ratio of ≥ 4 , >1 to <4 , and ≤ 1 . Occupation 1 to 3 respectively referred to upper socioeconomic index, lower socioeconomic index, and unemployment. Education 1 to 3 respectively referred to college or above, high school or equivalent, less than high school. Insurance 1 to 3 respectively referred to private health insurance, public health insurance only, and no health insurance.

Additionally, we evaluated the characteristics of each latent class in each model. For the three-latent-class solution, latent class 1 was characterized by high-level family income, occupation, education, and health insurance, which could be defined as “high SES”; latent class 2 was characterized by medium-level family income, occupation, and education, as well as high-level health insurance, which could be defined as “medium SES”; latent class 3 was characterized by medium- and low-level family income, occupation, and health insurance, as well as low-level education, which could be defined as “low SES”. As for the four-latent-class solution, the latent classes 1 to 3 were correspondingly similar to those in the three-latent-class solution, while latent class 4 was characterized by medium-level family income and occupation as well as high-level education and health insurance, which could be defined as “early high SES” (considering education levels could reflect ones’ SES before early adulthood while occupation and income tended to reflect ones’ SES in adulthood). As for the five-latent-class solution, the latent classes 1 to 3 were correspondingly similar to those in the three-latent-class solution, while latent class 4 was characterized by medium-level family income and occupation as well as low-level education and health insurance, which could be defined as “early low SES”; while latent class 5 was characterized by medium-level family income, high-level occupation and education, and low-level health insurance, which could be defined as “high socioeconomic prestige”. Considering we intended to compare mortality risks among individuals with different SES (especially comparing mortality risk among individuals with high versus low SES), sufficient sample size and events were needed among each group; however, the prevalence of “low SES” class was 12% and 7% in the four-latent-class solution and five-latent-class solution, which were relatively low. Besides, latent class 4 or 5 in the four-latent-class solution and five-latent-class solution was isolated from the medium and low SES, which was not of interest to us.

Above all, comprehensively considering statistics related to model selection, the uncertainty of posterior classification, meanings of latent classes, and parsimony, we chose the three-latent-class solution and divided individuals into high, medium, and low SES, and the practical definitions of which were shown in the following figure.

Figure for supplementary method. Practical definitions of high, medium, and low socioeconomic status in the three-latent-class solution (the US NHANES)

		High SES	Medium SES	Low SES						
		Upper socioeconomic index			Lower socioeconomic index			Unemployment		
		PIR ≥4	PIR >1 to <4	PIR ≤1	PIR ≥4	PIR >1 to <4	PIR ≤1	PIR ≥4	PIR >1 to <4	PIR ≤1
Private health insurance	College or above	12.2	5.1	0.3	9.7	10.6	1.0	2.0	1.8	0.3
	High school	1.1	0.9	0.1	3.9	8.9	0.6	0.6	1.3	0.3
	Less than high school	0.2	0.2	<0.1	1.0	4.6	0.7	0.2	1.0	0.3
Public health insurance	College or above	0.5	0.3	0.1	0.9	1.8	0.5	0.2	0.8	0.7
	High school	<0.1	<0.1	<0.1	0.3	1.4	0.5	0.1	0.8	0.8
	Less than high school	<0.1	<0.1	<0.1	0.1	1.4	0.9	0.1	0.9	1.5
No health insurance	College or above	0.4	0.7	0.1	0.4	2.5	0.7	0.2	0.9	0.5
	High school	0.1	0.3	<0.1	0.3	2.0	0.8	0.1	0.8	0.5
	Less than high school	<0.1	0.1	<0.1	0.1	2.0	1.2	<0.1	0.9	0.9

PIR=family income-to-poverty ratio; SES=socioeconomic status. The numbers in the cells represented the percentage of participants out of the total study population.

Total household income before tax, education qualification, and employment status were used to generate an overall SES parameter in the UK Biobank. We did not consider health insurance in the UK since the National Health Service is implemented in the UK, which aims to provide comprehensive, universal and free health services. We did not regroup household income and education qualification into three groups as we did in the US NHANES because of the larger sample size in the UK Biobank and failure of model convergence due to fewer observed groups if the two variables were regrouped. Participants were divided into five groups according to total household income before tax, i.e., “less than £18 000”, “£18 000 to 30 999”, “£31 000 to 51 999”, “£52 000 to 100 000”, “greater than £100 000”. There are seven groups according to education qualification, including “College or University degree”, “A levels/AS levels or equivalent”, “O levels/GCSEs or equivalent”, “CSEs or equivalent”, “NVQ or HND or HNC or equivalent”, “Other professional qualifications”, “None of the above” (equivalent to less than high school diploma). The UK Biobank only acquired employment status instead of specific occupation information at baseline, and we regrouped participants into two groups, i.e., employed (including those in paid employment or self-employed, retired, doing unpaid or voluntary work, or being full or part-time students), and unemployed. The procedure of the latent class analysis was similar to that in the US NHANES. Since the model with four latent classes failed to converge, we only reported parameters in the three-latent-class solution. In the three-latent class solution, the G^2 statistic is 2391, AIC is 2461, and BIC is 2845. Mean posterior probabilities, the prevalence of latent classes, and item-response probabilities in the three-latent class solution are shown below.

Table for supplementary method. Mean posterior probabilities, prevalence of latent classes, and item-response probabilities in models with three to five latent classes in the UK Biobank

Item†	Latent class 1	Latent class 2	Latent class 3
MeanPP	0.92	0.90	0.77
Prevalence*	0.31	0.23	0.46
Less than £18 000	0.72	<0.01	0.00
£18 000-30 999	0.22	<0.01	0.41
£31 000-51 999	0.04	0.24	0.42
£52 000-100 000	0.01	0.54	0.17
Greater than £100 000	0.01	0.22	<0.01
College or university degree	0.15	0.73	0.30
A/AS levels or equivalent	0.08	0.13	0.13
O/GCSEs level or equivalent	0.22	0.09	0.27

Item†	Latent class 1	Latent class 2	Latent class 3
CSEs or equivalent	0.06	0.01	0.07
NVQ/HND/HNC or equivalent	0.08	0.02	0.08
Other professional qualifications	0.05	0.03	0.06
None of the above	0.36	<0.01	0.08
Employed	0.84	0.96	0.98
Unemployed	0.16	0.04	0.02

meanPP=mean posterior probability.

* Prevalence indicated the prevalence of each latent class.

As shown above, the proportion of less than £31 000 of total household income before tax, O/GCSEs level and less than high school (i.e., none of the above), and unemployment were relatively high in latent class 1, which could be defined as “low SES”. The proportion of £52 000 or more of total household income before tax, college or university degree, and employment were relatively high in latent class 2, which could be defined as “high SES”. £18 000-51 999 of total household income before tax, college or university degree and O/GCSEs level, and employment status were prevalent in latent class 3, which could be defined as “medium SES”. Mean posterior probabilities of all latent classes were above 0.70, and the practical definitions of which were shown in the following figure.

Figure for supplementary method. Practical definitions of high, medium, and low socioeconomic status in the three-latent-class solution (the UK Biobank)

	Employed					Unemployed				
	Less than £18 000	£18 000-30 999	£31 000-51 999	£52 000-100 000	Greater than £100 000	Less than £18 000	£18 000-30 999	£31 000-51 999	£52 000-100 000	Greater than £100 000
College or university degree	2.8	6.4	9.7	11.0	3.8	0.5	0.3	0.3	0.3	0.2
A/AS levels or equivalent	1.5	2.8	3.4	2.7	0.5	0.3	0.1	0.2	0.1	0.1
O/GCSEs level or equivalent	4.0	6.2	5.9	3.3	0.4	0.7	0.3	0.2	0.1	0.1
CSEs or equivalent	1.0	1.5	1.6	0.7	0.1	0.3	0.1	0.1	<0.1	<0.1
NVQ/HND/HNC or equivalent	1.5	1.9	1.7	0.9	0.1	0.3	0.1	0.1	<0.1	<0.1
Other professional qualifications	1.0	1.5	1.3	0.8	0.2	0.1	0.1	<0.1	<0.1	<0.1
None of the above	6.5	3.8	1.8	0.6	0.1	1.3	0.3	0.1	0.1	<0.1

The numbers in the cells represented the percentage of participants out of the total study population.

Assessment of socioeconomic and lifestyle factors

In the US NHANES, dietary information was obtained through 24-hour dietary recalls, and other information on socioeconomic and lifestyle factors was obtained through questionnaires. All questionnaires could be obtained through the US NHANES website (<https://wwwn.cdc.gov/nchs/nhanes/default.aspx>).

- Family income level: Family income-to-poverty ratio which is a ratio of family income to poverty threshold is provided in the dataset. We regrouped participants into three groups (i.e., family income-to-poverty ratio of ≥ 4 , >1 to <4 , and ≤ 1) according to previous studies.
- Education attainment: The highest grade or level of school completed or the highest degree received was asked for each participant. Participants could choose one of the following options: less than 9th grade, 9-11th grade (including 12th grade with no diploma), high school graduates or general educational development or equivalent, some college or associate degree of Arts, and college graduate or above. We regrouped participants into three groups (i.e., less than high school, high school graduates, and some college or above) according to previous studies.
- Occupation: Types of occupation were asked for each participant. From 1988 to 1994, the classification of

occupation was based on categories defined by the US Bureau of Census in 1980. From 1999 to 2004, occupation groups were defined according to Industry and Occupation Coding for Death Certificates (US National Center for Health Statistics). Since 2005, occupation groups were defined according to 2000 Indexes of Industry and Occupation (US Census Bureau). Main reasons for not working last week were also obtained, including taking care of house or family, going to school, retired, unable to work for health reasons, on layoff, disabled, and others. Except for going to school and retired, other reasons for not working denoted unemployment. Participants were regrouped into three groups, including upper socioeconomic index, lower socioeconomic index, and unemployment.

- Health insurance: Participants were asked about whether they had any private health insurance, Medi-Gap, single-service plan, Medicare, Medicaid, State Children's Healthcare Plan, military health care, Indian Health Service, State Sponsored Health Plan, or other government program. We regrouped participants into three groups, i.e., those with private health insurance, those with public health insurance, and those with no health insurance.
- Cigarette smoking: Participants were asked about whether they have smoked over 100 cigarettes in life, and we defined those who have smoked over 100 cigarettes in life as ever smokers.
- Alcohol drinking: From 1988 to 1994, participants were asked about the monthly frequency of consuming beer and lite beer, wine, and hard liquor, and we assumed that each participant drank one drink per time. Thus, daily drinks that each participant consumed equaled to the sum of daily frequency of different alcoholic drink intakes. Since 1999, participants were asked about the frequency of alcohol drinking over the past 12 months and average alcoholic drink consumptions per day on those days that they drank. We calculated the daily consumption of alcohol by multiplying the probability of drinking alcohol on a given day and daily consumption of alcohol.
- Physical activity: We assessed the level of leisure-time physical activity since information on physical activity during work was not collected in some cycles and thusly we cannot estimate the level of total physical activity in all cycles. From 1988 to 1994, participants were asked about the monthly frequency of walking mile without stop, running or jogging, riding or exercising bicycle, swimming, doing aerobics or aerobic dancing, doing other dancing, doing calisthenics, doing garden or yard work, lifting weights, and doing other activities. Intensity rating was given for each kind of activity, and information on the duration of each activity per time was unavailable. Thus, we added the monthly frequency of all leisure-time physical activities up weighted by their intensity rating. From 1999 to 2006, participants were asked about the monthly frequency of multiple leisure-time physical activities (details are shown at https://wwwn.cdc.gov/Nchs/Nhanes/1999-2000/PAQIAF.htm#Data_Processing_and_Editing). For each activity, average number of minutes spent each time and metabolic equivalent score were also obtained. Since 2007, the dataset provided information on how many days and how much time per day did participants do recreational moderate and vigorous physical activity directly, and 4 and 8 of metabolic equivalent scores were given to moderate and vigorous physical activity. We calculated metabolic equivalent times for each participant by adding time spent on each activity weighted by its metabolic equivalent score from 1999 to 2014.
- Diet: Dietary information was obtained through 24-h dietary recalls, and an observation validation study showed that the 24-h dietary recall could accurately estimate intakes of energy and macronutrients. Before 2003, only one 24-h dietary recall was administered for each participant in the mobile examination center. Since 2003, two 24-h dietary recalls were administered to each participant. We only used recalls from the first day to harmonize the data from all cycles. The dietary interviews were conducted by trained investigators following the US Department of Agriculture Automated Multiple-Pass Method for the 24-h

recall. First, investigators asked respondents about what they consumed yesterday, which could match to foods from the Main Food List which contained more than 2600 food items. Then, some specific categories of foods that were frequently forgotten including fruits, vegetables, cheese, bread, sweets, snacks, non-alcoholic beverages, and alcoholic beverages were additionally asked. Next, eating occasions and time, food descriptions, and food amounts of each food were obtained. Consumptions of food groups and nutrients were determined using the US Department of Agriculture Nutrient Database for Dietary Studies and Food Patterns Equivalents Database. Components and scoring standards of Healthy Eating Index score-1995 and Healthy Eating Index score-2015 are shown in supplementary table 1.

In the UK Biobank, all information on socioeconomic and lifestyle factors was obtained through questionnaires. All questionnaires could be obtained through the UK Biobank website (<https://biobank.ndph.ox.ac.uk/showcase/index.cgi>).

- Family income level: Total household income before tax was obtained through questionnaires, and participants could choose an option from “less than £18 000”, “£18 000 to 30 999”, “£31 000 to 51 999”, “£52 000 to 100 000”, “greater than £100 000”, “do not know”, or “prefer not to answer”.
- Education attainment: Education qualification was obtained through questionnaires, and participants reported their education qualifications as “College or university degree”, “A levels/AS levels or equivalent”, “O levels/GCSEs or equivalent”, “CSEs or equivalent”, “NVQ or HND or HNC or equivalent”, “Other professional qualifications”, “None of the above” (equivalent to less than high school diploma), or “Prefer not to answer”.
- Employment status: The UK Biobank only acquired employment status instead of specific occupation information at baseline through questionnaires, and participants could report their employment status as in paid employment or self-employed, retired, doing unpaid or voluntary work, being full or part-time students, looking after home/family, unable to work because of sickness or disability, unemployed, none of the above, or prefer not to answer. Those who choose the first four options were grouped into the “employed” group, while others (except for the last two options, which were treated as missing values) were grouped into the “unemployed” group.
- Cigarette smoking: Participants were asked about their current tobacco smoking status, including yes (on most or all days), only occasionally, no, and prefer not to answer. Those who did not smoke on most or all days would be asked about the past tobacco smoking status, including smoked on most or all days, smoked occasionally, just tried once or twice, never smoked, or prefer not to answer. Those who reported that they smoked occasionally or just tried once or twice would be asked about whether they had smoked a total of at least 100 times in lifetime. According to the information, participants who never smoked and those who previously smoked occasionally or just tried once or twice but did not smoke 100 times in lifetime were categorized into “never smoking” group, similar to the US NHANES. Others with no missing information on smoking would be viewed as ever smokers.
- Alcohol drinking: Participants were asked about the frequency of drinking alcohol, i.e., (almost) daily, three or four times a week, once or twice a week, one to three times a month, special occasions only, never, and prefer not to answer. Those who reported to drink alcohol would be asked about how much red wine (glasses), white wine (glasses), beer or cider (pints), spirits or liqueurs (standard measures), fortified wine (glasses), and other alcoholic drinks (glasses) they consumed in an average month or week. We used the information to calculate the average units of alcohol each participant drank daily.
- Physical activity: To coincide with the US NHANES, we assessed the level of leisure-time physical activity in the UK Biobank. We took walking for pleasure, strenuous sports, and other exercises (e.g.,

swimming, cycling, keep fit, bowling) into consideration, which were given 3.3, 8, and 4 metabolic equivalent scores, respectively. The frequency and duration for each time were asked for each participant. Participants could choose one of the following frequency options, i.e., once in the last 4 weeks, 2-3 times in the last 4 weeks, once a week, 2-3 times a week, 4-5 times a week, every day, do not know, and prefer not to answer. Options including a range would be substituted by the midpoint of the range, e.g., we assigned 2.5 times a week for the option “2-3 times a week”. The duration for each time was also obtained by some options, i.e., less than 15 minutes, between 15 and 30 minutes, between 30 minutes and 1 hour, between 1 and 1.5 hours, between 1.5 and 2 hours, between 2 and 3 hours, over 3 hours, do not know, and prefer not to answer. Each option would be substituted by the midpoint of the range, and those who chose over 3 hours were substituted by 3 hours as recommended by other studies. We calculated metabolic equivalent times for each participant by adding time spent on each activity weighted by its metabolic equivalent score.

- Diet: According to a previous UK Biobank study, dietary quality was evaluated using more recent dietary recommendations for cardiovascular health, and details are shown in supplementary table 2. Fruit intakes were evaluated according to daily consumptions of fresh fruit (pieces) and dried fruit (pieces). Vegetable intakes were evaluated according to daily consumptions of cooked vegetables (tablespoons) and salad/raw vegetables (tablespoons). Wholegrain intakes were evaluated according to weekly consumptions of bread (slices, if the participant consumed whole meal/whole grain bread) and cereal (bowls, if the participant consumed bran, oat, or Muesli). (Shell)fish were evaluated according to the frequency of eating oily fish and non-oily fish. Dairy intakes were evaluated according to the frequency of cheese consumption and whether the participant consumed milk. Vegetable oils were evaluated according to the weekly consumption of bread (slices) if the participants consumed flora pro-active/benecol, soft margarine, olive oil based, polyunsaturated/sunflower oil based, or other low/reduced fat spread. Refined grain intakes were evaluated according to weekly consumptions of bread (slices, if the participant consumed white, brown, or other bread) and cereal (bowls, if the participant consumed biscuit or others). Processed meat consumptions were evaluated according to the frequency of consumption and whether the participants did not eat it anymore (according to a question about age when last ate meat). Unprocessed meat consumptions were evaluated according to the frequency of consumption of poultry, beef, lamb/mutton, and pork and whether the participants did not eat meat anymore (according to a question about age when last ate meat). Sugar-sweetened beverage intakes were evaluated by a question “Which of the following do you NEVER eat?” Those who chose sugar or foods/drinks containing sugar were regarded as never drinking sugar-sweetened beverages.

Construction of 5-point acculturation score

In the US NHANES, a 5-point acculturation score was constructed according to the country of birth, length of time in the US, and language spoken at home. A 3-point score was assigned to the country of birth and length of time in the US, i.e., 3 points for US-born, 2 points for foreign-born and lived in the US ≥ 20 years, 1 point for foreign-born and lived in the US 10 to 19 years, and 0 points for foreign-born and lived in the US < 10 years. A 2-point score was assigned to language spoken at home, i.e., 2 points for English only or predominantly, 1 point for both equally, and 0 points for other languages only or predominantly. These scores were summed to get a 5-point acculturation score with greater values indicating more acculturated, and participants were grouped into two groups (i.e., 0-2 points and 3-5 points).

In the UK Biobank, information on language spoken at home was not collected. Thus, the acculturation score was constructed according to the country of birth and length of time in the UK, and the score ranged

between 0 and 3, i.e., 3 points for UK-born, 2 points for foreign-born and lived in the UK ≥ 20 years, 1 point for foreign-born and lived in the UK 10 to 19 years, and 0 points for foreign-born and lived in the UK < 10 years. Participants were grouped into two groups, i.e., 0-1 point and 2-3 points.

Supplementary table 1. Components and scoring standards of Healthy Eating Index score-1995 and Healthy Eating Index score-2015

Component	Range of score	Standard for maximum score	Standard for minimum score
Healthy Eating Index score-1995*			
Grains	0 to 10	6-11 servings†	0 servings
Vegetables	0 to 10	3-5 servings†	0 servings
Fruits	0 to 10	2-4 servings†	0 servings
Milk	0 to 10	2-3 servings‡,‡	0 servings
Meat	0 to 10	2-3 servings†	0 servings
Total fat	0 to 10	30% or less energy from fat	45% or greater energy from fat
Saturated fat	0 to 10	10% or less energy from saturated fat	15% or greater energy from saturated fat
Cholesterol	0 to 10	300 mg or less	Greater than or equal to 450 mg
Sodium	0 to 10	2,400 mg or less	Greater than or equal to 4,800 mg
Variety	0 to 10	8 or more different items in a day	3 or fewer different items in a day
Healthy Eating Index score-2015*			
Total fruits§	0 to 5	≥0.8 cup equivalent per 1,000 kcal	No fruit
Whole fruits	0 to 5	≥0.4 cup equivalent per 1,000 kcal	No whole fruit
Total vegetables¶	0 to 5	≥1.1 cup equivalent per 1,000 kcal	No vegetables
Greens and beans¶	0 to 5	≥0.2 cup equivalent per 1,000 kcal	No dark green vegetables or legumes
Whole grains	0 to 10	≥1.5 oz equivalent per 1,000 kcal	No whole grains
Dairy**	0 to 10	≥1.3 cup equivalent per 1,000 kcal	No dairy
Total protein foods††	0 to 5	≥2.5 oz equivalent per 1,000 kcal	No protein foods
Seafood and plant proteins‡‡,‡‡	0 to 5	≥0.8 oz equivalent per 1,000 kcal	No seafood or plant proteins
Fatty acids	0 to 10	(PUFAs + MUFAs)/SFAs ≥2.5	(PUFAs + MUFAs)/SFAs ≤1.2
Refined grains	0 to 10	≤1.8 oz equivalent per 1,000 kcal	≥4.3 oz equivalent per 1,000 kcal
Sodium	0 to 10	≤1.1 gram per 1,000 kcal	≥2.0 grams per 1,000 kcal
Added sugars	0 to 10	≤6.5% of energy	≥26% of energy
Saturated fats	0 to 10	≤8% of energy	≥16% of energy

MUFA=monounsaturated fatty acid; PUFA=polyunsaturated fatty acid; SFA=saturated fatty acid.

*Intakes between the minimum and maximum standards are scored proportionately.

†Depends on different energy intake.

‡The required number of milk group servings is 3 for pregnant and breast-feeding women and for teenagers and young adults up to age 24 years.

§Includes 100% fruit juice.

||Includes all forms except juice.

¶Includes legumes (beans and peas).

**Includes all milk products, such as fluid milk, yogurt, and cheese, and fortified soy beverages.

††Includes legumes (beans and peas).

‡‡Includes seafood, nuts, seeds, soy products (other than beverages), and legumes (beans and peas).

Supplementary table 2. Components of more recent dietary recommendations for cardiovascular health*

Diet component	Intake goal
Fruit	≥ 3 servings/day
Vegetable	≥ 3 servings/day
Whole grains	≥ 3 servings/day
(Shell)fish	≥ 2 servings/week
Dairy	≥ 2 servings/day
Vegetable oils	≥ 2 servings/day
Refined grains	≤ 2 servings/day
Processed meats	≤ 1 serving/week
Unprocessed meats	≤ 2 servings/week
Sugar-sweetened beverages	No consumption

*A healthy diet was defined as meeting at least half of the dietary recommendation (at least 5 items).

Supplementary table 3. Baseline characteristics of participants included or excluded from analyses due to missing information*

Characteristics	NHANES		UK Biobank	
	Included participants (n=44 462)	Excluded participants (n=16 740)	Included participants (n=399 537)	Excluded participants (n=24 993)
Age, years	46.1 (45.7 to 46.5)	47.2 (46.7 to 47.7)	56.1 (56.1 to 56.1)	58.2 (58.1 to 58.2)
Male	21 870 (48.9)	7970 (47.1)	189 813 (47.5)	39 302 (38.17)
White	21 393 (73.5)	6632 (63.4)	382 053 (95.6)†	90 629 (90.5)†
Married	24 223 (58.8)	7850 (51.0)	-	-
Household income‡				
High	10 840 (34.9)	2065 (28.7)	105 098 (26.3)	4864 (16.8)
Medium	24 630 (52.1)	5978 (52.5)	206 809 (51.8)	13 849 (47.7)
Low	8992 (13.1)	2924 (18.8)	87 630 (21.9)	10 318 (35.5)
Education				
College or above	19 747 (55.3)	5626 (46.0)	188 002 (47.1)	33 360 (34.6)
High school or equivalent	11 512 (26.5)	3947 (26.5)	153 752 (38.5)	34 951 (36.2)
Less than high school	13 203 (18.3)	6857 (27.5)	57 783 (14.5)	28 251 (29.3)
Occupation				
At work, student, or retirement	35 382 (82.7)	12 184 (77.7)	372 167 (93.2)	85 487 (87.9)
Upper SI	7267 (23.6)	1894 (18.7)	-	-
Lower SI	28 115 (59.2)	10 290 (59.1)	-	-
Unemployment	9080 (17.3)	4029 (22.3)	27 370 (6.9)	11 819 (12.2)
Health insurance				
Private	26 795 (69.6)	8228 (61.1)	-	-
Public only	8907 (13.7)	3922 (17.7)	-	-
None	8760 (16.6)	3638 (21.3)	-	-
More accultured	37 585 (91.0)	12 055 (84.0)	367 865 (92.1)	90 073 (88.1)
Ever smoked 100 cigarettes	21 628 (49.2)†	7807 (48.3)†	180 562 (45.2)	40 554 (43.1)
Heavy drinkers	2715 (7.5)	504 (6.2)	147 637 (37.0)	28 857 (29.6)
Bottom two tertiles of				
LTPA	31 507 (66.3)	12 617 (70.2)	266 355 (66.7)	70 527 (73.0)
Unhealthy diet§	25 480 (58.0)†	5283 (58.1)†	342 645 (85.8)	75 469 (84.5)
BMI, kg/m ²				
18.5-24.9	13 827 (33.1)	3984 (34.8)	131 018 (32.8)	31 388 (31.4)
<18.5	755 (1.8)	296 (2.5)	1998 (0.5)	628 (0.6)
25.0-29.9	15 295 (33.5)	4095 (33.4)	170 781 (42.7)	41 331 (41.4)
≥30.0	14 585 (31.6)	3561 (29.2)	95 740 (24.0)	26 503 (26.5)
Self-reported comorbidities				
Hypertension	14 746 (28.9)†	5416 (28.0)†	112 082 (28.1)	33 256 (32.7)

Diabetes	4680 (7.5) [†]	1863 (7.7) [†]	19 819 (5.0)	6893 (6.8)
CVD	4609 (7.7)	2132 (9.4)	75 020 (18.8)	23 555 (23.1)
Cancer	4048 (8.9) [†]	1450 (8.3) [†]	33 816 (8.5)	9699 (9.6)
Emphysema, chronic bronchitis, or COPD	3238 (7.4) [†]	1166 (6.9) [†]	8847 (2.2)	2848 (2.8)

BMI=body mass index; COPD=chronic obstructive pulmonary disorder; HEI=healthy eating index; LTPA=leisure-time physical activity; SI=socioeconomic index.

* Continuous variables were expressed as mean (95% confidence interval), and categorical variables were expressed as number (percentage). In the US National Health and Nutrition Examination Survey, all estimates accounted for complex survey designs, and *P* values were calculated using analysis of variance adjusting for sampling weights and Rao-Scott χ^2 test for continuous and categorical variables, respectively. In the UK Biobank, *P* values were calculated using t test and χ^2 test for continuous and categorical variables, respectively. The numbers of participants from NHANES/UK Biobank with missing covariates were as follows: self-reported race (0/2777), marital status (631 in NHANES), household income (5773/73 924), education (310/6393), occupation or employment status (527/5649), health insurance (952 in NHANES), acculturation (1015/696), cigarette smoking (71/8746), alcohol consumption (5957/5364), LTPA (29/6276), diet (7528/13 671), BMI (4804/3105), and prevalent hypertension (286/1170), diabetes (8/1638), CVD (247/1056), cancer (6/1639), and chronic bronchitis, emphysema, or COPD (5/0),

[†]*P*>0.05 (others <0.05).

‡ In the US National Health and Nutrition Examination Survey, ≥ 4 , >1 to <4 , and ≤ 1 of family income-to-poverty ratios represented the high, medium, and low family income level, respectively. In the UK Biobank, less than £18 000, £18 000 to 51 999, and £52 000 or more of average total household income before tax represented the high, medium, and low family income level, respectively.

§ In the US National Health and Nutrition Examination Survey III, unhealthy diet denoted the bottom three quintiles of healthy eating index-1995 score. In the continuous US National Health and Nutrition Examination Survey, unhealthy diet denoted the bottom three quintiles of healthy eating index-2015 score. In the UK Biobank, unhealthy diet denoted ideal intakes of less than 5 dietary components for cardiovascular health.

Supplementary table 4. Hazard ratios (95% confidence intervals) of mortality and incident cardiovascular disease associated with each healthy lifestyle factor and the healthy lifestyle score*

Factors	US NHANES	UK Biobank		
	All-cause mortality	All-cause mortality	Cardiovascular disease mortality	Incident cardiovascular disease
Never smoking	0.74 (0.69 to 0.79)	0.68 (0.66 to 0.70)	0.69 (0.65 to 0.73)	0.75 (0.71 to 0.79)
No heavy alcohol drinking	0.81 (0.70 to 0.92)	1.00 (0.97 to 1.03)	1.05 (0.99 to 1.12)	1.11 (1.06 to 1.17)
Top tertile of leisure-time physical activity	0.85 (0.79 to 0.91)	0.77 (0.75 to 0.80)	0.78 (0.73 to 0.84)	0.86 (0.81 to 0.90)
Healthy diet†	0.90 (0.85 to 0.96)	0.91 (0.88 to 0.95)	0.94 (0.87 to 1.03)	0.83 (0.78 to 0.90)
One-point increase in the healthy lifestyle score	0.83 (0.80 to 0.85)	0.83 (0.82 to 0.84)	0.85 (0.83 to 0.88)	0.89 (0.87 to 0.91)

NHANES= National Health and Nutrition Examination Survey.

*The analysis adjusted for age, sex, marital status (US NHANES only), self-reported race, study center (UK Biobank only), acculturation, socioeconomic status, and self-reported comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). Analysis in the US NHANES included the US population and study design weights to account for the complex survey design.

†In the US National Health and Nutrition Examination Survey III, healthy diet denoted the top two quintiles of healthy eating index-1995 score. In the continuous US National Health and Nutrition Examination Survey, healthy diet denoted the top two quintiles of healthy eating index-2015 score. In the UK Biobank, healthy diet denoted ideal intakes of 5 or more dietary components for cardiovascular health.

Supplementary table 5. Associations of socioeconomic status with mortality and incident cardiovascular disease and mediation proportion of socioeconomic inequity in health attributed to lifestyle: sensitivity analyses*

Analyses	US NHANES	UK Biobank		
	All-cause mortality	All-cause mortality	CVD mortality	Incident CVD
Simultaneous adjustment for individual lifestyle factors				
HR (95% CI) of model 1	2.36 (2.11 to 2.65)	2.02 (1.92 to 2.12)	2.31 (2.06 to 2.59)	1.68 (1.56 to 1.82)
HR (95% CI) of model 2	2.16 (1.93 to 2.42)	1.87 (1.78 to 1.96)	2.13 (1.90 to 2.39)	1.58 (1.46 to 1.70)
Mediation proportion (%; 95% CI)	10.5 (8.01 to 13.01)	11.1 (10.2 to 12.0)	9.4 (8.0 to 10.9)	12.3 (10.4 to 14.5)
Weighted lifestyle score				
HR (95% CI) of model 1	2.36 (2.11 to 2.65)	2.02 (1.92 to 2.12)	2.31 (2.06 to 2.59)	1.69 (1.55 to 1.83)
HR (95% CI) of model 2	2.13 (1.90 to 2.38)	1.94 (1.84 to 2.04)	2.23 (1.98 to 2.50)	1.64 (1.51 to 1.78)
Mediation proportion (%; 95% CI)	12.3 (10.7 to 13.9)	5.7 (5.1 to 6.2)	4.3 (3.6 to 5.1)	5.2 (4.4 to 6.3)
Lifestyle score including body mass index				
HR (95% CI) of model 1	2.38 (2.13 to 2.67)	2.04 (1.94 to 2.14)	2.37 (2.11 to 2.66)	1.72 (1.58 to 1.86)
HR (95% CI) of model 2	2.21 (1.97 to 2.47)	1.97 (1.88 to 2.08)	2.29 (2.04 to 2.57)	1.67 (1.54 to 1.81)
Mediation proportion (%; 95% CI)	8.8 (7.6 to 10.0)	4.4 (4.0 to 4.8)	3.7 (3.1 to 4.4)	5.4 (4.5 to 6.4)
Excluding individuals with prevalent diabetes, CVD, cancer, chronic bronchitis, emphysema, or COPD				
HR (95% CI) of model 1	2.70 (2.31 to 3.15)	1.92 (1.80 to 2.06)	2.24 (1.90 to 2.63)	1.66 (1.52 to 1.82)
HR (95% CI) of model 2	2.43 (2.08 to 2.84)	1.87 (1.75 to 2.00)	2.18 (1.86 to 2.57)	1.63 (1.49 to 1.78)
Mediation proportion (%; 95% CI)	10.5 (8.6 to 12.5)	4.2 (3.7 to 4.9)	3.1 (2.4 to 4.1)	3.9 (3.2 to 4.9)
Excluding events that occurred within the first three years of follow-up				
HR (95% CI) of model 1	2.32 (2.05 to 2.62)	1.96 (1.86 to 2.07)	2.27 (2.00 to 2.58)	1.66 (1.51 to 1.82)
HR (95% CI) of model 2	2.09 (1.85 to 2.37)	1.91 (1.81 to 2.02)	2.22 (1.96 to 2.52)	1.63 (1.48 to 1.79)
Mediation proportion (%; 95% CI)	12.1 (10.3 to 14.0)	3.9 (3.4 to 4.3)	2.9 (2.3 to 3.5)	3.4 (2.7 to 4.3)
Among individuals aged 40 years or older				
HR (95% CI) of model 1	2.23 (1.97 to 2.52)	-	-	-
HR (95% CI) of model 2	1.98 (1.75 to 2.24)	-	-	-
Mediation proportion (%; 95% CI)	14.7 (12.6 to 16.7)	-	-	-

Multiple imputation

HR (95% CI) of model 1	2.43 (2.22 to 2.66)	1.93 (1.72 to 2.17)	2.20 (1.94 to 2.49)	1.51 (1.42 to 1.62)
HR (95% CI) of model 2	2.19 (1.99 to 2.40)	1.86 (1.65 to 2.10)	2.13 (1.87 to 2.42)	1.48 (1.39 to 1.58)
Mediation proportion (%; 95% CI)	11.8 (10.5 to 13.2)	5.4 (3.9 to 6.9)	4.2 (3.1 to 5.4)	5.0 (3.9 to 6.0)

Using socioeconomic score to investigate more extreme socioeconomic disparity

HR (95% CI) of model 1	3.29 (2.64 to 4.09)	3.41 (3.18 to 3.67)	3.53 (3.01 to 4.13)	2.56 (2.24 to 2.94)
HR (95% CI) of model 2	2.87 (2.31 to 3.58)	3.23 (3.00 to 3.47)	3.37 (2.88 to 3.94)	2.46 (2.15 to 2.82)
Mediation proportion (%; 95% CI)	8.6 (7.3 to 10.3)	4.6 (4.3 to 4.9)	3.7 (3.3 to 4.2)	4.3 (3.8 to 4.7)

Additional inclusion of quadratic terms of age in the model

HR (95% CI) of model 1	2.31 (2.06 to 2.58)	2.02 (1.92 to 2.12)	2.30 (2.05 to 2.59)	1.70 (1.57 to 1.85)
HR (95% CI) of model 2	2.06 (1.84 to 2.31)	1.96 (1.86 to 2.06)	2.24 (2.00 to 2.52)	1.67 (1.54 to 1.81)
Mediation proportion (%; 95% CI)	13.3 (11.5 to 15.2)	4.1 (3.7 to 4.6)	3.1 (2.6 to 3.8)	3.8 (3.2 to 4.6)

CI=confidence interval; COPD=chronic obstructive pulmonary disorder; CVD=cardiovascular disease; HR=hazard ratio; US NHANES= the US National Health and Nutrition Examination Survey.

*Socioeconomic status was generated through latent class analysis using the information on family income-to-poverty ratio, occupation, education level, and health insurance in the US NHANES, and household income, education level, and employment status in the UK Biobank. Only the results comparing the low with high socioeconomic status are reported. Model 1 controlled for age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). Model 2 additionally included the healthy lifestyle score consisting of never smoking, no heavy alcohol drinking, higher physical activity level, and a higher diet quality score. For lifestyle score additionally including body mass index, body mass index was not controlled. Analysis in US NHANES included the US population and study design weights to account for the complex survey design.

Supplementary table 6. C-statistics of models without and with the healthy lifestyle score*

	C-statistics (95% CI) unadjusted for the lifestyle score (model 1)	C-statistics (95% CI) adjusted for the lifestyle score (model 2)	Difference of c-statistics between model 2 and model 1 (95% CI)
All-cause mortality in US NHANES	0.84 (0.84-0.85)	0.84 (0.84-0.85)	0.00 (-0.01-0.01)
All-cause mortality in UK Biobank	0.75 (0.75-0.75)	0.75 (0.75-0.76)	0.00 (0.00-0.01)
Cardiovascular mortality in UK Biobank	0.81 (0.80-0.81)	0.81 (0.80-0.82)	0.00 (-0.01-0.02)
Incident cardiovascular disease in UK Biobank	0.72 (0.71-0.72)	0.72 (0.71-0.73)	0.00 (-0.01-0.02)

CI=confidence interval; US NHANES= the US National Health and Nutrition Examination Survey.

*Socioeconomic status was generated through latent class analysis using the information on family income-to-poverty ratio, occupation, education level, and health insurance in the US NHANES, and household income, education level, and employment status in the UK Biobank. All models included age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). The healthy lifestyle score consisted of never smoking, no heavy alcohol drinking, higher physical activity level, and a higher diet quality score. For incident myocardial infarction and stroke, only those free from cardiovascular disease at baseline were included. Analysis in US NHANES included the US population and study design weights to account for the complex survey design.

Supplementary table 7. Associations of each individual socioeconomic factor with mortality and incident cardiovascular disease and mediation proportion of socioeconomic inequity in health attributed to lifestyle*

Factors	US NHANES	UK Biobank		
	All-cause mortality	All-cause mortality	Cardiovascular disease mortality	Incident cardiovascular disease
Household income				
HR (95% CI) of model 1	1.45 (1.28 to 1.64)	1.77 (1.69 to 1.85)	2.09 (1.87 to 2.33)	1.39 (1.29 to 1.51)
HR (95% CI) of model 2	1.42 (1.25 to 1.61)	1.76 (1.68 to 1.85)	2.09 (1.87 to 2.33)	1.39 (1.29 to 1.51)
Mediation proportion (%; 95% CI)	6.9 (4.5 to 9.2)	<1	<1	<1
Education attainment				
HR (95% CI) of model 1	1.28 (1.17 to 1.40)	1.18 (1.14 to 1.21)	1.17 (1.09 to 1.25)	1.25 (1.17 to 1.33)
HR (95% CI) of model 2	1.21 (1.11 to 1.33)	1.13 (1.10 to 1.17)	1.13 (1.06 to 1.22)	1.21 (1.14 to 1.29)
Mediation proportion (%; 95% CI)	22.2 (16.3 to 28.0)	22.2 (18.2 to 26.7)	19.0 (12.0 to 28.8)	12.7 (9.8 to 16.3)
Occupation				
HR (95% CI) of model 1	1.80 (1.56 to 2.08)	-	-	-
HR (95% CI) of model 2	1.75 (1.51 to 2.02)	-	-	-
Mediation proportion (%; 95% CI)	5.1 (3.3 to 6.9)	-	-	-
Health insurance				
HR (95% CI) of model 1	1.28 (1.12 to 1.46)	-	-	-
HR (95% CI) of model 2	1.24 (1.09 to 1.41)	-	-	-
Mediation proportion (%; 95% CI)	13.1 (0.2 to 26.1)	-	-	-

US NHANES=US National Health and Nutrition Examination Survey.

*Only the results comparing the low with high socioeconomic factor are reported. Model 1 included all individual socioeconomic factors, as well as age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). Model 2 additionally included the healthy lifestyle score consisting of never smoking, no heavy alcohol drinking, higher physical activity level, and a higher diet quality score. Analysis in US NHANES included the US population and study design weights to account for the complex survey design.

Supplementary table 8. Associations of socioeconomic status with secondary outcomes and mediation proportion of socioeconomic inequity in health attributed to lifestyle*

	HR (95% CI)		
	unadjusted for the lifestyle score	HR (95% CI) adjusted for the lifestyle score	Mediation proportion (95% CI)
Heart disease mortality in US NHANES			
High SES	1 [Reference]	1 [Reference]	-
Medium SES	2.03 (1.65 to 2.49)	1.94 (1.58 to 2.38)	6.6% (3.3% to 9.8%)
Low SES	2.67 (2.07 to 3.43)	2.46 (1.92 to 3.16)	8.2% (5.9% to 10.5%)
Coronary heart disease mortality in UK Biobank			
High SES	1 [Reference]	1 [Reference]	-
Medium SES	1.45 (1.23 to 1.70)	1.42 (1.21 to 1.67)	4.7% (2.8% to 7.7%)
Low SES	2.71 (2.30 to 3.19)	2.62 (2.23 to 3.09)	3.3% (2.7% to 4.1%)
Stroke mortality in UK Biobank			
High SES	1 [Reference]	1 [Reference]	-
Medium SES	1.26 (0.94 to 1.68)	1.25 (0.94 to 1.66)	4.3% (1.1% to 14.8%)
Low SES	2.07 (1.54 to 2.78)	2.03 (1.51 to 2.72)	2.8% (1.8% to 4.4%)
Incident myocardial infarction in UK Biobank			
High SES	1 [Reference]	1 [Reference]	-
Medium SES	1.35 (1.23 to 1.49)	1.34 (1.22 to 1.48)	3.4% (2.2% to 5.2%)
Low SES	1.83 (1.65 to 2.03)	1.79 (1.62 to 1.99)	3.2% (2.6% to 4.0%)
Incident stroke in UK Biobank			
High SES	1 [Reference]	1 [Reference]	-
Medium SES	1.19 (1.06 to 1.35)	1.18 (1.05 to 1.33)	5.6% (2.6% to 11.6%)
Low SES	1.48 (1.30 to 1.69)	1.45 (1.28 to 1.66)	4.7% (3.3% to 6.7%)

CI=confidence interval; HR=hazard ratio; US NHANES= the US National Health and Nutrition Examination Survey.

*Socioeconomic status was generated through latent class analysis using the information on family income-to-poverty ratio, occupation, education level, and health insurance in the US NHANES, and household income, education level, and employment status in the UK Biobank. All models included age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). The healthy lifestyle score consisted of never smoking, no heavy alcohol drinking, higher physical activity level, and a higher diet quality score. For incident myocardial infarction and stroke, only those free from cardiovascular disease at baseline were included. Analysis in US NHANES included the US population and study design weights to account for the complex survey design.

Supplementary table 9. Associations of the healthy lifestyle score with mortality and incident cardiovascular disease by socioeconomic status: sensitivity analyses*

Analyses	US NHANES	UK Biobank		
	All-cause mortality	All-cause mortality	CVD mortality	Incident CVD
Main analysis				
High socioeconomic status	0.79 (0.73 to 0.86)	0.91 (0.87 to 0.95)	0.99 (0.89 to 1.10)	0.92 (0.86 to 0.98)
Medium socioeconomic status	0.82 (0.79 to 0.86)	0.85 (0.84 to 0.87)	0.89 (0.84 to 0.93)	0.92 (0.89 to 0.96)
Low socioeconomic status	0.87 (0.81 to 0.93)	0.79 (0.77 to 0.81)	0.80 (0.77 to 0.84)	0.83 (0.79 to 0.86)
Weighted lifestyle score†				
High socioeconomic status	0.84 (0.79 to 0.89)	0.93 (0.91 to 0.96)	0.97 (0.91 to 1.04)	0.93 (0.89 to 0.98)
Medium socioeconomic status	0.88 (0.86 to 0.91)	0.89 (0.88 to 0.91)	0.91 (0.89 to 0.94)	0.94 (0.92 to 0.96)
Low socioeconomic status	0.91 (0.87 to 0.95)	0.85 (0.84 to 0.86)	0.85 (0.83 to 0.88)	0.87 (0.85 to 0.90)
Lifestyle score including body mass index				
High socioeconomic status	0.84 (0.78 to 0.91)	0.91 (0.87 to 0.94)	0.92 (0.84 to 1.01)	0.90 (0.85 to 0.95)
Medium socioeconomic status	0.88 (0.85 to 0.91)	0.88 (0.86 to 0.89)	0.88 (0.84 to 0.92)	0.90 (0.88 to 0.93)
Low socioeconomic status	0.91 (0.86 to 0.96)	0.85 (0.83 to 0.87)	0.85 (0.81 to 0.88)	0.85 (0.82 to 0.88)
Excluding individuals with prevalent diabetes, CVD, cancer, chronic bronchitis, emphysema, or COPD				
High socioeconomic status	0.83 (0.74 to 0.93)	0.89 (0.85 to 0.95)	0.92 (0.84 to 1.01)	0.91 (0.85 to 0.98)
Medium socioeconomic status	0.83 (0.78 to 0.89)	0.86 (0.83 to 0.88)	0.88 (0.84 to 0.92)	0.92 (0.89 to 0.96)
Low socioeconomic status	0.87 (0.78 to 0.96)	0.77 (0.75 to 0.80)	0.85 (0.81 to 0.88)	0.82 (0.78 to 0.86)
Excluding events that occurred within the first three years of follow-up				
High socioeconomic status	0.78 (0.71 to 0.85)	0.91 (0.87 to 0.95)	0.99 (0.88 to 1.11)	0.94 (0.87 to 1.01)
Medium socioeconomic status	0.83 (0.79 to 0.87)	0.86 (0.84 to 0.88)	0.89 (0.84 to 0.94)	0.94 (0.90 to 0.98)
Low socioeconomic status	0.90 (0.83 to 0.97)	0.80 (0.78 to 0.82)	0.81 (0.77 to 0.85)	0.83 (0.79 to 0.87)
Among individuals aged 40 years or older				
High socioeconomic status	0.79 (0.72 to 0.86)	-	-	-
Medium socioeconomic status	0.80 (0.77 to 0.83)	-	-	-
Low socioeconomic status	0.85 (0.79 to 0.91)	-	-	-

Multiple imputation

High socioeconomic status	0.80 (0.74 to 0.85)	0.89 (0.85 to 0.92)	0.92 (0.85 to 1.00)	0.94 (0.90 to 0.99)
Medium socioeconomic status	0.81 (0.78 to 0.84)	0.84 (0.82 to 0.86)	0.87 (0.82 to 0.92)	0.92 (0.89 to 0.95)
Low socioeconomic status	0.86 (0.82 to 0.91)	0.79 (0.78 to 0.81)	0.80 (0.77 to 0.83)	0.83 (0.79 to 0.86)

Additional inclusion of quadratic terms of age in the model

High socioeconomic status	0.79 (0.73 to 0.86)	0.91 (0.87 to 0.95)	0.99 (0.89 to 1.10)	0.92 (0.86 to 0.98)
Medium socioeconomic status	0.82 (0.78 to 0.85)	0.85 (0.84 to 0.87)	0.88 (0.84 to 0.93)	0.92 (0.89 to 0.96)
Low socioeconomic status	0.87 (0.81 to 0.93)	0.79 (0.77 to 0.81)	0.80 (0.77 to 0.84)	0.83 (0.79 to 0.86)

COPD=chronic obstructive pulmonary disorder; CVD=cardiovascular disease; US NHANES= the US National Health and Nutrition Examination Survey.

*Hazard ratios (95% confidence intervals) associated with each additional healthy lifestyle factor are shown. Socioeconomic status was generated through latent class analysis using the information on family income-to-poverty ratio, occupation, education level, and health insurance in the US NHANES, and household income, education level, and employment status in the UK Biobank. Hazard ratios were adjusted for age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). Only those free from CVD at baseline were included in the analysis for incident CVD. Analysis in US NHANES included the US population and study design weights to account for the complex survey design.

†Hazard ratios associated with one-quintile increase of the weighted healthy lifestyle score.

Supplementary table 10. Joint associations of lifestyles and socioeconomic status with mortality and incident cardiovascular disease: sensitivity analyses*

Analyses	US NHANES	UK Biobank		
	All-cause mortality	All-cause mortality	CVD mortality	Incident CVD
Main analysis	3.53 (3.01 to 4.14)	2.65 (2.39 to 2.94)	2.65 (2.09 to 3.38)	2.09 (1.78 to 2.46)
Weighted lifestyle score†	3.35 (2.83 to 3.95)	2.96 (2.70 to 3.24)	3.08 (2.49 to 3.81)	2.36 (2.04 to 2.72)
Lifestyle score including body mass index	3.49 (2.92 to 4.18)	2.82 (2.44 to 3.27)	2.89 (2.03 to 4.11)	2.35 (1.88 to 2.95)
Excluding individuals with prevalent diabetes, CVD, cancer, chronic bronchitis, emphysema, or COPD	3.88 (3.12 to 4.83)	2.55 (2.24 to 2.91)	2.70 (1.97 to 3.70)	2.04 (1.72 to 2.43)
Excluding events that occurred within the first three years of follow-up	3.38 (2.84 to 4.01)	2.55 (2.28 to 2.86)	2.53 (1.96 to 3.27)	2.08 (1.73 to 2.51)
Among individuals aged 40 years or older	3.46 (2.91 to 4.10)	-	-	-
Multiple imputation	3.65 (3.19 to 4.19)	2.80 (2.54 to 3.09)	2.73 (2.31 to 3.21)	2.03 (1.81 to 2.27)
Additional inclusion of quadratic terms of age in the model	3.49 (2.97 to 4.10)	2.65 (2.39 to 2.94)	2.65 (2.09 to 3.37)	2.10 (1.79 to 2.47)
Using socioeconomic score to investigate more extreme socioeconomic disparity	5.23 (3.57 to 7.67)	4.52 (3.99 to 5.12)	4.18 (3.16 to 5.54)	2.90 (2.36 to 3.58)

COPD=chronic obstructive pulmonary disorder; CVD=cardiovascular disease; US NHANES= the US National Health and Nutrition Examination Survey.

*Hazard ratios (95% confidence intervals) comparing those with low socioeconomic status and 0-1 healthy lifestyle factor versus those with high socioeconomic status and 3-4 healthy lifestyle factors are shown.

Socioeconomic status was generated through latent class analysis using the information on family income-to-poverty ratio, occupation, education level, and health insurance in the US NHANES, and household income, education level, and employment status in the UK Biobank. Hazard ratios were adjusted for age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). Only those free from CVD at baseline were included in the analysis for incident CVD. Analysis in US NHANES included the US population and study design weights to account for the complex survey design.

†Participants were equally divided into three groups according to weighted healthy lifestyle score.

Supplementary table 11. Associations of socioeconomic status with mortality and incident cardiovascular disease and mediation proportion of socioeconomic inequity in health attributed to lifestyle: subgroup analyses*

Subgroups	US NHANES	UK Biobank		
	All-cause mortality	All-cause mortality	CVD mortality	Incident CVD
Females				
HR (95% CI) of model 1	2.00 (1.67 to 2.38)	1.74 (1.60 to 1.90)	2.29 (1.76 to 2.98)	1.64 (1.40 to 1.92)
HR (95% CI) of model 2	1.84 (1.54 to 2.20)	1.73 (1.59 to 1.88)	2.29 (1.76 to 2.98)	1.63 (1.39 to 1.92)
Mediation proportion (%; 95% CI)	12.0 (9.8 to 14.2)	1.1 (0.7 to 1.7)	<1	<1
Males				
HR (95% CI) of model 1	2.59 (2.29 to 2.93)	2.17 (2.04 to 2.31)	2.32 (2.04 to 2.65)	1.72 (1.56 to 1.89)
HR (95% CI) of model 2	2.29 (2.02 to 2.60)	2.09 (1.96 to 2.22)	2.25 (1.98 to 2.56)	1.67 (1.52 to 1.84)
Mediation proportion (%; 95% CI)	12.7 (10.4 to 15.1)	5.4 (4.9 to 6.1)	3.8 (3.1 to 4.6)	4.8 (3.8 to 5.9)
Whites				
HR (95% CI) of model 1	2.34 (2.04 to 2.67)	2.03 (1.93 to 2.13)	2.31 (2.05 to 2.60)	1.69 (1.56 to 1.84)
HR (95% CI) of model 2	2.07 (1.81 to 2.37)	1.97 (1.87 to 2.07)	2.25 (2.00 to 2.53)	1.66 (1.53 to 1.80)
Mediation proportion (%; 95% CI)	14.0 (11.6 to 16.4)	4.0 (3.6 to 4.5)	3.1 (2.6 to 3.7)	3.7 (3.1 to 4.5)
Non-whites				
HR (95% CI) of model 1	2.71 (2.22 to 3.31)	1.77 (1.32 to 2.36)	2.48 (1.30 to 4.73)	1.43 (0.97 to 2.10)
HR (95% CI) of model 2	2.50 (2.04 to 3.08)	1.74 (1.30 to 2.32)	2.44 (1.28 to 4.65)	1.40 (0.95 to 2.06)
Mediation proportion (%; 95% CI)	7.9 (5.7 to 10.1)	3.0 (1.4 to 6.2)	1.8 (0.5 to 6.4)	4.9 (1.3 to 16.2)
60 years or older				
HR (95% CI) of model 1	1.83 (1.62 to 2.06)	1.78 (1.66 to 1.91)	1.98 (1.69 to 2.33)	1.62 (1.43 to 1.85)
HR (95% CI) of model 2	1.65 (1.46 to 1.86)	1.75 (1.63 to 1.88)	1.95 (1.66 to 2.28)	1.61 (1.41 to 1.83)
Mediation proportion (%; 95% CI)	17.2 (14.1 to 20.4)	3.2 (2.5 to 4.1)	2.6 (1.9 to 3.6)	2.1 (1.5 to 3.0)
Less than 60 years				
HR (95% CI) of model 1	3.20 (2.65 to 3.87)	2.38 (2.21 to 2.56)	2.88 (2.42 to 3.42)	1.74 (1.56 to 1.95)
HR (95% CI) of model 2	2.74 (2.27 to 3.31)	2.28 (2.12 to 2.45)	2.77 (2.33 to 3.29)	1.68 (1.50 to 1.88)
Mediation proportion (%; 95% CI)	13.4 (11.1 to 15.8)	4.7 (4.2 to 5.3)	3.9 (3.0 to 5.0)	6.4 (5.1 to 8.0)

CI=confidence interval; CVD=cardiovascular disease; HR=hazard ratio; US NHANES= the US National Health and Nutrition Examination Survey.

*Socioeconomic status was generated through latent class analysis using the information on family income-to-poverty ratio, occupation, education level, and health insurance in the US NHANES, and household income, education level, and employment status in the UK Biobank. Only the results comparing the low with high socioeconomic status are reported. Model 1 included all individual socioeconomic factors, as well as age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). Model 2 additionally included the healthy lifestyle score consisting of never smoking, no heavy alcohol drinking, higher physical activity level, and a higher diet quality score. Analysis in US NHANES included the US population and study design weights to account for the complex survey design.

Supplementary table 12. Joint associations of lifestyles and socioeconomic status with mortality and incident cardiovascular disease: subgroup analyses*

Subgroups	US NHANES	UK Biobank		
	All-cause mortality	All-cause mortality	CVD mortality	Incident CVD
Sex				
Females	2.85 (2.22 to 3.66)	2.18 (1.85 to 2.57)	2.58 (1.57 to 4.23)	2.15 (1.57 to 2.95)
Males	4.06 (3.35 to 4.93)	2.96 (2.59 to 3.39)	2.70 (2.05 to 3.55)	2.10 (1.74 to 2.54)
<i>P</i> for interaction†	0.003	0.011	0.64	0.21
Race				
Whites	3.63 (2.99 to 4.42)	2.66 (2.39 to 2.95)	2.55 (2.01 to 3.25)	2.06 (1.75 to 2.43)
Non-whites	4.31 (3.05 to 6.09)	2.44 (1.34 to 4.46)	-‡	2.56 (1.07 to 6.16)
<i>P</i> for interaction†	0.24	0.38	0.89	0.22
Age groups				
≥60 years	2.51 (2.05 to 3.08)	2.40 (2.05 to 2.82)	1.91 (1.38 to 2.65)	2.27 (1.68 to 3.05)
<60 years	5.34 (4.07 to 7.01)	3.12 (2.72 to 3.59)	3.97 (2.77 to 5.68)	2.14 (1.75 to 2.61)
<i>P</i> for interaction†	<0.001	<0.001	<0.001	0.83

US NHANES= the US National Health and Nutrition Examination Survey.

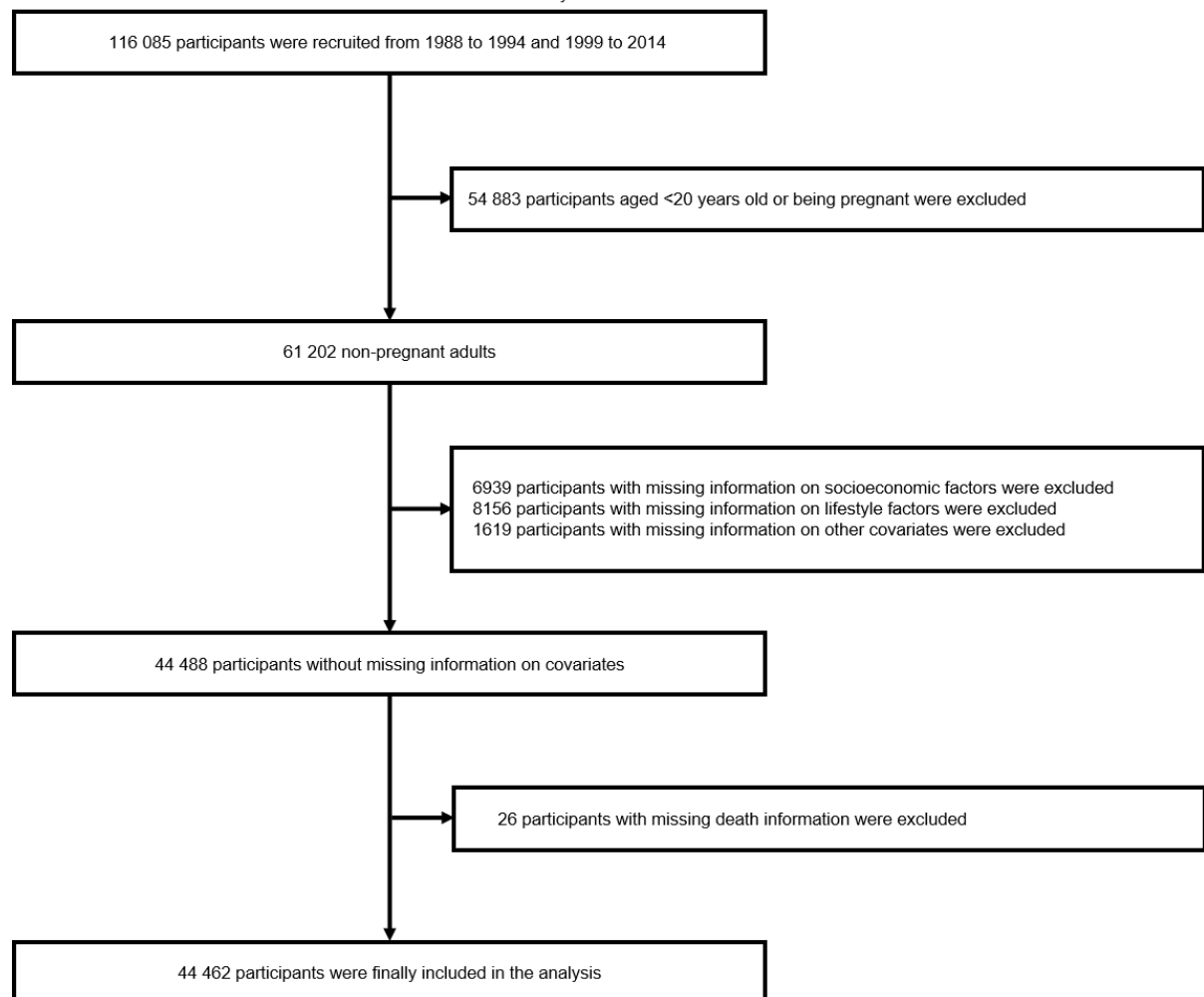
*Hazard ratios (95% confidence intervals) comparing those with low socioeconomic status and 0-1 healthy lifestyle factor versus those with high socioeconomic status and 3-4 healthy lifestyle factors are shown. Socioeconomic status was generated through latent class analysis using the information on family income-to-poverty ratio, occupation, education level, and health insurance in the US NHANES, and household income, education level, and employment status in the UK Biobank. Only the results comparing the low with high socioeconomic status are reported. Hazard ratios were adjusted for age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). For incident cardiovascular disease, only those free from cardiovascular disease at baseline were included. Analysis in US NHANES included the US population and study design weights to account for the complex survey design.

†*P* for interaction indicated the difference of hazard ratio comparing those with low socioeconomic status and 0-1 healthy lifestyle factor versus those with high socioeconomic status and 3-4 healthy lifestyle factors between two subgroups was statistically significant or not.

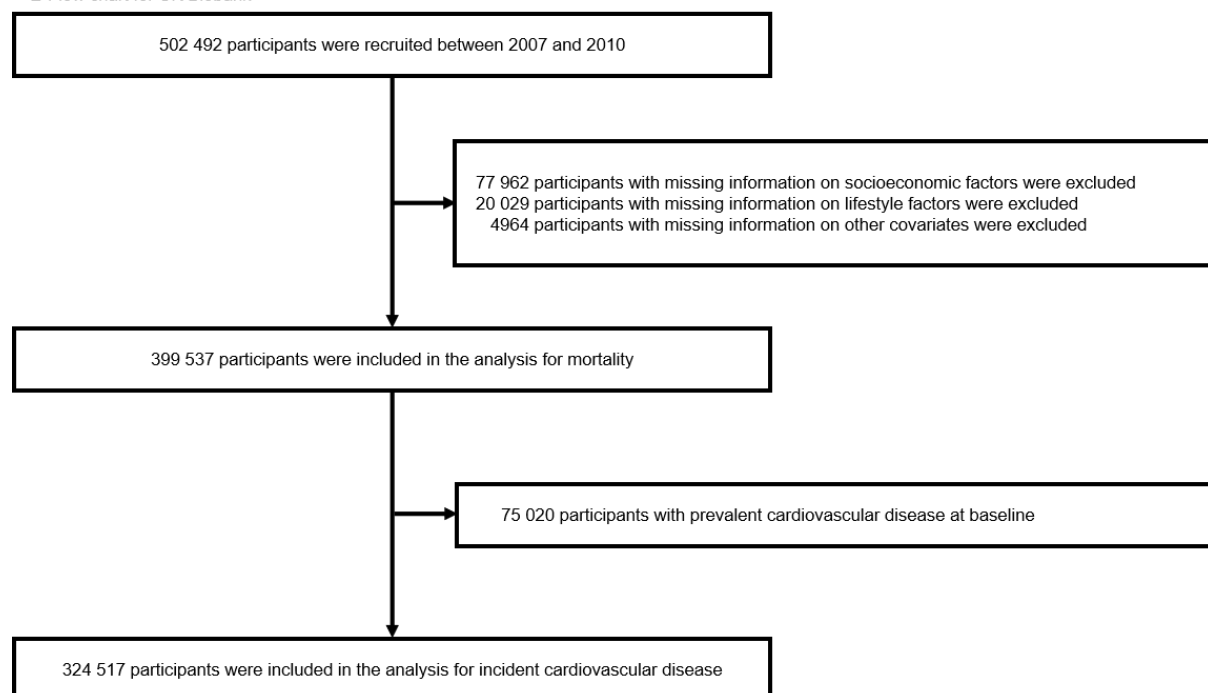
‡Data is not shown since limited events in extreme groups.

Supplementary fig 1. Flowchart of the study

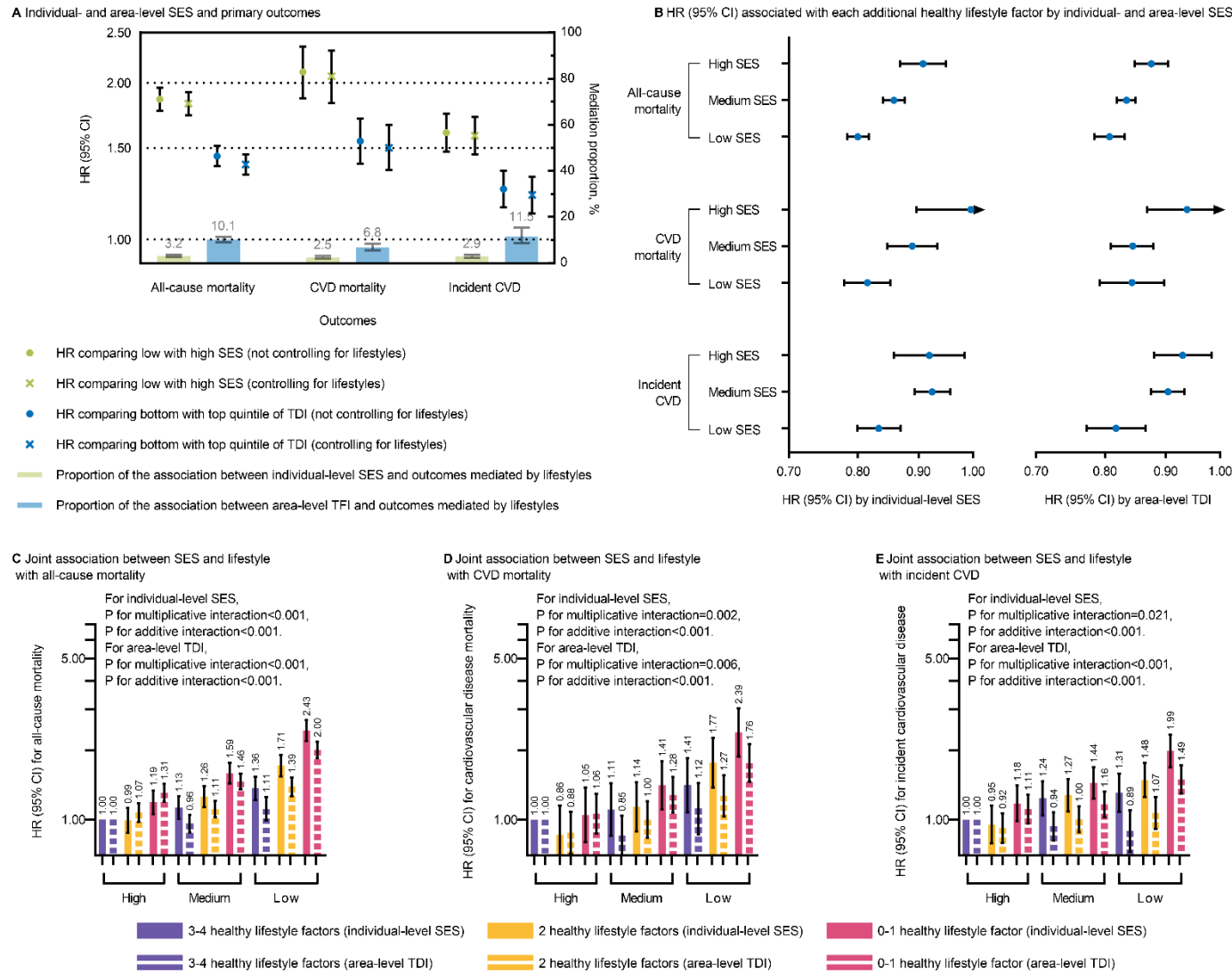
A Flow chart for US National Health and Nutrition Examination Survey



B Flow chart for UK Biobank



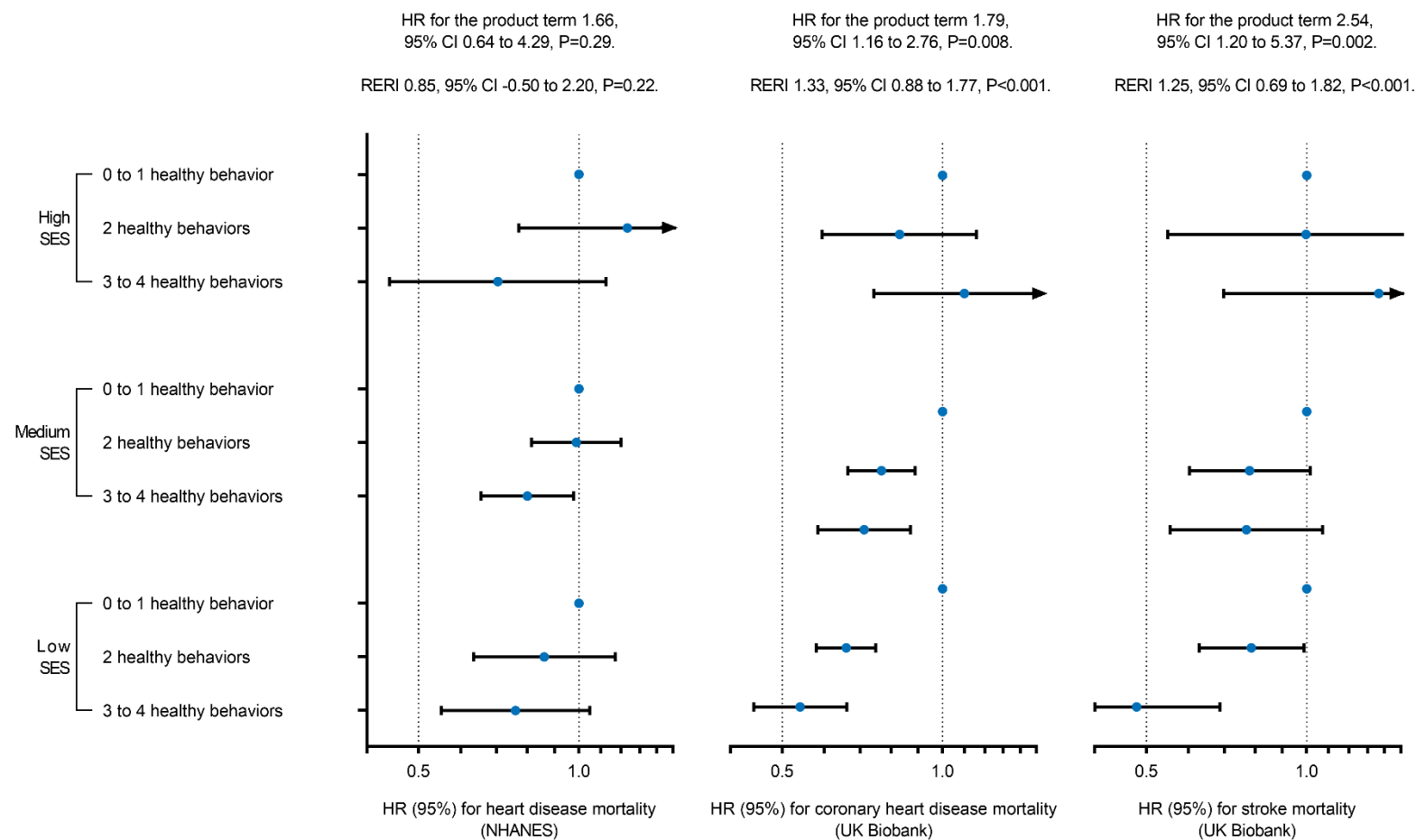
Supplementary fig 2. Individual-level socioeconomic status, Townsend Deprivation Index, lifestyles, and primary outcomes in the UK Biobank



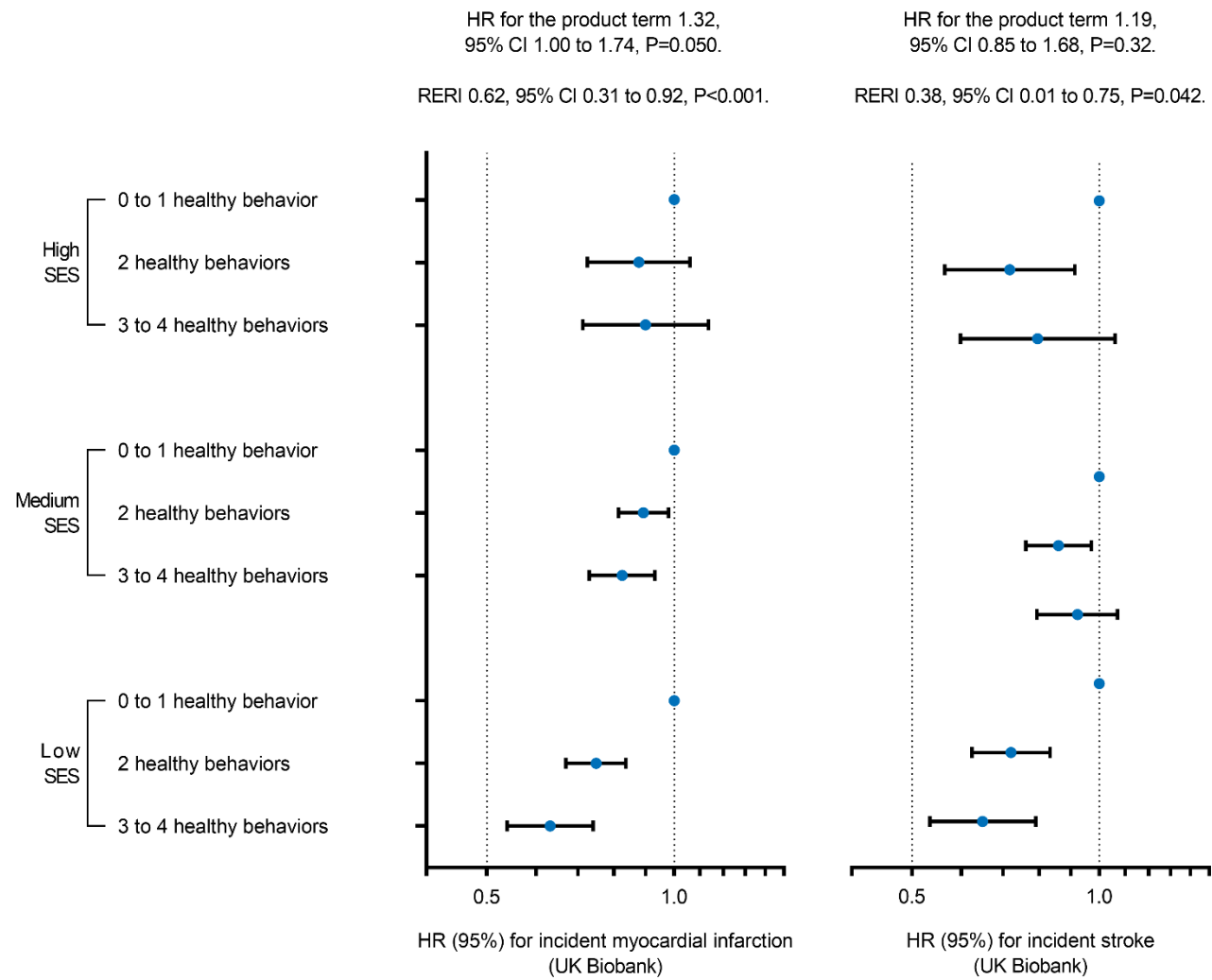
Hazard ratios (HRs) were adjusted for age, sex, self-reported race, acculturation, study center, body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic obstructive pulmonary disorder). Individual-level socioeconomic status (SES) and Townsend deprivation index (TDI) were adjusted for each other. For incident cardiovascular disease, only those free from cardiovascular disease at baseline were included.

Supplementary fig 3. Associations of the healthy lifestyle score with mortality and morbidity for cardiovascular disease subtypes by socioeconomic status

A Mortality from heart disease, coronary heart disease, and stroke



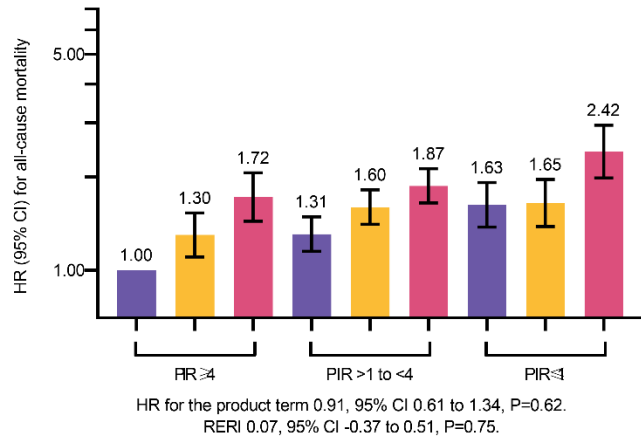
B Incident myocardial infarction and stroke



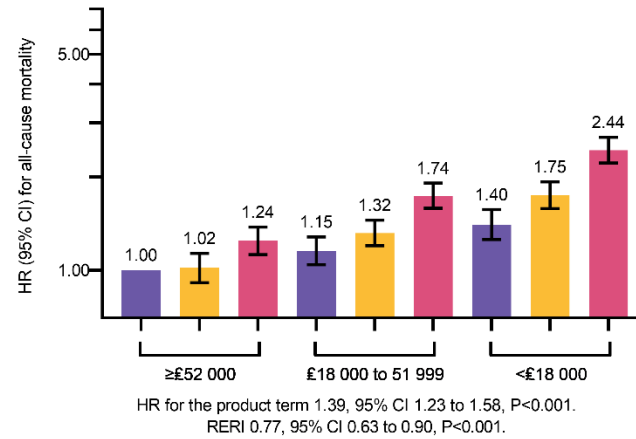
In the US National Health and Nutrition Examination Survey (US NHANES), models included US population and study design weights to account for the complex survey design. Hazard ratios (HRs) were adjusted for age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary disorder). Only those free from cardiovascular disease at baseline were included in the analysis for incident myocardial infarction and stroke. Error bars indicate 95% confidence intervals (CIs). Multiplicative interaction was evaluated using HR for the product term between the healthy lifestyle score (0-1 point versus 3-4 points) and socioeconomic status (low versus high), and the multiplicative interaction was statistically significant when its CI did not include 1. Additive interaction was evaluated using relative excess risk due to interaction (RERI) between the healthy lifestyle score (0-1 point versus 3-4 points) and socioeconomic status (low versus high), and the additive interaction was statistically significant when its CI did not include 0.

Supplementary fig 4. Joint associations of the healthy lifestyle score and individual socioeconomic factors with mortality and incident cardiovascular disease

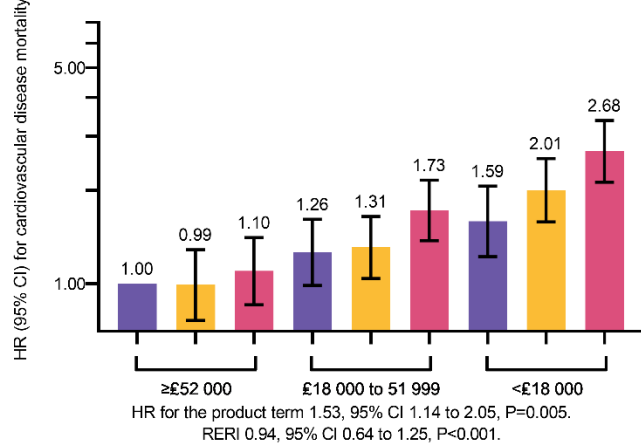
A Family poverty-to-income ratio (PIR) and all-cause mortality in NHANES



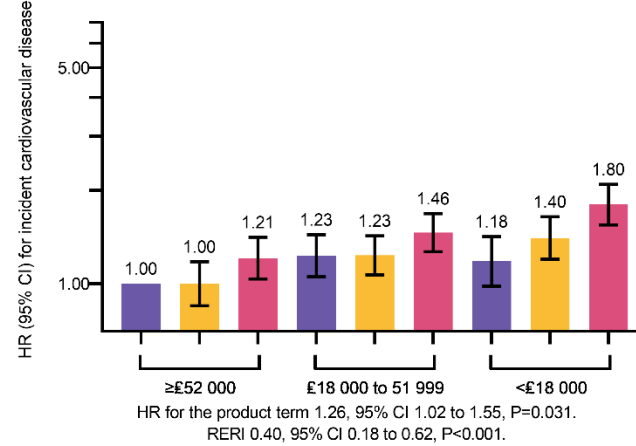
B Household income and all-cause mortality in UK Biobank



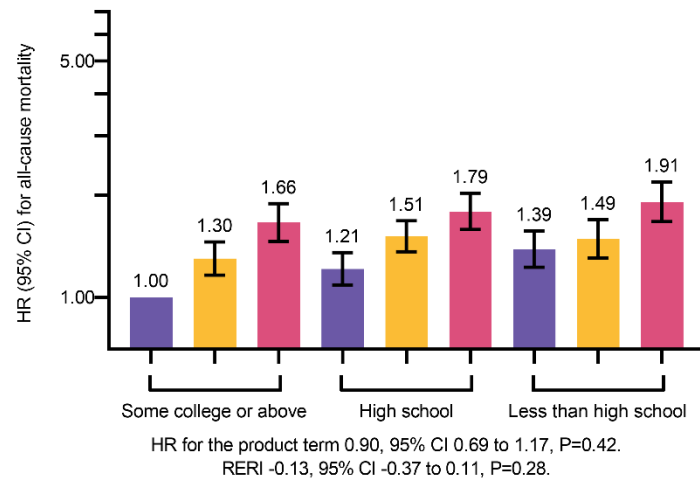
C Household income and cardiovascular disease mortality in UK Biobank



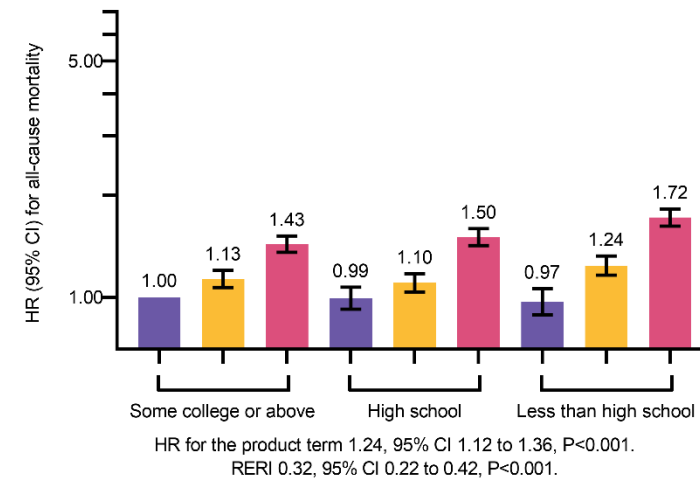
D Household income and incident cardiovascular disease in UK Biobank



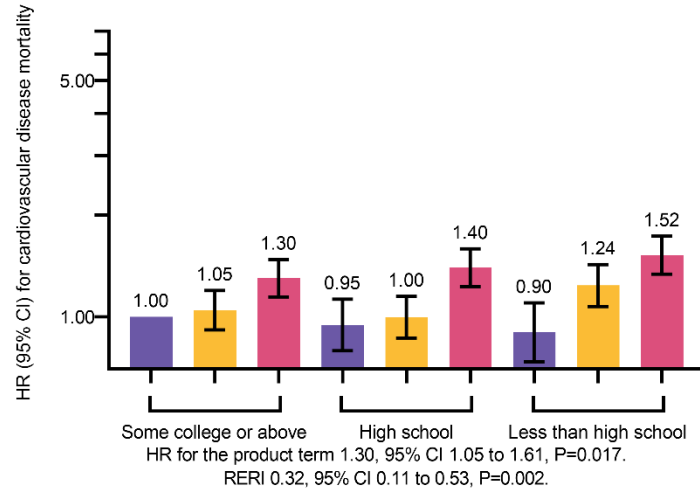
E Education and all-cause mortality in NHANES



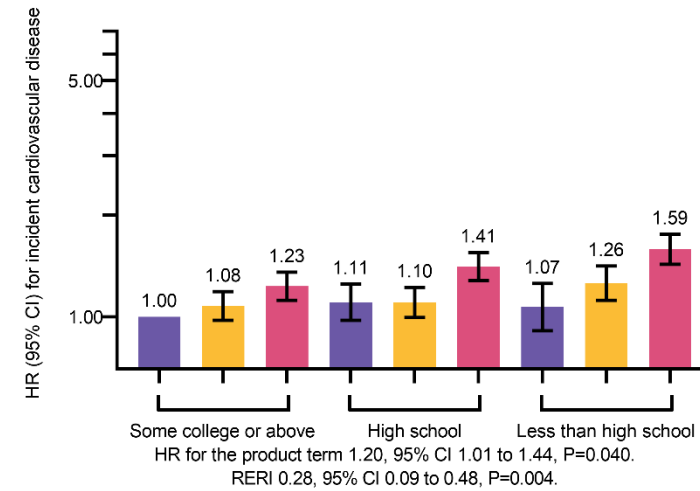
F Education and all-cause mortality in UK Biobank



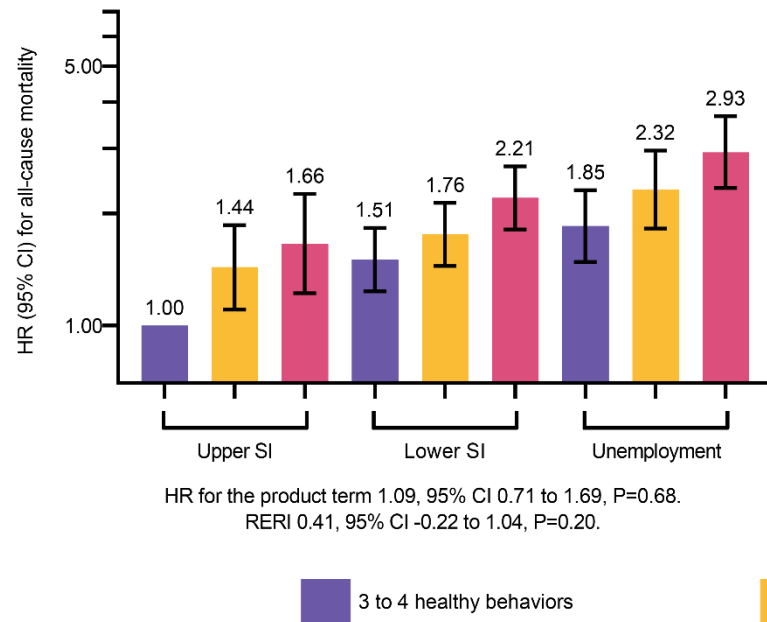
G Education and cardiovascular disease mortality in UK Biobank



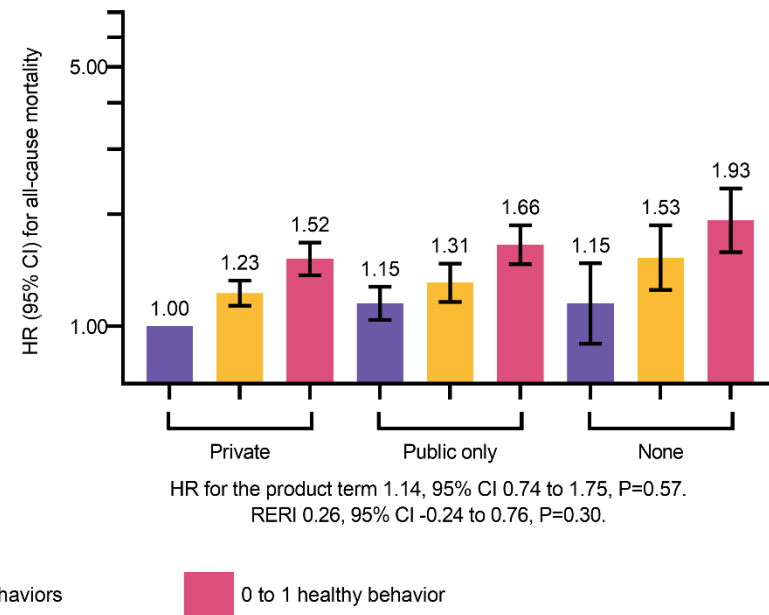
H Education and incident cardiovascular disease in UK Biobank



I Occupation and all-cause mortality in NHANES



J Health insurance and all-cause mortality in NHANES



In the US National Health and Nutrition Examination Survey (NHANES), models included US population and study design weights to account for the complex survey design. Hazard ratios (HRs) were adjusted for other socioeconomic factors, age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic obstructive pulmonary disorder). For incident cardiovascular disease and cancer, only those free from cardiovascular disease and cancer at baseline were included. Error bars indicate 95% confidence intervals (CIs). Multiplicative interaction was evaluated using HR for the product term between the healthy lifestyle score (0-1 point versus 3-4 points) and socioeconomic status (low versus high). Additive interaction was evaluated using relative excess risk due to interaction (RERI) between the healthy lifestyle score (0-1 point versus 3-4 points) and each socioeconomic factor (low versus high level). SI=socioeconomic index

Supplementary fig 5. Associations of the healthy lifestyle score with mortality and incident cardiovascular disease by socioeconomic status: subgroup analyses

A By sex

- Men
- Women

For men, HR for the product term 0.83,
95% CI 0.60 to 1.17, P=0.28.
RERI 0.58, 95% CI -0.27 to 1.44, P=0.18.

For men, HR for the product term 1.41,
95% CI 1.18 to 1.68, P<0.001.
RERI 1.04, 95% CI 0.85 to 1.24, P<0.001.

For men, HR for the product term 1.37,
95% CI 0.96 to 1.96, P=0.08.
RERI 0.84, 95% CI 0.46 to 1.22, P<0.001.

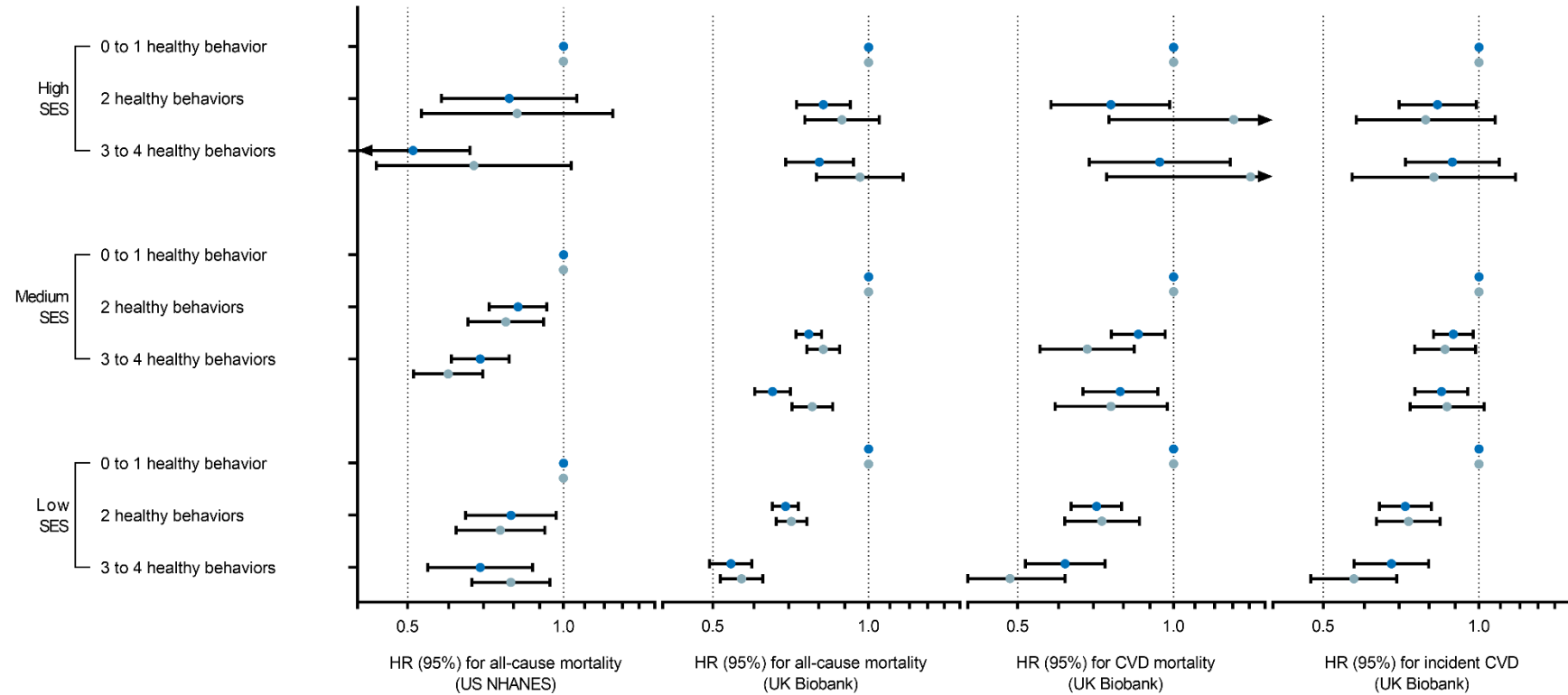
For men, HR for the product term 1.21,
95% CI 0.93 to 1.58, P=0.15.
RERI 0.45, 95% CI 0.15 to 0.76, P=0.004.

For women, HR for the product term 0.96,
95% CI 0.62 to 1.48, P=0.84.
RERI 0.35, 95% CI -0.40 to 1.09, P=0.36.

For women, HR for the product term 1.68,
95% CI 1.36 to 2.08, P<0.001.
RERI 0.90, 95% CI 0.71 to 1.08, P<0.001.

For women, HR for the product term 2.97,
95% CI 1.51 to 5.86, P=0.00.
RERI 1.65, 95% CI 1.06 to 2.23, P<0.001.

For women, HR for the product term 1.50,
95% CI 1.00 to 2.25, P=0.051.
RERI 0.75, 95% CI 0.37 to 1.14, P<0.001.



B By self-reported race

- Whites
- Non-whites

For whites, HR for the product term 0.93, 95% CI 0.70 to 1.23, P=0.60.
RERI 0.62, 95% CI -0.06 to 1.29, P=0.072.

For non-whites, HR for the product term 0.58, 95% CI 0.34 to 0.97, P=0.040.
RERI -0.32, 95% CI -1.52 to 0.88, P=0.60.

For whites, HR for the product term 1.54, 95% CI 1.35 to 1.77, P<0.001.
RERI 1.02, 95% CI 0.88 to 1.15, P<0.001.

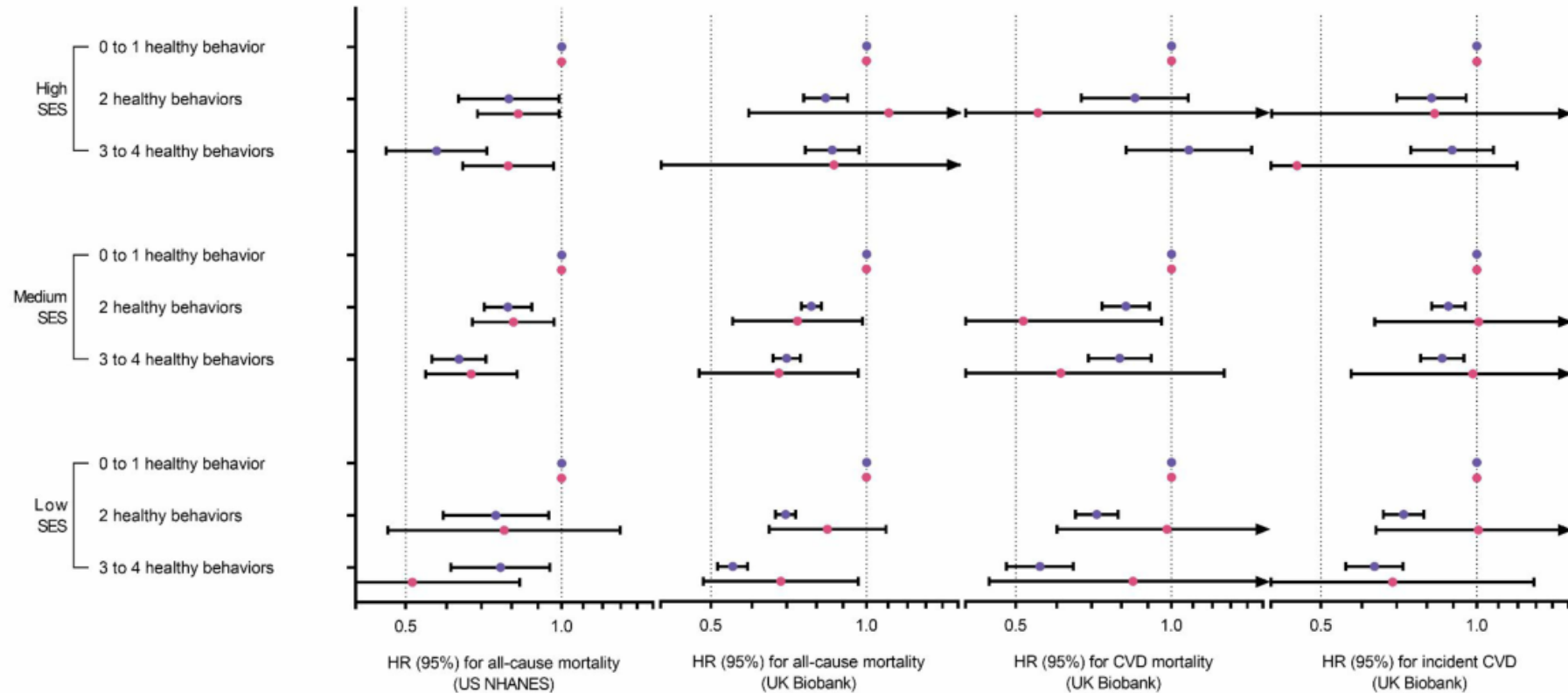
For non-whites, HR for the product term 1.32, 95% CI 0.59 to 2.97, P=0.50.
RERI 0.68, 95% CI -0.18 to 1.54, P=0.12.

For whites, HR for the product term 1.75, 95% CI 1.28 to 2.39, P<0.001.
RERI 1.10, 95% CI 0.81 to 1.38, P<0.001.

For non-whites, P for the product term=0.98.
P for RERI >0.99.

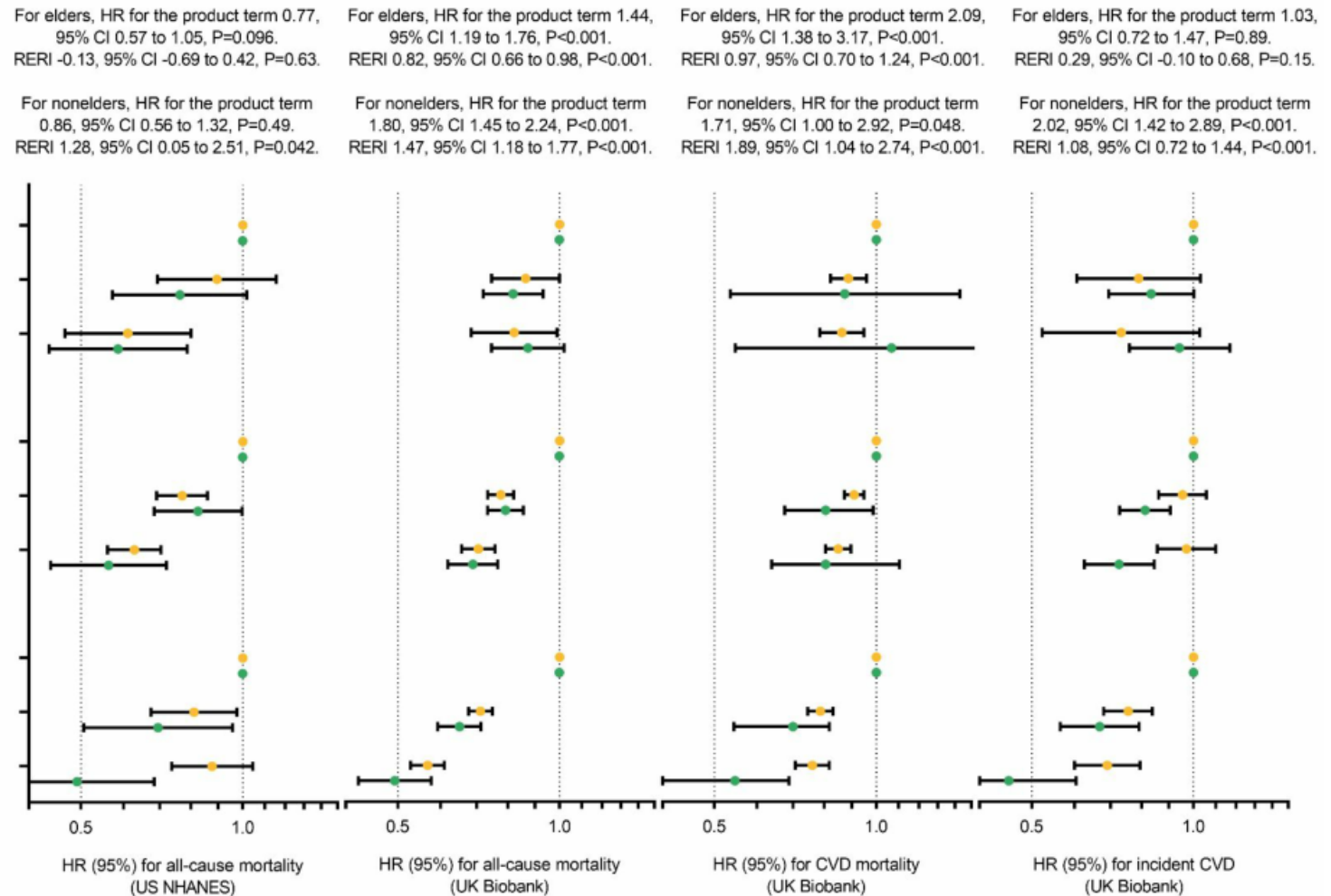
For whites, HR for the product term 1.33, 95% CI 1.07 to 1.66, P=0.011.
RERI 0.57, 95% CI 0.34 to 0.80, P<0.001.

For non-whites, HR for the product term 0.70, 95% CI 0.23 to 2.17, P=0.54.
RERI -0.28, 95% CI -2.21 to 1.66, P=0.78.



C By age group

- Elders (aged 60 years or above)
- Nonelders (aged <60 years)



In the US National Health and Nutrition Examination Survey (US NHANES), models included US population and study design weights to account for the complex survey design. Hazard ratios (HRs) were adjusted for age, sex, marital status (US NHANES only), self-reported race, acculturation, study center (UK Biobank only), body mass index, and prevalent comorbidities (including hypertension, diabetes, cardiovascular disease, cancer, and chronic bronchitis, emphysema, or chronic obstructive pulmonary

disorder). Only those free from cardiovascular disease at baseline were included in the analysis for incident cardiovascular disease. Error bars indicate 95% confidence intervals (CIs). Multiplicative interaction was evaluated using HR for the product term between the healthy lifestyle score (0-1 point versus 3-4 points) and socioeconomic status (low versus high), and the multiplicative interaction was statistically significant when its CI did not include 1. Additive interaction was evaluated using relative excess risk due to interaction (RERI) between the healthy lifestyle score (0-1 point versus 3-4 points) and socioeconomic status (low versus high), and the additive interaction was statistically significant when its CI did not include 0.