

APPENDIX 1. ASSESSMENT OF LIFESTYLE FACTORS

At baseline and every 2 years, participants returned a mailed validated questionnaire that obtained updated information on age, body weight, smoking status, physical activity, aspirin and other medications use, multivitamin use, menopausal status and postmenopausal hormone use in women, and physician diagnosis of chronic diseases. Baseline histories of hypertension, hypercholesterolemia, and type 2 diabetes mellitus were determined through self-reporting. Self-reported smoking status and the number of cigarettes smoked were updated biennially. BMI was calculated as weight in kilograms divided by the square of the height in meters. These self-reported measures have demonstrated validity in these cohorts: among a sample of 123 men in the Health Professional's Follow-up Study (HPFS) and 140 women in the Nurses' Health Study (NHS), Pearson correlations coefficients between self-reported weight and technician-measured weight were 0.97.¹

Participants reported in the questionnaire the average time spent per week in the previous year on specific leisure-time physical activities, including brisk walking, jogging, running, lap swimming, tennis/squash/racquetball, rowing, etc., by choosing 1 of the 10 different duration options, ranging from 0 to ≥ 11 h/wk. The validity and the reproducibility of these measurements have been previously reported.^{2,3}

Diet and alcohol information was assessed every 4 years using a validated food frequency questionnaire asking the frequency, on average, a participant had consumed a particular amount of a specific type of food during the previous year.⁴ The intake of nutrients was computed by multiplying the frequency of consumption of each unit of food by its nutrient content. Quality of diet was assessed using the Alternate Healthy Eating Index (AHEI) score. The AHEI score is based on 11 foods and nutrients predictive of chronic disease risk, emphasizing higher intake of vegetables (excluding potatoes), fruits, whole grains, nuts and legumes, long chain (n-3) fats, and polyunsaturated fatty acids; moderate intake of alcohol; and lower intake of sugar sweetened drinks and fruit juice, red and processed meats, trans fat, and sodium. Each component was scored from 0 (unhealthiest) to 10 (healthiest) points, with intermediate values scored proportionally. All component scores were summed to obtain a total score ranging from 0 (non-adherence) to 110 (best adherence) points.

The food frequency questionnaire also collected alcoholic beverage consumption, including red and white wine separately, beer, and liquor. The amount of alcohol in grams per specified portion size was multiplied by servings per day, the midpoint of the frequency category was determined, and this was summed across all beverages to estimate the average alcohol consumption (g/day).

Information on habitual sleep duration was collected several times during the follow-up questionnaires in both NHS (1986, 2000, 2002, 2008, and 2012) and HPFS (1987, 2000, 2008, and 2012). Participants reported their average sleep duration over a 24-h period with the following categories: 5 or less, 6, 7, 8, 9, 10, or more than 11 hours. To aid recall, participants simultaneously reported their employment status, work schedules, and frequency of rotating night shifts in each period. In a subset of 54,021 women participating in The Nurses' Health Study 2 who also reported their current sleep duration in 2001, the reliability of recalled sleep duration was evaluated in 2009 by comparison with prospectively assessed sleep duration in

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2001. For each participant, sleep duration reported in 2001 was compared with sleep duration recalled in 2009 for a specific age period corresponding to her age in 2001. The intraclass correlation coefficient between the 2 measurements was 0.52 (95% CI 0.51, 0.53), suggesting moderate reproducibility of recalled sleep duration.⁵ Self-reported sleep duration has a correlation of 0.79 ($p < 0.001$) with sleep duration recorded in sleep diaries in a previous validation study.⁶

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Appendix Table 1. Healthy Lifestyle Score Including Sleep Duration

Health factor	Definition of low-risk
Smoking	Not currently smoking
Physical activity	≥3.5 hours/week or 30 minutes/day of moderate to vigorous physical activity
Alternative Healthy Eating Index -2010	Top 40% of the diet quality score Alternative Healthy Eating Index-2010
BMI	18.5–24.9 kg/m ²
Alcohol intake	5–14.9 g/day for women and 5–30 g/day for men
Sleep duration	≥6 to <8 hours/day
Traditional lifestyle score	5 points
Traditional lifestyle score + sleep (healthy lifestyle score including sleep duration)	6 points

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Appendix Table 2. Baseline Characteristics According to Sleep Duration Categories

Variable	Sleep duration hours/day			
	<6 hours/day	≥6 to <8 hours/day	≥8 to <9 hours/day	≥9 hours/day
Nurses' Health Study				
n (%)	20,151 (29.9)	43,929 (65.3)	2,734 (4.1)	436 (0.7)
Age, years	46.4 (7)	46.3 (7.2)	46.9 (7.4)	47.5 (7)
BMI, kg/m ²	25.9 (5.1)	25.2 (4.5)	25.7 (5)	26.5 (5.5)
AHEI	46.8 (10.6)	47 (10.6)	46.1 (10.7)	44.4 (10.9)
Physical activity, hours/week	1.9 (3.5)	1.9 (3.3)	1.6 (2.8)	1.2 (2.7)
Alcohol intake, g/day	5.5 (10.1)	6.3 (10.7)	7.6 (13.2)	9 (16.8)
White, %	96.5	98.4	98.8	98.6
Multivitamin use, %	42.2	42.7	44.4	36.6
Aspirin use, %	66.4	68.4	66.1	66.6
Baseline high blood pressure, %	17.5	15.4	18.9	22.8
Baseline high blood cholesterol, %	13.4	12.8	14.5	14.9
Baseline diabetes, %	4.3	3.6	5.7	7.4
Family history of diabetes, %	31.3	29.4	30.9	33.6
Family history of cancer, %	14.4	15.0	14.9	15.6
Family history of myocardial infarction, %	26.8	25.2	25.4	29.7
Smoking, current%	22.8	19.6	20.7	24.6
Sleep, hours/day	4.9 (0.2)	6.4 (0.5)	8 (0)	9.1 (0.3)
Health Professionals Follow-up Study				
n (%)	609 (2.1)	19,569 (67.2)	7,488 (25.7)	1,448 (5)
Age, years	57 (10.3)	54.1 (9.4)	56.3 (9.9)	60.8 (10)
BMI, kg/m ²	25.9 (3.5)	25.2 (3)	25.3 (3)	25.6 (3.2)
AHEI	47.3 (10.8)	47.5 (11)	46.4 (10.8)	45.8 (11.1)
Physical activity, hours/week	3 (4.6)	2.9 (4.2)	2.7 (4.2)	2.3 (3.7)
Alcohol intake, g/day	10.6 (17)	10.9 (14.6)	12.8 (16.6)	15.9 (19.8)
White, %	90.9	94.4	95.7	95.5
Multivitamin use, %	64.0	62.7	60.5	59.3
Aspirin use, %	29.4	30.2	30.2	31.9
Baseline high blood pressure, %	31.0	24.2	25.6	32.2
Baseline high blood cholesterol, %	16.7	12.8	11.9	14.9
Baseline diabetes, %	4.4	2.6	3.1	4.3
Family history of myocardial infarction, %	31.8	34.1	33.1	32.5
Family history of cancer, %	39.7	36.9	36.7	39.4
Family history of diabetes, %	28.9	24.5	24.3	23.5
Smoking, current%	31.8	34.1	33.1	32.5
Sleep, hours/day	5 (0)	6.7 (0.5)	8 (0)	9.1 (0.4)

Notes: Values are means (SD) for continuous variables; percentages for categorical variables, and are standardized to the age distribution of the study population.

AHEI, Alternative Healthy Eating Index-2010.

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Appendix Table 3. Hazard Ratios (95% CI) of CVD, CHD, and Stroke Incidence According to Individual Lifestyle Factors, Data From Both Cohorts Combined

Variable	CVD		CHD		Stroke	
	Cases/ Person-Years	HR (95% CI)	Cases/ Person-Years	HR (95% CI)	Cases/ Person-Years	HR (95% CI)
Cigarette smoking						
Never	4,353/1,247,921	1.00 (ref)	2,721/1,249,857	1.00 (ref)	1,689/1,249,933	1.00 (ref)
Past	6,214/1,257,188	1.27 (1.22, 1.32)	4,139/1,259,383	1.33 (1.27, 1.40)	2,137/1,259,928	1.16 (1.09, 1.24)
Current 1–14/day	508/111,259	1.61 (1.47, 1.77)	324/111,423	1.64 (1.46, 1.84)	206/111,418	1.64 (1.42, 1.90)
Current ≥15/day	635/137,670	2.23 (2.05, 2.42)	425/137,806	2.25 (2.03, 2.50)	231/137,846	2.05 (1.78, 2.35)
Alcohol consumption, g/day						
0	5,538/1,073,380	1.43 (1.35, 1.51)	3,509/1,075,624	1.53 (1.44, 1.64)	2,114/1,075,734	1.28 (1.17, 1.40)
1–4.9	2,561/725,943	1.17 (1.11, 1.25)	1,761/726,757	1.26 (1.18, 1.36)	847/727,151	1.01 (0.91, 1.11)
5–14.9	1,930/542,898	1.00 (ref)	1,273/543,594	1.00 (ref)	684/543,765	1.00 (ref)
15–29.9	905/248,296	0.90 (0.83, 0.98)	562/248,696	0.84 (0.76, 0.93)	343/248,706	1.00 (0.88, 1.14)
≥30	776/163,522	1.09 (1.00, 1.18)	504/163,798	1.03 (0.93, 1.14)	275/163,770	1.20 (1.05, 1.39)
Physical activity, hours/week						
0	6,024/1,053,113	1.00 (ref)	3,785/1,055,335	1.00 (ref)	2,296/1,055,373	1.00 (ref)
0.1–0.9	1,544/371,872	0.89 (0.84, 0.94)	1,019/372,437	0.89 (0.83, 0.96)	564/372,539	0.89 (0.81, 0.97)
1.0–2.5	1,518/410,799	0.80 (0.75, 0.84)	1,023/411,437	0.79 (0.74, 0.85)	524/411,633	0.79 (0.72, 0.87)
2.6–5	1,168/405,655	0.63 (0.59, 0.67)	783/406,126	0.62 (0.58, 0.67)	406/406,247	0.64 (0.58, 0.72)
>5	1,456/512,600	0.56 (0.53, 0.59)	999/513,134	0.55 (0.51, 0.59)	473/513,333	0.58 (0.52, 0.64)
BMI, kg/m ²						
18.5–22.9	2,761/719,061	1.04 (0.98, 1.10)	1,600/720,383	1.00 (0.92, 1.07)	1,175/720,298	1.09 (0.99, 1.19)
22.9–24.9	1,982/538,150	1.00 (ref)	1,294/538,913	1.00 (ref)	724/539,071	1.00 (ref)
25–29.9	3,840/934,998	1.16 (1.10, 1.23)	2,489/936,418	1.16 (1.08, 1.24)	1,411/936,886	1.16 (1.06, 1.27)
30.0–34.9	1,363/335,477	1.36 (1.27, 1.46)	873/336,046	1.40 (1.28, 1.53)	521/336,066	1.30 (1.16, 1.45)
≥35	641/145,909	1.72 (1.57, 1.88)	436/146,102	1.93 (1.72, 2.15)	226/146,181	1.45 (1.25, 1.69)
AHEI						
Quintile 1	2,714/542,484	1 (ref)	1,717/543,379	1.00 (ref)	996/543,500	1.00 (ref)
Quintile 2	2,464/548,294	0.91 (0.86, 0.96)	1,561/549,240	0.89 (0.83, 0.96)	930/549,268	0.95 (0.87, 1.04)
Quintile 3	2,429/551,612	0.91 (0.86, 0.96)	1,600/552,554	0.91 (0.85, 0.98)	883/552,710	0.92 (0.84, 1.01)
Quintile 4	2,133/554,660	0.80 (0.75, 0.85)	1,415/555,493	0.79 (0.74, 0.85)	754/555,634	0.81 (0.73, 0.89)
Quintile 5	1,970/556,989	0.75 (0.70, 0.79)	1,316/557,804	0.74 (0.69, 0.79)	700/558,013	0.77 (0.69, 0.84)
Sleep duration, hours/day						
<6	1,310/338,151	1.29 (1.22, 1.38)	837/338,595	1.33 (1.23, 1.43)	511/338,707	1.23 (1.12, 1.36)
≥6 to <8	6,045/1,593,168	1.00 (ref)	4,076/1,614,632	1.00 (ref)	2,125/1,615,256	1.00 (ref)
≥8 to <9	2,826/598,359	0.96 (0.92, 1.00)	1,846/599,407	0.93 (0.88, 0.99)	1,008/599,606	1.02 (0.95, 1.11)
≥9	1,529/224,361	1.13 (1.07, 1.20)	913/225,177	1.02 (0.95, 1.10)	628/224,959	1.36 (1.25, 1.49)

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Notes: Multivariable-adjusted HR was adjusted for age; ethnicity; current multivitamin use; current aspirin use; family history of diabetes mellitus, myocardial infarction, or cancer; and menopausal status and hormone use (women only). Results for Nurses' Health Study and Health Professionals Follow-up Study pooled and stratified by cohort.

AHEI, Alternative Healthy Eating Index; CHD, coronary heart disease; CVD, cardiovascular disease; HR, hazard ratio.

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Appendix Table 4. Area Under the Curve (AUC), Net Reclassification Improvement (NRI) and Integrated Discrimination Improvement (IDI) of the Risk Prediction Models for CVD

Variable	Traditional lifestyle score ^a	Traditional lifestyle score and sleep duration ^b	
	Values (95% CI)	Values (95% CI)	<i>p</i> -value
AUC	0.64 (0.63, 0.64)	0.65 (0.64, 0.65)	<0.0001
NRI			
Category-free NRI (%)	ref	15 (13.3, 16.8)	<0.0001
% of events correctly reclassified	–	26	
% of non-events correctly reclassified	–	41	
IDI	ref	0.00017 (0.0001, 0.0002)	<0.0001

Notes: Low-risk factors in the score included cigarette smoking (not smoking), physically active (≥ 3.5 hours/week of moderate to vigorous intensity activity), high diet quality (top 40% of Alternate Healthy Eating Index), moderate alcohol intake of 5 to 14.9 g/day (women) or 5 to 30 g/day (men), normal weight (BMI, 18.5–24.9 kg/m²), and sleep duration (≥ 6 to < 8 hours/day). Traditional lifestyle score included all factors except sleep duration. Results for Nurses' Health Study and Health Professionals Follow-up Study pooled and stratified by cohort.

^aTraditional lifestyle score included age, and the traditional lifestyle score.

^bTraditional lifestyle score and sleep duration included age, the traditional lifestyle score, and sleep duration.

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Appendix Table 5. Hazard Ratios (95% CI) of CVD Incidence Stratified by Age and History of Diseases

Number of low-risk factors^a	Age <65 years	Age ≥65 years
None	1.00 (ref)	1.00 (ref)
1	0.60 (0.47, 0.75)	0.83 (0.65, 1.07)
2	0.45 (0.36, 0.56)	0.71 (0.55, 0.91)
3	0.38 (0.30, 0.47)	0.61 (0.48, 0.79)
≥4	0.27 (0.22, 0.34)	0.47 (0.37, 0.61)
	No history of diabetes	History of diabetes
None	1.00 (ref)	1.00 (ref)
1	0.71 (0.59, 0.84)	0.50 (0.31, 0.78)
2	0.58 (0.48, 0.69)	0.45 (0.29, 0.71)
3	0.50 (0.42, 0.60)	0.40 (0.25, 0.62)
≥4	0.39 (0.32, 0.46)	0.32 (0.20, 0.50)
	No history of hypertension	History of hypertension
None	1.00 (ref)	1.00 (ref)
1	0.70 (0.52, 0.94)	0.66 (0.54, 0.81)
2	0.54 (0.40, 0.72)	0.56 (0.46, 0.69)
3	0.43 (0.33, 0.58)	0.52 (0.42, 0.63)
≥4	0.34 (0.26, 0.46)	0.41 (0.33, 0.50)
	No history of hypercholesterolemia	History of hypercholesterolemia
None	1.00 (ref)	1.00 (ref)
1	0.66 (0.50, 0.86)	0.69 (0.56, 0.85)
2	0.51 (0.40, 0.66)	0.58 (0.47, 0.72)
3	0.46 (0.35, 0.59)	0.49 (0.40, 0.61)
≥4	0.33 (0.26, 0.44)	0.38 (0.31, 0.47)

Notes: P for interaction were all >0.05. Results for Nurses' Health Study and Health Professionals Follow-up Study pooled and stratified by cohort. Multivariable-adjusted HR adjusted for age (except for the stratified analysis by age); ethnicity; current multivitamin use; current aspirin use; family history of diabetes mellitus, myocardial infarction, or cancer; and menopausal status and hormone use (women only).

^aLow-risk factors in the score included cigarette smoking (not smoking), physically active (≥3.5 hours/week of moderate to vigorous intensity activity), high diet quality (top 40% of Alternate Healthy Eating Index), moderate alcohol intake of 5 to 14.9 g/day (women) or 5 to 30 g/day (men), normal weight (BMI, 18.5–24.9 kg/m²), and sleep duration (≥6 to <8 hours/day). Traditional lifestyle score included all factors except sleep duration. (Score ranging from 0 to 6).

CVD, cardiovascular disease; HR, hazard ratio.

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Appendix Table 6. Hazard Ratios (95% CI) of Total CVD Incidence by Combined Lifestyle Factors Excluding 1 Component at a Time

Number of low-risk factors^a	None	1	2	3	4	5
Excluding alcohol	1.00 (ref)	0.63 (0.54, 0.73)	0.55 (0.47, 0.63)	0.49 (0.42, 0.56)	0.43 (0.37, 0.50)	0.26 (0.21, 0.32)
Excluding smoking	1.00 (ref)	0.88 (0.83, 0.93)	0.75 (0.71, 0.80)	0.62 (0.58, 0.66)	0.52 (0.47, 0.57)	0.27 (0.21, 0.35)
Excluding BMI	1.00 (ref)	0.69 (0.61, 0.78)	0.58 (0.52, 0.65)	0.49 (0.44, 0.55)	0.40 (0.35, 0.46)	0.31 (0.26, 0.38)
Excluding diet	1.00 (ref)	0.67 (0.58, 0.77)	0.54 (0.46, 0.62)	0.46 (0.39, 0.52)	0.36 (0.30, 0.41)	0.23 (0.19, 0.29)
Excluding physical activity	1.00 (ref)	0.67 (0.57, 0.78)	0.57 (0.49, 0.67)	0.51 (0.43, 0.60)	0.44 (0.37, 0.51)	0.36 (0.30, 0.44)

Notes: Multivariable-adjusted HR adjusted for age (except for the stratified analysis by age); ethnicity; current multivitamin use; current aspirin use; family history of diabetes mellitus, myocardial infarction, or cancer; and menopausal status and hormone use (women only), and the excluded factor.

^aLow-risk factors in the score included cigarette smoking (not smoking), physically active (≥ 3.5 hours/week of moderate to vigorous intensity activity), high diet quality (top 40% of Alternate Healthy Eating Index), moderate alcohol intake of 5 to 14.9 g/day (women) or 5 to 30 g/day (men), normal weight (BMI, 18.5–24.9 kg/m²), and sleep duration (≥ 6 to < 8 hours/day). Traditional lifestyle score included all factors except sleep duration. (Score ranging from 0 to 6). Results using NHS and HPFS pooled. Lifestyle score excluding sleep is the traditional lifestyle score presented in Table 2. Results for Nurses' Health Study and Health Professionals Follow-up Study pooled and stratified by cohort.

CVD, cardiovascular disease; HR, hazard ratio; NHS, Nurses' Health Study; HPFS, Health Professional's Follow-up Study.

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Appendix Table 7. Hazard Ratios (95% CI) of CVD, CHD, and Stroke Incidence According to the Healthy Lifestyle Score Using 7–9 Hours/Day as Optimal Sleep, Data From Both Cohorts Combined

Healthy Lifestyle Score including sleep duration ^a	CVD		CHD		Stroke	
	Cases/ Person-years	HR ^b (95% CI)	Cases/ Person-years	HR (95% CI)	Cases/ Person-years	HR (95% CI)
None	162/32,847	1.00 (ref)	104/32,869	1.00 (ref)	65/32,873	1.00 (ref)
1	1,703/334,774	0.64 (0.54, 0.75)	1,151/335,247	0.70 (0.57, 0.85)	611/335,313	0.55 (0.43, 0.72)
2	3,726/774,804	0.52 (0.44, 0.61)	2,426/776,026	0.55 (0.45, 0.67)	1,342/776,283	0.49 (0.38, 0.63)
3	3,606/831,549	0.43 (0.37, 0.51)	2,304/833,101	0.44 (0.36, 0.54)	1,330/833,230	0.42 (0.33, 0.54)
4	1,847/527,549	0.34 (0.29, 0.40)	1,190/528,339	0.34 (0.28, 0.42)	673/528,462	0.34 (0.26, 0.44)
5	585/211,040	0.27 (0.23, 0.33)	387/211,270	0.28 (0.22, 0.34)	208/211,359	0.29 (0.22, 0.38)
6	81/41,476	0.19 (0.14, 0.25)	47/41,516	0.16 (0.11, 0.22)	34/41,505	0.25 (0.17, 0.38)

^aLow-risk factors in the score included cigarette smoking (not smoking), physically active (≥ 3.5 hours/week of moderate to vigorous intensity activity), high diet quality (top 40% of Alternate Healthy Eating Index), moderate alcohol intake of 5 to 14.9 g/day (women) or 5 to 30 g/day (men), normal weight (BMI, 18.5–24.9 kg/m²), and sleep duration (≥ 7 to < 7 hours/day).

^bMultivariable-adjusted HR was adjusted for age; ethnicity; current multivitamin use; current aspirin use; family history of diabetes mellitus, myocardial infarction, or cancer; and menopausal status and hormone use (women only).

CHD, coronary heart disease; CVD, cardiovascular disease; HR, hazard ratio.

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Appendix Table 8. HR (95% CI) and PAR of CVD by Adhering to All Low-Risk Lifestyle Factors Versus Other Categories

Lifestyle score and PAR	Total CVD		CHD		Stroke	
	Cases/Person-years at low-risk	MV-adjusted HR (95% CI)	Cases/Person-years at low-risk	MV-adjusted HR (95% CI)	Cases/Person-years at low-risk	MV-adjusted HR (95% CI)
Traditional lifestyle score	123/64,853	0.44 (0.37, 0.52)	71/64,924	0.36 (0.28, 0.45)	53/64,895	0.61 (0.46, 0.80)
Healthy lifestyle score including sleep duration ^a	56/40,524	0.34 (0.26, 0.44)	37/40,546	0.32 (0.23, 0.44)	20/40,545	0.39 (0.25, 0.61)
PAR% traditional score ^b	54 (45, 62)		60 (49, 69)		40 (23, 55)	
PAR% lifestyle score including sleep duration	66 (56, 75)		67 (54, 77)		62 (42, 76)	

^aLow-risk factors in the score included cigarette smoking (not smoking), physically active (≥ 3.5 hours/week of moderate to vigorous intensity activity), high diet quality (top 40% of Alternate Healthy Eating Index), moderate alcohol intake of 5 to 14.9 g/day (women) or 5 to 30 g/day (men), normal weight (BMI, 18.5–24.9 kg/m²), and sleep duration (≥ 6 to < 8 hours/day) (Score ranging from 0 to 6). Traditional lifestyle score included all factors except sleep duration.

^bHR and PAR for adhering to all low-risk lifestyle factors of the score (5 factors for the Traditional Lifestyle score and 6 factors for the Healthy Lifestyle Score including sleep duration) vs all other categories (not adhering to all the low-risk factors). HR adjusted for age (months), ethnicity, menopausal status [pre or postmenopausal (never, past or current menopausal hormone use)] (only in women), family history of diabetes (yes/no), family history of myocardial infarction (yes/no), family history of cancer (yes/no), current aspirin use (yes/no), current multivitamin use (yes/no). PAR was adjusted for age and time period. Results for Nurses' Health Study and Health Professional's Follow-up Study pooled and stratified by cohort.

PAR, population attributable risk; CVD, cardiovascular disease; CHD, coronary heart disease; MV, multivariable; HR, hazard ratio.