Red Meat Intake and Risk of Coronary Heart Disease Among US Men

Laila Al-Shaar,[1] postdoctoral research fellow, Ambika Satija,[1] postdoctoral research fellow, Dong D Wang,[1,2] member of the faculty of medicine, Eric B Rimm,[1,2,3] professor of epidemiology and nutrition, Stephanie A Smith-Warner,[1,3] senior lecturer, Meir J Stampfer,[1,2,3] professor of epidemiology and nutrition, Frank B Hu,[1,2,3] professor of epidemiology and nutrition, Walter C Willett(https//orcid.org/0000-0003-1458-7597),[1,2,3] professor of epidemiology and nutrition

[1]Department of Nutrition, Harvard TH Chan School of Public Health, 655 Huntington Avenue, Boston, MA 02115, USA

[2]Channing Division of Network Medicine, Department of Medicine, Brigham and Women's Hospital, Harvard Medical School, Boston, MA, USA

[3]Department of Epidemiology, Harvard TH Chan School of Public Health, Boston, MA, USA

Correspondence to:

Walter C. Willett, MD, Dr.PH

Department of Nutrition

Harvard T.H. Chan School of Public Health,

655 Huntington Avenue, Boston, MA 02115, USA

Phone: 617.432.4680

Email: wwillett@hsph.harvard.edu

Supplementary Table 1: Serving sizes of major protein sources on Food Frequency questionnaires in the Health Professionals Follow up Study, 1986 - 2014.

Food group	Constituent food items
Red meat	
Processed	Beef or pork hot dogs Bacon Salami, bologna, or other processed meat sandwiches Other processed meats, e.g., sausage, kielbasa, etc.
Unprocessed	Hamburger, Lean or extra lean

	Hamburger, Regular
	Beef, pork, or lamb as a sandwich or mixed dish, e.g., stew, casserole, lasagna, frozen dinners, etc.
	Pork as a main dish, e.g., ham or chops
	Beef or lamb as a main dish, e.g., steak, roast
Poultry	
Unprocessed	Chicken/turkey sandwich or frozen dinner
	Other chicken or turkey, with skin -including ground
	Other chicken or turkey, without skin
Fish	
	Canned tuna fish
	Breaded fish cakes, pieces, or fish sticks
	Other fish, e.g., cod, haddock, halibut
	Dark meat fish, e.g. mackerel, salmon, sardines, bluefish, swordfish
Regular Eggs	Regular eggs including yolk
Dairy	
High-fat	Whole milk
	Cream, e.g., coffee, sour (exclude fat free)
	Regular ice cream
	Cottage or ricotta cheese
	Cream cheese
	Other cheese Regular, e.g., American, cheddar, etc., plain or as part of a dish
Low-fat	Skim milk
	1 or 2 % milk
	Frozen yogurt, sherbet, sorbet or low-fat ice cream
	Plain Yogurt
	Artificially sweetened (e.g., light peach) Yogurt
	Sweetened (e.g., strawberry, vanilla) Yogurt
	Other cheese Lowfat or Lite, e.g., American, cheddar, etc., plain or as part of a dish
	Other cheese fat-free, e.g., American, cheddar, etc., plain or as part of a dish
Nuts	
	Peanuts
	Walnuts
	Other Nuts
	Peanut Butter
Mature Beans/Legumes	
	Beans or lentils, baked, dried or soup
	Peas or lima beans (fresh, frozen, canned) or soup
Soy	Tofu, soy burger, soybeans, miso or other soy protein
Whole Grains	
	Whole grain breakfast cereal
	Other cooked breakfast cereal
	Cooked Oatmeal
	Dark Bread
	Rye/Pumpernickle bread

Crispbreads (e.g., Wasa)
Brown Rice
Other grains, e.g. bulgar, kasha, couscous, etc.
Oat bran, added to food
Other Bran, added to food
Wheat Germ
Regular popcorn
Fat free/Light Popcorn
Tortillas

Supplementary Table 2: Hazard Ratios (95% CI) for fatal CHD associated with quintiles of total, unprocessed, and processed red meat intake (N=43,272).

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5	HR per 1 serving/d	P-trend*
Total red meat							
Median servings/d	0.21	0.52	0.78	1.14	1.72		
Cases/PY	329/204335	350/206578	362/204205	348/206600	471/204680		
Age-adjusted Model	1	1.15 (0.99, 1.33)	**1.24 (1.07, 1.44)**	**1.18 (1.02, 1.38)**	**1.63 (1.42, 1.87)**	**1.26 (1.18, 1.34)**	<0.001
Multivariable-adjusted Model 1	1	1.13 (0.97, 1.32)	**1.20 (1.03, 1.39)**	1.12 (0.95, 1.31)	**1.46 (1.24, 1.72)**	**1.19 (1.10, 1.28)**	<0.001
Multivariable-adjusted Model 2	1	1.16 (0.99, 1.35)	**1.23 (1.04, 1.44)**	1.13 (0.95, 1.35)	**1.38 (1.15, 1.66)**	**1.13 (1.03, 1.23)**	0.003
Unprocessed red meat							
Median servings/d	0.14	0.35	0.5	0.71	1.09		
Cases/PY	355/206393	385/199832	332/207613	357/202472	431/210088		
Age-adjusted Model	1	**1.20 (1.04, 1.38)**	1.07 (0.92, 1.24)	**1.17 (1.01, 1.36)**	**1.47 (1.28, 1.70)**	**1.35 (1.22, 1.50)**	<0.001
Multivariable-adjusted Model 1	1	**1.19 (1.03, 1.38)**	1.05 (0.90, 1.23)	1.13 (0.97, 1.32)	**1.35 (1.15, 1.58)**	**1.25 (1.11, 1.41)**	0.001
Multivariable-adjusted Model 2	1	**1.21 (1.04, 1.41)**	1.08 (0.92, 1.27)	1.15 (0.97, 1.35)	**1.29 (1.08, 1.53)**	**1.18 (1.04, 1.34)**	0.02
Processed red meat							
Median servings/d	0.02	0.14	0.21	0.38	0.71		
Cases/PY	354/224944	332/182073	360/211873	333/201933	481/205575		
Age-adjusted Model	1	**1.18 (1.02, 1.38)**	**1.20 (1.04, 1.39)**	1.14 (0.98, 1.32)	**1.51 (1.32, 1.73)**	**1.38 (1.25, 1.52)**	<0.001
Multivariable-adjusted Model 1	1	**1.17 (1.00, 1.36)**	1.15 (0.99, 1.34)	1.06 (0.91, 1.24)	**1.29 (1.11, 1.50)**	**1.21 (1.08, 1.36)**	0.005
Multivariable-adjusted Model 2	1	**1.18 (1.01, 1.38)**	1.17 (0.99, 1.37)	1.09 (0.92, 1.28)	**1.21 (1.02, 1.43)**	1.11 (0.98, 1.26)	0.14

Age-adjusted Model: Adjusted for age and year of questionnaire return

Multivariable-adjusted Model 1: Adjusted for variables in Age-adjusted Model + race/ethnicity (white, black, Asian, other), marital status (married, divorced, widowed, never married), living arrangement (lives with family, lives alone, other arrangements), profession (dentist, pharmacist, optometrist, podiatrist, veterinary), work status (full time, part time, retired), smoking status (never smoker, past smoker, current 1 to 14 cigarettes per day, current 15 to 24 cigarettes per day, current ≥ 25 cigarettes per day), physical activity(< 3, 3-8.9, 9-17.9, 18-26.9, and ≥ 27 in metabolic equivalents per week), body mass index;(< 21, 21-22.9, 23-24.9, 25-26.9, 27-29.9, 30-32.9, 33-34.9, 35-39.9, ≥ 40 in kg/m2), alcohol intake (0, 0.1-4.9, 5.0-9.9, 10-14.9, or ≥ 15.0 g per day), multivitamin use (yes, no), aspirin use (yes, no), family history of early CHD or stroke (diagnosis before 60 years of age; yes, no), and total energy intake (in quintiles).

Multivariable-adjusted Model 2: Adjusted for variables in Model 1 + intakes of poultry, fish, egg, high fat dairy, low fat dairy, nuts, legumes, soy, whole grains, fruits, vegetables, and coffee, and glycemic index

* P-value when each quintile was assigned the median value and treated as a continuous variable

Abbreviations: CHD, Coronary Heart Disease; PY, Person-Years; HR, Hazard Ratio; CI, Confidence Interval

Supplementary Table 3: Hazard Ratios (95% CI) for total CHD associated with quintiles of total, unprocessed, and processed red meat intake after including baseline comorbidities or a modified alternative healthy eating index (AHEI) score in the models.

	Quintile 1	Quintile 2	Quintile 3	Quintile 4	Quintile 5
Total red meat					
Median servings/d	0.21	0.52	0.78	1.14	1.72
Cases/PY	811/203879	833/206108	859/203718	865/206087	1087/204079
Model 1* + baseline comorbidities	1	1.05 (0.95, 1.17)	1.09 (0.99, 1.22)	1.05 (0.94, 1.17)	**1.21 (1.07, 1.36)**
Model$^{\Psi}$ + modified AHEI	1	1.01 (0.92, 1.12)	1.03 (0.93, 1.14)	1.00 (0.90, 1.11)	**1.21 (1.08, 1.35)**
Unprocessed red meat					
Median servings/d	0.14	0.35	0.5	0.71	1.09
Cases/PY	847/205918	876/199361	840/207111	877/201942	1016/209540
Model 1* + baseline comorbidities	1	1.09 (0.99, 1.21)	1.04 (0.94, 1.15)	1.08 (0.97, 1.20)	1.11 (0.99, 1.25)
Model$^{\Psi}$ + modified AHEI	1	1.07 (0.97, 1.17)	0.99 (0.89, 1.09)	1.03 (0.93, 1.14)	**1.14 (1.02, 1.27)**
Processed red meat					
Median servings/d	0.02	0.14	0.21	0.38	0.71
Cases/PY	889/224469	734/181661	883/211353	843/201440	1107/204950
Model 1* + baseline comorbidities	1	1.02 (0.92, 1.13)	1.08 (0.97, 1.19)	1.07 (0.96, 1.19)	**1.15 (1.03, 1.28)**
Model$^{\Psi}$ + modified AHEI	1	0.98 (0.88, 1.08)	1.01 (0.92, 1.12)	0.97 (0.88, 1.07)	**1.12 (1.01, 1.24)**

*Adjusted for age, race/ethnicity (white, black, Asian, other), marital status (married, divorced, widowed, never married), living arrangement (lives with family, lives alone, other arrangements), profession (dentist, pharmacist, optometrist, podiatrist, veterinary), work status (full time, part time, retired), smoking status (never smoker, past smoker, current 1 to 14 cigarettes per day, current 15 to 24 cigarettes per day, current ≥ 25 cigarettes per day), physical activity(< 3, 3-8.9, 9-17.9, 18-26.9, and ≥ 27 in metabolic equivalents per week), body mass index;(< 21, 21-22.9, 23-24.9, 25-26.9, 27-29.9, 30-32.9, 33-34.9, 35-39.9, ≥ 40 in kg/m2), alcohol intake (0, 0.1-4.9, 5.0-9.9, 10-14.9, or ≥ 15.0 g per day), multivitamin use (yes, no), aspirin use (yes, no), family history of early CHD or stroke (diagnosis before 60 years of age; yes, no), and total energy intake (in quintiles) in addition to intakes of poultry, fish, egg, high fat dairy, low fat dairy, nuts, legumes, soy, whole grains, fruits, vegetables, and coffee, and glycemic index

$^{\Psi}$ Adjusted for variables in Model 1 excluding alcohol intake, poultry, fish, egg, high fat dairy, low fat dairy, nuts, legumes, soy, whole grains, fruits, and vegetables.

Modified AHEI score is the diet score of the Alternative Healthy Eating Index (AHEI), after excluding the red meat component.

Supplementary Table 4: Hazard Ratios (95% CI) for total CHD associated with replacement of 1 serving/day of total, unprocessed, and processed red meat with 1 serving/day of other protein sources and whole grains.

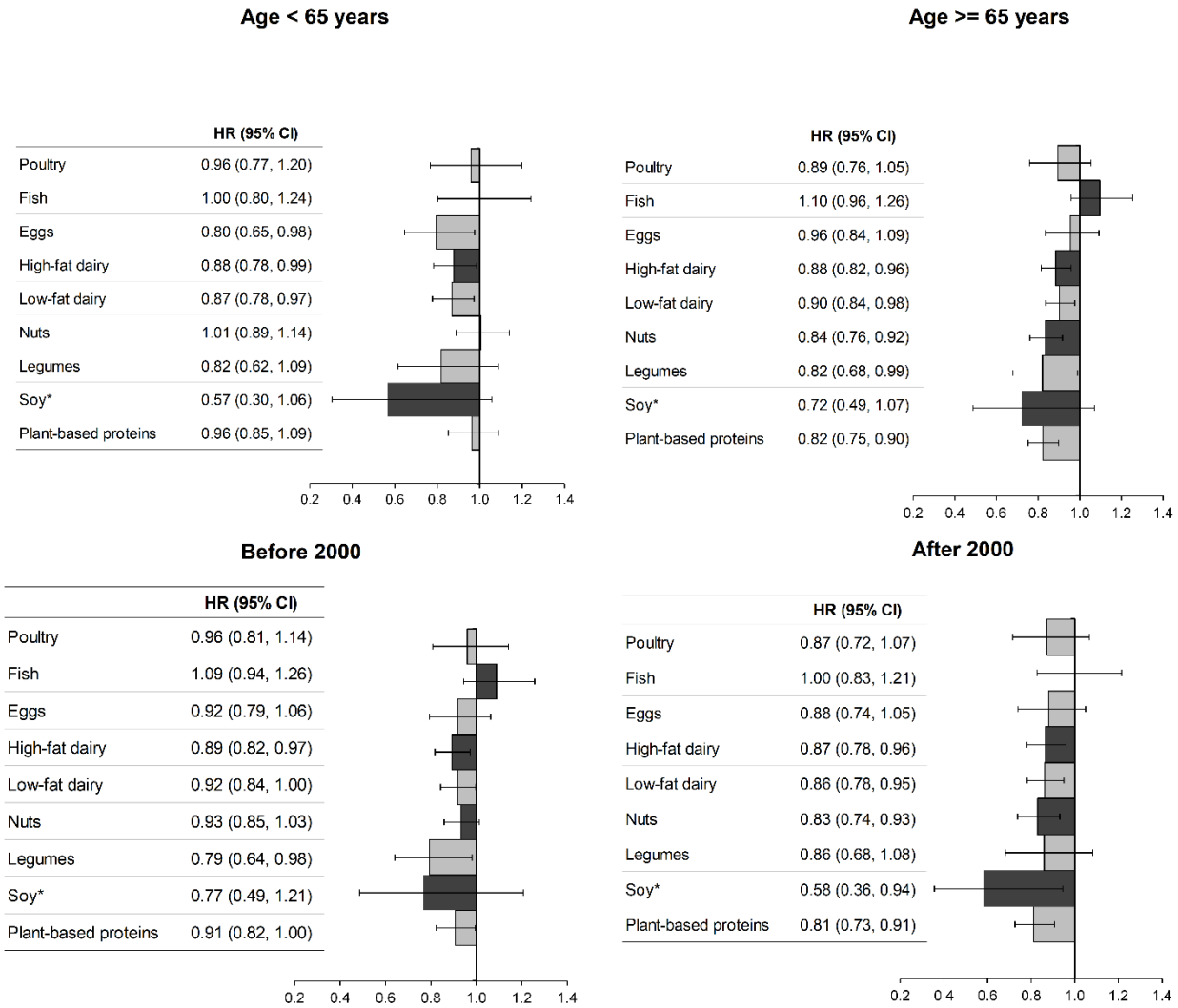
Total red meat	**HR (95% CI)**	**p-value**
Poultry	0.92 (0.81, 1.05)	0.24
Fish	1.06 (0.95, 1.19)	0.31
Eggs	0.90 (0.81, 1.01)	0.07
High-fat dairy	0.88 (0.82, 0.94)	<0.001
Low-fat dairy	0.89 (0.84, 0.95)	<0.001
Nuts	0.89 (0.82, 0.96)	0.002
Legumes	0.82 (0.70, 0.96)	0.01
Soy*	0.67 (0.48, 0.93)	0.02
Plant-based proteins	0.86 (0.80, 0.93)	<0.001
Whole grains	0.62 (0.53, 0.73)	<0.001
Unprocessed Red meat	**HR (95% CI)**	**p-value**
Poultry	0.92 (0.79, 1.06)	0.24
Fish	1.05 (0.93, 1.20)	0.43
Eggs	0.93 (0.82, 1.05)	0.26
High-fat dairy	0.89 (0.81, 0.97)	0.01
Low-fat dairy	0.90 (0.82, 0.98)	0.02
Nuts	0.89 (0.81, 0.98)	0.02
Legumes	0.83 (0.70, 0.99)	0.03
Soy*	0.66 (0.48, 0.92)	0.01
Plant-based proteins	0.87 (0.79, 0.95)	0.003
Whole grains	0.61 (0.51, 0.72)	<0.001
Processed Red Meat	**HR (95% CI)**	**p-value**
Poultry	0.89 (0.77, 1.02)	0.10
Fish	1.01 (0.88, 1.15)	0.91
Eggs	0.87 (0.76, 0.99)	0.04
High-fat dairy	0.85 (0.78, 0.93)	<0.001
Low-fat dairy	0.86 (0.79, 0.94)	<0.001
Nuts	0.85 (0.77, 0.94)	0.001

Legumes	0.80 (0.68, 0.95)	0.009
Soy*	0.66 (0.47, 0.91)	0.01
Plant-based proteins	0.83 (0.76, 0.91)	<0.001
Whole grains	0.59 (0.49, 0.69)	<0.001

Models were adjusted for age, year of questionnaire return,, race/ethnicity (white, black, Asian, other), marital status (married, divorced, widowed, never married), living arrangement (lives with family, lives alone, other arrangements), profession (dentist, pharmacist, optometrist, podiatrist, veterinary), work status (full time, part time, retired), smoking status (never smoker, past smoker, current 1 to 14 cigarettes per day, current 15 to 24 cigarettes per day, current ≥ 25 cigarettes per day), physical activity(< 3, 3-8.9, 9-17.9, 18-26.9, and ≥ 27 in metabolic equivalents per week), body mass index;(< 21, 21-22.9, 23-24.9, 25-26.9, 27-29.9, 30-32.9, 33-34.9, 35-39.9, ≥ 40 in kg/m2), alcohol intake (0, 0.1-4.9, 5.0-9.9, 10-14.9, or ≥ 15.0 g per day), multivitamin use (yes, no), aspirin use (yes, no), family history of early CHD or stroke (diagnosis before 60 years of age; yes, no), and total energy intake (in quintiles), and intakes of poultry, fish, egg, high fat dairy, low fat dairy, nuts, legumes, soy (or combined plant protein sources of nuts, legumes, and soy), whole grains, fruits, vegetables, and coffee, and glycemic index.

Abbreviations: CHD, Coronary Heart Disease; HR, Hazard Ratio; CI, Confidence Interval

Supplementary Figure 1: HRs (95% CI) for total CHD associated with replacement of 1 serving/day of total red meat with 1 serving/day of other protein sources, stratified by age and calendar year.



* Replacing ≥2 servings/week of red meat with ≥2 servings/week of soy

One daily serving of nuts (28g); low-fat dairy products (240 ml milk, 28g cheese, or 120 ml yogurt); high fat dairy product (240 ml whole milk, 28g cream cheese, or 1 cup of regular ice cream); legumes (1/2 cup); whole grains (32 g (1 slice) of bread or 200 g (1 cup) of cooked brown rice or cereals);

Models were adjusted for age, year of questionnaire return, race/ethnicity (white, black, Asian, other), marital status (married, divorced, widowed, never married), living arrangement (lives with family, lives alone, other arrangements), profession (dentist, pharmacist, optometrist, podiatrist, veterinary), work status (full time, part time, retired), smoking status (never smoker, past smoker, current 1 to 14 cigarettes per day, current 15 to 24 cigarettes per day, current ≥ 25 cigarettes per day), physical activity(< 3, 3-8.9, 9-17.9, 18-26.9, and ≥ 27 in metabolic equivalents per week), body mass index;(< 21, 21-22.9, 23-24.9, 25-26.9, 27-29.9, 30-32.9, 33-34.9, 35-39.9, ≥ 40 in kg/m2), alcohol intake (0, 0.1-4.9, 5.0-9.9, 10-14.9, or ≥ 15.0 g per day), multivitamin use (yes, no), aspirin use (yes, no), family history of early CHD or stroke (diagnosis before 60 years of age; yes, no), and total energy intake (in quintiles), and intake of poultry, fish, egg, high fat dairy, low fat dairy, nuts, legumes, soy (or combined plant protein sources of nuts, legumes, and soy), whole grains, fruits, vegetables, coffee, and glycemic index.

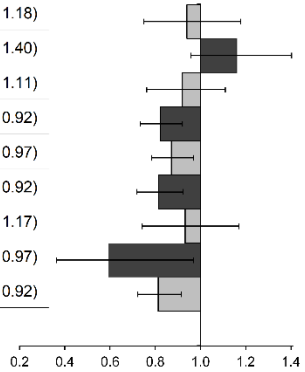
P-values for the interaction between total red meat and each of age and period was 0.48 and 0.45 respectively. The interactions between nuts and plant-based proteins with age were significant (p=0.002 and 0.004, respectively).

Abbreviations: CHD, Coronary Heart Disease; HR, Hazard Ratio; CI, Confidence Interval

Supplementary Figure 2: HRs (95% CI) for total CHD associated with replacement of 1 serving/day of total red meat with 1 serving/day of other protein sources, stratified by Body Mass Index (BMI) and total fiber intake.

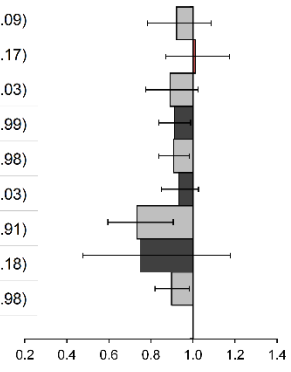
BMI < 25 kg/m^2

	HR (95% CI)
Poultry	0.94 (0.75, 1.18)
Fish	1.16 (0.96, 1.40)
Eggs	0.92 (0.76, 1.11)
High-fat dairy	0.82 (0.73, 0.92)
Low-fat dairy	0.87 (0.78, 0.97)
Nuts	0.82 (0.72, 0.92)
Legumes	0.93 (0.74, 1.17)
Soy*	0.59 (0.36, 0.97)
Plant-based proteins	0.81 (0.72, 0.92)



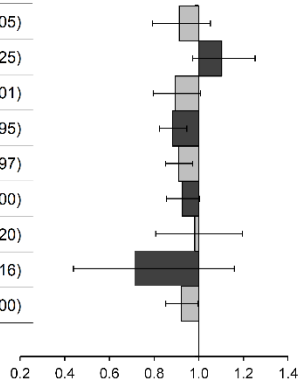
BMI >= 25 kg/m^2

	HR (95% CI)
Poultry	0.92 (0.78, 1.09)
Fish	1.01 (0.87, 1.17)
Eggs	0.89 (0.78, 1.03)
High-fat dairy	0.91 (0.84, 0.99)
Low-fat dairy	0.91 (0.84, 0.98)
Nuts	0.93 (0.85, 1.03)
Legumes	0.73 (0.59, 0.91)
Soy*	0.75 (0.48, 1.18)
Plant-based proteins	0.90 (0.82, 0.98)



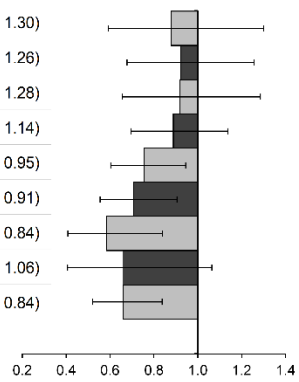
Total Fiber < 28g/day

	HR (95% CI)
Poultry	0.91 (0.79, 1.05)
Fish	1.10 (0.97, 1.25)
Eggs	0.90 (0.80, 1.01)
High-fat dairy	0.88 (0.82, 0.95)
Low-fat dairy	0.91 (0.85, 0.97)
Nuts	0.93 (0.85, 1.00)
Legumes	0.98 (0.81, 1.20)
Soy*	0.71 (0.44, 1.16)
Plant-based proteins	0.92 (0.85, 1.00)



Total Fiber >=28 g/day

	HR (95% CI)
Poultry	0.88 (0.59, 1.30)
Fish	0.92 (0.68, 1.26)
Eggs	0.92 (0.66, 1.28)
High-fat dairy	0.89 (0.69, 1.14)
Low-fat dairy	0.75 (0.60, 0.95)
Nuts	0.71 (0.55, 0.91)
Legumes	0.58 (0.41, 0.84)
Soy*	0.66 (0.41, 1.06)
Plant-based proteins	0.66 (0.52, 0.84)



* Replacing ≥2 servings/week of red meat with ≥2 servings/week of soy

One daily serving of nuts (28g); low-fat dairy products (240 ml milk, 28g cheese, or 120 ml yogurt); high fat dairy product (240 ml whole milk, 28g cream cheese, or 1 cup of regular ice cream); legumes (1/2 cup); whole grains (32 g (1 slice) of bread or 200 g (1 cup) of cooked brown rice or cereals);

Models were adjusted for age, year of questionnaire return, race/ethnicity (white, black, Asian, other), marital status (married, divorced, widowed, never married), living arrangement (lives with family, lives alone, other arrangements), profession (dentist, pharmacist, optometrist, podiatrist, veterinary), work status (full time, part time, retired), smoking status (never smoker, past smoker, current 1 to 14 cigarettes per day, current 15 to 24 cigarettes per day, current ≥ 25 cigarettes per day), physical activity(< 3, 3-8.9, 9-17.9, 18-26.9, and ≥ 27 in metabolic equivalents per week), body mass index;(< 21, 21-22.9, 23-24.9, 25-26.9, 27-29.9, 30-32.9, 33-34.9, 35-39.9, ≥ 40 in kg/m2), alcohol intake (0, 0.1-4.9, 5.0-9.9, 10-14.9, or ≥ 15.0 g per day), multivitamin use (yes, no), aspirin use (yes, no), family history of early CHD or stroke (diagnosis before 60 years of age; yes, no), and total energy intake (in quintiles), and intake of poultry, fish, egg, high fat dairy, low fat dairy, nuts, legumes, soy (or combined plant protein sources of nuts, legumes, and soy), whole grains, fruits, vegetables, coffee, and glycemic index.

P-values for the interaction between total red meat and each of BMI and fiber intake was 0.30 and 0.28 respectively. The interactions between nuts, legumes, and plant-based proteins with fiber intake were significant (p=0.04, 0.006, and 0.000, respectively).

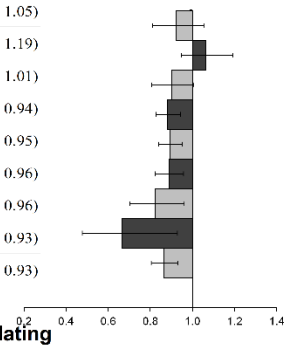
In the stratified analysis by BMI, models were adjusted for BMI as a continuous variable.

Abbreviations: CHD, Coronary Heart Disease; HR, Hazard Ratio; CI, Confidence Interval

Supplementary Figure 3: Hazard Ratios (95% CI) for total CHD associated with replacement of 1 serving/day of total red meat with 1 serving/day of other protein sources with different ways of modeling diet.

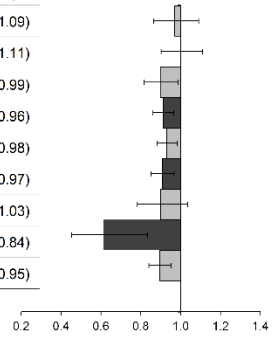
A. Cumulative updating till major diseases develop (Primary Model)

	HR (95% CI)
Poultry	0.92 (0.81, 1.05)
Fish	1.06 (0.95, 1.19)
Eggs	0.90 (0.81, 1.01)
High-fat dairy	0.88 (0.82, 0.94)
Low-fat dairy	0.89 (0.84, 0.95)
Nuts	0.89 (0.82, 0.96)
Legumes	0.82 (0.70, 0.96)
Soy*	0.67 (0.48, 0.93)
Plant-based proteins	0.86 (0.80, 0.93)



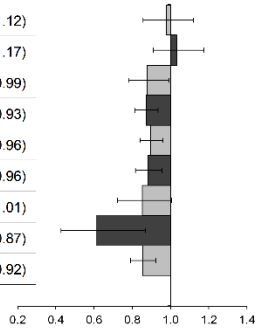
B. Baseline Diet

	HR (95% CI)
Poultry	0.97 (0.86, 1.09)
Fish	1.00 (0.90, 1.11)
Eggs	0.90 (0.82, 0.99)
High-fat dairy	0.91 (0.86, 0.96)
Low-fat dairy	0.93 (0.88, 0.98)
Nuts	0.91 (0.85, 0.97)
Legumes	0.90 (0.78, 1.03)
Soy*	0.61 (0.45, 0.84)
Plant-based proteins	0.90 (0.84, 0.95)



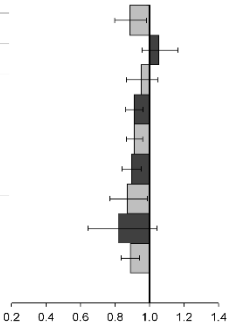
C. Continuous Cumulative updating

	HR (95% CI)
Poultry	0.98 (0.86, 1.12)
Fish	1.03 (0.91, 1.17)
Eggs	0.88 (0.78, 0.99)
High-fat dairy	0.87 (0.81, 0.93)
Low-fat dairy	0.90 (0.84, 0.96)
Nuts	0.88 (0.82, 0.96)
Legumes	0.85 (0.72, 1.01)
Soy*	0.61 (0.43, 0.87)
Plant-based proteins	0.85 (0.79, 0.92)



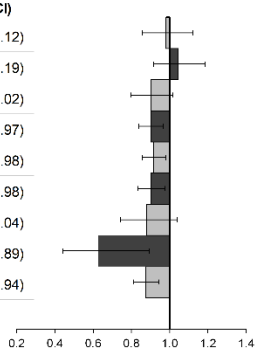
D. Most recent Diet

	HR (95% CI)
Poultry	0.88 (0.80, 0.98)
Fish	1.05 (0.96, 1.16)
Eggs	0.95 (0.87, 1.05)
High-fat dairy	0.91 (0.86, 0.96)
Low-fat dairy	0.91 (0.87, 0.96)
Nuts	0.90 (0.84, 0.95)
Legumes	0.87 (0.77, 0.99)
Soy*	0.82 (0.64, 1.04)
Plant-based proteins	0.89 (0.84, 0.94)



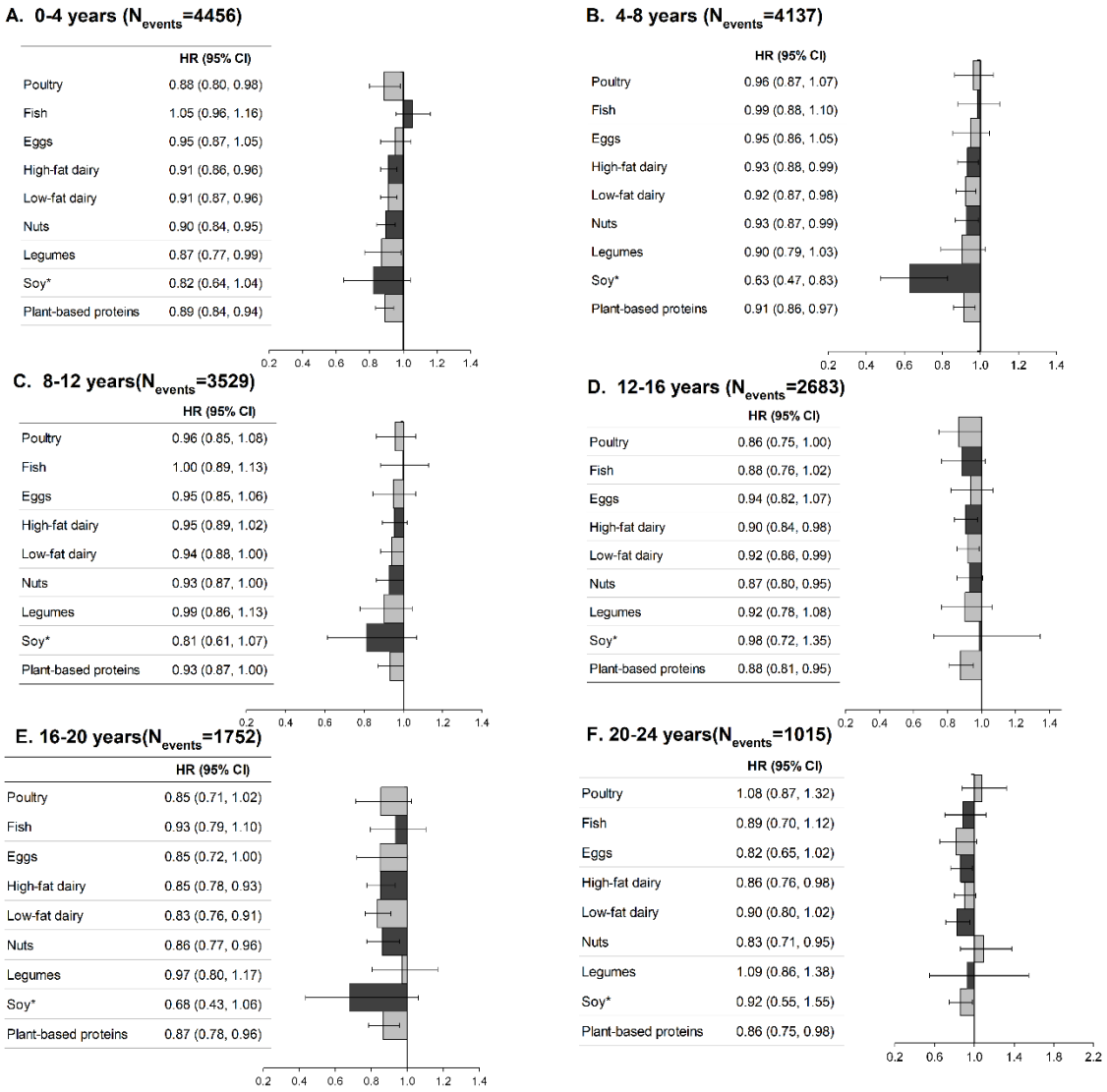
E. Continuous Cumulative updating (adjusting for major diseases)

	HR (95% CI)
Poultry	0.98 (0.86, 1.12)
Fish	1.04 (0.92, 1.19)
Eggs	0.90 (0.80, 1.02)
High-fat dairy	0.90 (0.84, 0.97)
Low-fat dairy	0.92 (0.86, 0.98)
Nuts	0.90 (0.83, 0.98)
Legumes	0.88 (0.74, 1.04)
Soy*	0.63 (0.44, 0.89)
Plant-based proteins	0.87 (0.81, 0.94)



* Replacing ≥2 servings/week of red meat with ≥2 servings/week of soy
One daily serving of nuts (28g); low-fat dairy products (240 ml milk, 28g cheese, or 120 ml yogurt); high fat dairy product (240 ml whole milk, 28g cream cheese, or 1 cup of regular ice cream); legumes (1/2 cup); whole grains (32 g (1 slice) of bread or 200 g (1 cup) of cooked brown rice or cereals);
Models were adjusted for age, year of questionnaire return, race/ethnicity (white, black, Asian, other), marital status (married, divorced, widowed, never married), living arrangement (lives with family, lives alone, other arrangements), profession (dentist, pharmacist, optometrist, podiatrist, veterinary), work status (full time, part time, retired), smoking status (never smoker, past smoker, current 1 to 14 cigarettes per day, current 15 to 24 cigarettes per day, current ≥ 25 cigarettes per day), physical activity(< 3, 3-8.9, 9-17.9, 18-26.9, and ≥ 27 in metabolic equivalents per week), body mass index;(< 21, 21-22.9, 23-24.9, 25-26.9, 27-29.9, 30-32.9, 33-34.9, 35-39.9, ≥ 40 in kg/m2), alcohol intake (0, 0.1-4.9, 5.0-9.9, 10-14.9, or ≥ 15.0 g per day), multivitamin use (yes, no), aspirin use (yes, no), family history of early CHD or stroke (diagnosis before 60 years of age; yes, no), and total energy intake (in quintiles), and intake of poultry, fish, egg, high fat dairy, low fat dairy, nuts, legumes, soy (or combined plant protein sources of nuts, legumes, and soy), whole grains, fruits, vegetables, coffee, and glycemic index.
Major diseases included cancer, stroke, diabetes, angina, and coronary artery bypass grafting surgery. Panel A is identical to Figure 1 of the main manuscript.
Abbreviations: CHD, Coronary Heart Disease; HR, Hazard Ratio; CI, Confidence Interval.

Supplementary Figure 4: Hazard Ratios (95% CI) for total CHD associated with replacement of 1 serving/day of total red meat with 1 serving/day of other protein sources, with various lagged analyses incorporated into the cumulative update model.



* Replacing ≥2 servings/week of red meat with ≥2 servings/week of soy

One daily serving of nuts (28g); low-fat dairy products (240 ml skimmed milk, 28g cheese, or 120 ml yogurt); high fat dairy product (240 ml whole milk, 28g cream cheese, or 1 cup of regular ice cream); legumes (1/2 cup); whole grains (32 g (1 slice) of bread or 200 g (1 cup) of cooked brown rice or cereals); Models were adjusted for age, year of questionnaire return, race/ethnicity (white, black, Asian, other), marital status (married, divorced, widowed, never married), living arrangement (lives with family, lives alone, other arrangements), profession (dentist, pharmacist, optometrist, podiatrist, veterinary), work status (full time, part time, retired), smoking status (never smoker, past smoker, current 1 to 14 cigarettes per day, current 15 to 24 cigarettes per day, current ≥ 25 cigarettes per day), physical activity(< 3, 3-8.9, 9-17.9, 18-26.9, and ≥ 27 in metabolic equivalents per week), body mass index;(< 21, 21-22.9, 23-24.9, 25-26.9, 27-29.9, 30-32.9, 33-34.9, 35-39.9, ≥ 40 in kg/m2), alcohol intake (0, 0.1-4.9, 5.0-9.9, 10-14.9, or ≥ 15.0 g per day), multivitamin use (yes, no), aspirin use (yes, no), family history of early CHD or stroke (diagnosis before 60 years of age; yes, no), and total energy intake (in quintiles), and intake of poultry, fish, egg, high fat dairy, low fat dairy, nuts, legumes, soy (or combined plant protein sources of nuts, legumes, and soy), whole grains, fruits, vegetables, coffee, and glycemic index.
Abbreviations: CHD, Coronary Heart Disease; HR, Hazard Ratio; CI, Confidence Interval