

Web Material

Association Between Ultra-Processed Food Intake and All-Cause Mortality: A Systematic Review and Meta-Analysis

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Web Table 1. Summary of the studies included in systematic review

Author, year (Reference No)	Country, Cohort name	Funding	Age at entry	Sex, Ethnicity	Cohort size	No. of deaths	Follow up years	Dietary assessment method	Type of exposure	Outcome assessment method	Adjustment variables	Highest vs. lowest intake	Risk Ratio (RR)	Quality score
Alshahrani, 2019 (1)	USA, Canada; The Adventist Health Study-2 (AHS-2)	National Cancer Institute (NCI)	30–112 (60.2)	Men and women; White (non-Hispanic)	72,149	7,961	11.8 years	Validated quantitative food frequency questionnaire (FFQ)	Processed meat: processed beef, lamb (e.g., sausage, salami, and bologna), processed chicken or turkey (e.g., turkey bologna, and turkey ham), pork (bacon, sausage, ham, chops, ribs, and lunchmeat)	National Death Index	Model 1: Age, sex, race, total energy intake Model 2: Model 1 + marital status, educational level, multivitamin use, smoking status, alcohol use, exercise, sleep, aspirin use, having ever been diagnosed with or received treatment in the last 12 months for diabetes, having been diagnosed in	Lowest: Zero intake Highest: Fourth quartile	Model 1: 1.59 (1.46–1.74) Model 2: 1.27 (1.15–1.40) Model 3: 1.16 (1.04–1.29)	8

											<p>the last 5 years with or received treatment in the last 12 months for hypertension or hypercholesterolemia, use of statin for at least 2 years in the last 5 years, use of blood pressure medications for at least 2 years in the last 5 years, dietary variables (Cruciferous vegetables, fruits, whole grain, legumes, nuts and seeds, total dairy, eggs), menopausal status, hormone therapy.</p> <p>Model 3: Model 2+ fish, unprocessed</p>			
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											poultry, unprocessed meat			
Ander son, 2020 (2)	UK Biobank study	Wellcome Trust, Medical Research Council, Department of Health, Scottish Government and Northwest Regional Development Agency. Welsh Assembly Government and British Heart Foundation	56.1 (7.9)	Men and women; white, non-white	198.285	3166	7 years	Web-based 24-h dietary assessment tool	Glasses/cans of sugar- and artificially sweetened beverages (e.g. squash, cordial or fizzy drinks)	Death certificates held by the National Health Service (NHS) Information Centre for England and Wales, and the NHS Central Register for Scotland	Model 4: sex, age, ethnicity, income, highest qualification, physical activity, sedentary behaviour, total energy intake, body mass index, smoking status, alcohol intake, total fat intake, fresh fruit intake, vegetable intake, total fibre intake, red meat intake and processed meat intake. Model 5: model 4 adjusted for intake of other drinks – sugar-sweetened, artificially-sweetened	Highest: >2/day Lowest: None	SSB Model 4: 1.87 (1.45–2.42) Model 5: 1.84 (1.42–2.37) ASB Model 4: 1.44 (1.12–1.84) Model 5: 1.44 (1.12–1.84)	8

											or fruit/vegetable juices as applicable			
Argyri dou, 2019 (3)	UK Biobank study	National Institute for Health Research (NIHR) Leicester Biomedical Research Centre, Leicester, UK, NIHR Collaboration for Leadership in Applied Health Research and Care (CLAHRC)- East Midlands	56.5 (4.3)	Men and women; white, non- white	419.0 75	8586	7 years	Food frequenc y question naire (FFQ)	Processed meat: any intake of bacon, ham, sausages, meat pies, kebabs, burgers, and nuggets	NHS Informatio n Centre for participants , from England and Wales, and from the NHS Central Register, for participants from Scotland	Age, gender, ethnicity, Townsend score, employment , number of medications, education, smoking status, alcohol use, diet (fresh fruit, dried fruit, cooked and raw vegetable consumptio n; poultry, oily-fish, non-oily fish, salt added to food), time TV viewing, physical activity (walking, moderate and vigorous), Body Mass Index, red meat	Consum ption/ no consum ption	1.053 (1.030- 1.077)	8

Baer, 2010 (4)	USA, NHS	National Institutes of Health	30-55	Women; N/A	50,112	4,893	18 years	FFQ	Cereal fiber	National Death Index	Age, BMI, weight, height, smoking, physical activity, alcohol intake, nut consumption, polyunsaturated fat, glycemic load, cholesterol, systolic blood pressure, Use of blood pressure medications, diabetes mellitus, Parental MI before age 60 years, time of menopause	per 4 g	0.84 0.78, 0.91	8
Barrington, 2016 (5)	USA, The Vitamins and Lifestyle (VITAL)	National Cancer Institute and Office of Dietary Supplements	50-76	Men and women; White, hispanic, african-american, american-indian, asian-american	69.582	4.187	6.9 years	Semi-quantitative FFQ	Fast-food items (FFI), Sugar-sweetened drinks (SSD)	Washington State death records, Social Security Death Index, Western Washington	Model 1: age and sex Model 2: race, marital status, education, annual income, BMI at age	FFI: Lowest: 0-0.5/wk Highest: ≥2.5/wk SSD: Lowest: 0-0.1/wk	FFI Model 1: 1.56 (1.42-1.70) Model 2: 1.16 (1.04, 1.29) SSD	8

										<p>n Surveillance Epidemiology and End Results cancer registry</p>	<p>45 years, average yearly change in BMI from age 45 years, morbidity score, self- rated health, current use of cholesterol- lowering medication, aspirin use in last 10 years, non- aspirin non- steroidal anti- inflammator y drug use in last 10 years, years of oestrogen therapy, years of oestrogen plus progestin therapy, age at menopause, age at death of father, age at death of mother,</p>	<p>Highest: ≥2.8/wk</p>	<p>Model 1: 1.25 (1.15, 1.35) Model 2: 1.19 (1.08, 1.30)</p>	
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											average physical activity in 10 years before baseline (tertiles of metabolic equivalents of task), smoking status, average alcohol intake, mammogram in past 2 years, prostate-specific antigen test in the last 2 years, sigmoidoscopy in the last 10 years, number of servings/d of fruits, number of servings/d of vegetables and total daily energy intake			
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Bellavia, 2016 (6)	Sweden; Swedish Mammography Cohort and the Cohort of Swedish Men	Swedish Research Council, Swedish Cancer Foundation, and Swedish Research Council for Health, Working Life and Welfare	Men: 45-79 Women: 48-83	Men and women; N/A	74.645	17.909	16 years	96-item food-frequency questionnaire	Sausages, hot dogs, salami, ham, processed meat cuts, liver pate, and blood sausage	Swedish Cause of Death Register at the National Board of Health and Welfare	Gender, pack-years of smoking, physical activity, body mass index, alcohol consumption, diabetes, fish consumption, total energy, and mutually adjusted for non-processed red meat intake	Lowest: <15 g/day Highest: 49.1-200 g/day	1.13 (1.06, 1.20)	8
Blanco-Rojo, 2019 (7)	Spain, ENRICA study	State Secretary of Research and Development Initiatives and Fondo Europeo de Desarrollo Regional/Fondo Social Europeo, Instituto de Salud Carlos III	46.9	Men and women, N/A	11.898	440	7.7	Validated computer-based dietary history (DH-ENRICA)	Ultra-processed foods from NOVA classification	Spanish National Death Index	Model 1: adjusted for sex and age. Model 2: Model 1 + educational level, and living alone. Model 3: Model 2 + smoking status, former drinker, physical activity index, time watching television,	Lowest: First quarter Highest: Fourth quarter	Model 1: 1.44 (1.00-2.06) Model 2: 1.51 (1.05-2.16) Model 3: 1.42 (0.99-2.04) Model 4:	9

											and time devoted to other sedentary activities. Model 4: Model 3 + the number of medications per day, and specific chronic conditions diagnosed by a physician (chronic respiratory disease, coronary heart disease, stroke, heart failure, osteoarthritis, cancer, and depression)		1.44 (1.01-2.07)	
Bonaccio, 2020 (8)	Italy, Moli-sani Study	Pfizer Foundation, Italian Ministry of University and Research—Programma Triennale di	55 ± 12	Men and women; N/A	22,475	1216	8.2y	FFQ	Ultra-processed food (UPF)	Italian mortality registry (ReNCaM registry) validated by Italian death certificates	Sex, age, energy intake, educational level, housing tenure, smoking, BMI,	18.5 vs. 4.8 weight ratio in%	1.26 (1.09, 1.46)	9

		Ricerca decree 1588, and Instrumentation Laboratory, AIRC “5xMILLE” and the Italian Ministry of Health								(ISTAT form)	leisure-time physical activity, history of cancer, CVD, diabetes, hypertension, hyperlipidemia, and residence, Mediterranean Diet Score			
Burke, 2007 (9)	Australia; N/A	Australian Research Council Discovery Project Grant	15-88	Men and women; Australian Aborigines	514	130	14 years	Interviewer administered food frequency questionnaires	Take away foods (sausages, meat pies, pasties, sausage rolls, hamburger, chicken fried or roasted, fish fried, fish fingers, “Chinese” meals)	Western Australian Data Linkage Unit	Sex, age, total cholesterol, mean arterial pressure and waist girth	Lowest: ≤ 9 serves/month Highest: > 9 serves/month	1.78 (0.96, 3.29)	6
Chuang, 2012 (10)	France, Italy, Spain, The Netherlands, United Kingdom, Greece,	Europe Against Cancer Program of the European Commission, Deutsche	50.8 \pm 9.8	Men, women; N/A	452,717	23,582	12.7 years	FFQ	Cereal fiber	Death indexes, record linkages with cancer registries,	Age at recruitment, sex, and center and adjusted for education	Per 5-g/d increase in fiber intake	Men: 0.93 (0.91-0.95) Women: 0.92	8

	Germany, Sweden, Norway, and Denmark; European Prospective Investigation into Cancer and Nutrition (EPIC)	Krebshilfe, Deutsches Krebsforschungszentrum, German Federal Ministry of Education and Research; Danish Cancer Society; Health Research Fund (FIS) of the Spanish Ministry of Health, Spanish Regional Governments of Andalusia, Asturias, Basque Country, Murcia and Navarra; ISCIII RCESP exp. C03/09, Spain; Cancer Research UK; Medical Research Council, United Kingdom; Stroke Association,							and boards of health	(none or primary school completed, technical or professional school, secondary school, longer education, and not specified), smoking (never; current 1–15, 16–25, or 26 cigarettes/d; former quit 10, 11–20, or 20 y; current pipe or cigar occasional, current/former missing, or unknown), alcohol consumption (never or former; current 6, .6–18, .18–30, .30–60, or .60 g/d; or missing),	(0.89–0.95)	
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		<p>United Kingdom; British Heart Foundation; Department of Health, United Kingdom; Food Standards Agency, United Kingdom; Wellcome Trust, United Kingdom; the Hellenic Health Foundation and the Stavros Niarchos Foundation; Italian Association for Research on Cancer (AIRC); Italian National Research Council, Fondazione-Istituto Banco Napoli, Italy; Dutch Ministry of Public Health, Welfare and</p>								<p>BMI (in kg/m² : ,18.5, 18.5–24.9, 25–29.9, or 30), physical activity (based on the Cambridge/Bilthoven Physical Activity Index: inactive, moderately inactive, moderately active, or missing), total energy intake (kcal/d), other sources of fiber intake, and ever use of menopausal hormone therapy for women</p>			
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		Sports (VWS), Netherlands Cancer Registry (NKR), LK Research Funds, Dutch Prevention Funds, Dutch ZON (Zorg Onderzoek Nederland), World Cancer Research Fund (WCRF), Statistics Netherlands (The Netherlands); Swedish Cancer Society; Swedish Scientific Council; Regional Government of Skåne, Sweden; Nordforsk the Norwegian Cancer Society; French League against Cancer											
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		(LNCC); National Institute for Health and Medical Research (INSERM), France; Mutuelle Générale de l'Éducation Nationale (MGEN), France; 3M Co, France; Gustave Roussy Institute (IGR), France; and General Councils of France.												
Collin, 2019 (11)	USA, The Reasons for Geographic and Racial Differences in Stroke (REGARDS)	National Institute of Neurological Disorders and Stroke and the National Institutes of Health	63.6 ±9.1	Men and women; Non-Hispanic black and white	13.440	1.000	6.0±9.1 years	Self-administered Block 98 food frequency questionnaire (FFQ)	Sugary beverages	Interview by telephone, Social Security Administration Master Death File	Model 1: unadjusted Model 2: demographic characteristics, smoking, and alcohol use Model 3: Model 2+ body mass index Model 4: Model 3+	Lowest: 0%-<5% of Total Energy Highest: ≥10% of Total Energy	Model 1: 1.31 (1.13-1.51) Model 2: 1.16 (1.00-1.35) Model 3: 1.15 (0.99-1.34) Model 4: 1.14	8

											physical activity, and diet.		(0.97-1.33)	
Dominiguez, 2018 (12)	Spain; SUN (Seguimiento Universitario de Navarra)	Spanish Government-Instituto de Salud Carlos III, and the European Regional Development Fund (FEDER), Navarra Regional Government, University of Navarra	18-101 Men: 42.7 ±13.3 Women: 35.1 ±10.7	Men and women; N/A	18.540	255	9.5 years	136-item FFQ	Processed meat (dry cured ham [Serrano ham type], cooked ham [York ham type], sausages [salami, mortadella, blood sausage, spicy pork sausage, würstel], bacon, pancetta, paté);	Uninterrupted and dynamic 135 follow-up, National Death Index	Multivariate adjusted: age, sex, year of entering the cohort, years of university education, body mass index, smoking, Alcohol, physical activity, hours per day spent watching television, baseline hypercholesterolemia, baseline hypertension, history of depression, history of cardiovascular disease, history of cancer, history of diabetes, following special diets at baseline,	Processed meat Lowest: <3 servings/wk Highest: >7 servings/wk	For participants older than 45 years in the SUN: Processed meat Age-, sex-adjusted: 1.52 (0.77, 3.02) Multivariate-adjusted 1.57 (0.76, 3.24)	8

											snacking between meals, and total energy intake.			
Etemadi, 2017 (13)	USA; NIH-AARP Diet and Health Study	Intramural Research Program in the Division of Cancer Epidemiology and Genetics, the US National Institutes of Health (NIH), National Cancer Institute (NCI).	50-71	Men and women; Non-Hispanic white, non-Hispanic black, Hispanic, and Asian/Pacific Islander/Native American	536.969	128.524	15.6 years	A 124 item food frequency questionnaire	National Cancer Institute Diet History Questionnaire (DHQ); Processed red meat (bacon, beef cold cuts, ham, hotdogs, and sausage), processed white meat (poultry cold cuts, low fat sausages, and low fat hotdogs made from poultry)	Annual linkage of the cohort to the Social Security Administration Death Master File in the US verification of vital status	Sex, age at entry to study, marital status, ethnicity, education, fifths of a composite deprivation index as an indicator of socioeconomic status, perceived health at baseline	Lowest: First quintile Highest: Fifth quintile	Processed red meat: 1.15 (1.13,1.17) Processed white meat: 0.95 (0.93,0.96) Processed meat: 1.12 (1.09,1.14)	8
Fortes, 2000 (14)	Italy, N/A	Lazio Regional Health Authority	80	Men, women; N/A	162	53	5 years	FFQ	Sausages	Registry Office of the	Not adjusted (crude RR)	High: ≥ 1 per week	0.87 (0.37-2.04)	6

										Municipality of Rome		Low: <1 per week		
Gonzalez, 2008 (15)	Spain; N/A	Fondo de Investigaciones Sanitarias (Instituto de Salud Carlos III, Madrid, Spain)	60-85	Men and women; N/A	304	83	6 years	Semiquantitative food frequency questionnaire (FFQ)	Sugar and sweets (chocolate, honey, candies), cereal and bakery products	Nursing institutions	Age, gender, BMI, energy intake, hyperglycemia, hypercholesterolemia, chewing ability, physical activity, smoking, self perceived health, education level and institution	1 SD increase	Cereals and bakery: 0.96 (0.73–1.27) Sugar and sweets: 1.29 (0.88–1.90)	8
He, 2010 (16)	USA, Nurses' Health Study	National Institutes of Health, the American Heart Association Scientist Development Award, and the Boston Obesity Nutrition Research Center	30-55	Women, N/A	121 700	852	26 years	FFQ	Cereal fiber	Reported by next of kin or the postal system or identified through the National Death Index	Multivariate model 1: age, smoking status, BMI, alcohol intake, physical activity, parental history of MI, menopausal status and use of hormone therapy, and	Lowest: First quintile Highest: Fifth quintile	Multivariate model 1: 0.81 (0.64–1.03) Multivariate model 2: 0.86 (0.66–1.12)	7

											duration of diabetes mellitus Multivariate model 2: age, smoking status , BMI , alcohol intake, physical activity, parental history of MI, menopausal status and use of hormone therapy, and duration of diabetes mellitus, total energy, intakes of polyunsaturated, saturated, and trans fat, magnesium, and folate			
Huang , 2015 (17)	USA, NIH-AARP	NutraSource	50-71	Men, women; white, black, Hispanic/Asian/Pacific	367,442	46,067	14 years	FFQ	Cereal fiber	Social Security Administration Death Master File	Model 1: Age and gender; Model 2: Age, gender,	Lowest: First quintile (2.02 g/day)	Model 1: 0.59 (0.58–0.61)	8

				Islander/American Indian/Alaskan native, or unknown/						and follow-up searches of the National Death Index Plus	the number of cigarettes smoked per day, and time of smoking cessation (<1 years, 1 to 5 years, 5 to 10 years, or ≥10 years before baseline); Model 3: Age, gender, the number of cigarettes smoked per day, time of smoking cessation (<1 years, 1 to 5 years, 5 to 10 years, or ≥10 years before baseline), race or ethnicity group, alcohol intake, education level, marital status (yes,	Highest: Fifth quintile (10.22 g/day)	Model 2: 0.76 (0.73–0.78) Model 3: 0.81 (0.79–0.84)
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											no), health status (poor, fair, good, very good), obesity (underweight, overweight, obesity), physical activity, consumption of red meat, total fruit and total vegetables, total energy intake, and hormone usage.			
Johnsen, 2015 (18)	Norway, Sweden, Denmark, The HELGA cohort (the Norwegian Women and Cancer Study+ the Vasterbotten Intervention Programme	Nordforsk and the Danish Cancer Society	Women= 51y (median) Men = 54y (median)	Men and women, Scandinavia	120.009	7.839	11.1-14.2 years	FFQ	Whole-grain intake (breakfast cereals, non-white bread and crisp bread)	National Central Population Registries	Age, follow-up time, education, smoking intensity, alcohol, BMI, total energy intake and alcohol intake	Highest: Fourth quartile (50 g/d) Lowest: First quartile (0 g/d)	Breakfast cereals women : 0.75 (0.69, 0.82) men: 0.74 (0.68, 0.84)	8

	(VIP cohort+ and the Danish Diet Cancer and Health Study)													
Kahn, 1984 (19)	USA; N/A	National Cancer Institute, National Institute on Aging	30+	Men and women; N/A	27.530	N/A	21 years	Questionnaire	Bread, rolls, or biscuits, cereal	The file of death certificates	Age, sex, smoking, history of disease, and age at initial exposure to the Seventh-Day Adventist Church	Lowest: <1 days/week Highest: 7 days/week	Bread, rolls, or biscuits : 0.82 (0.71, 0.96, 99%CI) Cereal: 0.84 (0.73, 0.97, 99%CI)	6
Kappler, 2013 (20)	USA; NHANES III	Department of health and human services, Food and drug administration , Health resources and services administration , National Institutes of Health, Substance abuse and mental health services administration	18+	Men and women; Non-hispanic white, Non-hispanic black, Mexican-American, Other	17.611	3.683	22 years	81-item food frequency questionnaire	Bacon, sausage and other processed meats	National Center for Health Statistics	Age, race, sex, cigarette smoking, alcohol consumption, physical activity, socioeconomic status, BMI, marital status, fruit and vegetables intake, history of	Lowest: 0 times/month Highest: 30 times/month	1.06 (0.85–1.33)	9

		, social security administration, department of agriculture, environmental protection agency, department of commerce									hypertension, diabetes, hypercholesterolemia, use of aspirin and ibuprofen, use of mineral and vitamin supplements, family history of diabetes or hypercholesterolemia; hormone replacement therapy and oral contraceptive use (in women)			
Kim, 2019 (21)	USA; The Third National Health and Nutrition Examination Survey (NHANES III)	Department of health and human services, Food and drug administration, Health resources and services administration, National Institutes of Health, Substance abuse and mental health	≥20 y	Men and women; Non-Hispanic White; non-Hispanic Black; Mexican American, others	11.898	2.451	19 years	81 item FFQ, which assessed participants' usual intakes of foods and beverages consumed in the past	Ultra-processed foods from NOVA classification	National Death Index	Model 1: age, sex, race/ethnicity and total energy intake Model 2: Model 1 plus poverty level, education level, smoking status, physical activity and	Lowest: First quartile Highest: Fourth quartile	Model 1: 1.29 (1.09-1.53) Model 2: 1.31 (1.09-1.58) Model 3: 1.30 (1.08-1.57)	9

		services administration, social security administration, department of agriculture, environmental protection agency, department of commerce						month, and a 24 h dietary recall			alcohol intake Model 3: Model 2 plus BMI, hypertension status, total cholesterol and estimated glomerular filtration rate			
Lee, 1998 (22)	USA; Harvard alumni health study	National Institutes of Health	60-72	Men; N/A	7.841	514	5 years	Questionnaire	Candy	Death certificates	Multivariable adj: Age, BMI, Energy expenditure, Cigarette habit, Duration of smoking, Intake of alcohol, Intake of red meat, Intake of vegetables or green salad, using vitamin or mineral supplements	Lowest: Non-consumers Highest: Consumers	Adj for age: 0.83 (0.70-0.98) Multivariable adj: 0.73 (0.60-0.89)	4
Li, 2014 (23)	USA; NHS, HPFS	National Institutes of Health	HPFS: 40-75	Men, women; N/A	2639 women and	682 women, 451	9 years	FFQ	Cereal fiber	Vital records, the national	Time since MI onset, age at diagnosis,	Lowest: First quintile	0.73 (0.58 to 0.91)	7

			NHS: 30-55		2081 men	men				death index, and reports by the participant' s next of kin, or the postal system	and calendar year, total caloric intake, physical activity, aspirin use, diabetes, high blood pressure , use of lipid lowering drugs, alcohol consumption , saturated fat intake, n3 fatty acid intake, trans fatty acid intake, married, body mass index, coronary artery bypass surgery, folate intake , and pre-MI intake	women: 4.0 (1.7) men: 5.3 (2.1)g/d Highest: Fifth quintile women: 8.4 (4.0) men: 11.2 (4.8)		
Liu, 2003 (24)	USA; The Physicians ' Health Study	National Institutes of Health	40– 84	Men; N/A	86.19 0	3.114	5.5 years	Semiqua ntitative food- frequenc y	Whole- grain breakfast cereals, Refined-	National Death Index	Model 1 : age Model 2: age, cigarette	Lowest: Rarely or never	Whole- grain: Model 1:	8

								question naire	grain breakfast cereals		smoking, alcohol intake, physical activity, BMI, history of type 2 diabetes, high cholesterol, and hypertensio n and use of multivitami ns.	Highest: ≥1 serving/ d	0.73 (0.65, 0.82) Model 2: 0.83 (0.73, 0.94) Refined -grain: Model 1: 1.03 (0.91, 1.16) Model 2: 1.09 (0.95, 1.25)	
Liu, 2018 (25)	China, Mr. and Ms. OS Hong Kong Study	National Institutes of Health R01 grant AR049439- 01A1 and the Research Grants Council EarmarkedGr ant CUHK4101/0 2M	72.5 (5.2)	Men, women; asian	4000	769	11.1 years	FFQ	Free sugar as defined by WHO includes monosacc haraides and disacchari des that are added to foods (added sugar) by the manufact urers, cooks or	Death Registry of the Department of Health of Hong Kong	Full adjustment: age (y), sex (M or F), education, body mass index (kg/m2), dietary protein and carbohydrat e (g/1000 kcal), fish intake (g/ 1000 kcal), fruits and vegetables intake	Free sugar intake (% calories): Highest: 8.46 (6.56– 54.9) Lowest: 0.87 (0– 1.61) Added sugar intake (%)	Free sugar intake: 0.770 (0.608, 0.975) Added sugar intake: 0.750 (0.590, 0.954)	8

									consumer s, and sugars naturally present (natural sugar) in honey, syrups, fruit juices	(g/1000 kcal), cigarette smoking (packs/y), coffee drinking (mi/d), tea drinking (ml/w), alcohol (g/d), multivitami n intake (y or n), total score of AHA- DLR (American Heart Association Dietary and Lifestyle Recommend ations); history of any cardiovascul ar diseases(y or n), history of any cancers (y or n), medication for hypertensio n (y or n),	calories) Highest: 6.86 (4.99– 54.9) Lowest: 0.67 (0– 1.12)		
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											PASE total scores.			
Malik, 2019 (26)	USA, Health Professionals Follow-up study (HPFS), Nurses' Health study (NHS)	National Institutes of Health	HPFS: 40-75 NHS: 30-55	Men and women; white and non-white	118.363	36.436	HPFS: 28 years NHS: 34 years	Self-administered food frequency questionnaire (FFQ)	Sugar-sweetened beverages (SSB) and Artificially sweetened beverages (ASB)	State vital statistics records, the National Death Index, reports from next of kin or the postal authorities	Model 1: age, smoking, alcohol intake, postmenopausal hormone use (NHS), physical activity, family history of diabetes, family history of myocardial infarction, family history of cancer, multivitamin use, ethnicity, and aspirin use Model 2: Model 1+ baseline history of hypertension and hypercholesterolemia; intake of whole grains, fruit,	Lowest: <1/mo Highest: ≥ 2/d	SSB Age-adj: 1.52 (1.43, 1.61) Model 1: 1.30 (1.22, 1.38) Model 2: 1.21 (1.13, 1.28) ASB Age-adj: 1.27 (1.21, 1.33) Model 1: 1.16 (1.11, 1.21) Model 2: 1.07 (1.02, 1.12)	8

											vegetables, and red and processed meat; total energy, and body mass index			
Mejborn, 2020 (27)	Denmark; N/A	Promilleafgiftsfonden for Landbrug, Denmark	54	Men and women, Danish Western Non-Western	9848	640	Mean 10.8	self-administered, quantitative seven-day pre-coded food diaries	Processed meat	Register of Causes of Death	Model 2: adjusted by sex, Model 2: adjusted by sex, educational attainment, ethnicity, smoking, physical activity, alcohol, BMI, and total energy intake.	<19g/d vs. >58g/d	1: 0.88 (0.69;1.12) 2: 1.02 (0.82;1.26)	8
Mullee, 2019 (28)	Denmark, France, Germany, Greece, Italy, the Netherlands, Norway, Spain, Sweden, and the United Kingdom; European Prospectiv	Europe Against Cancer Program of the European Commission, Deutsche Krebshilfe, Deutsches Krebsforschungszentrum, German Federal Ministry of Education and	50.8 ± 9.8	Men and women; N/A	451.743	41.693	16.4 years	Combined semiquantitative food frequency questionnaire and 7-day dietary diary and diet interview	Soft drinks (soft drinks, carbonated and isotonic drinks, and diluted syrups): Artificially sweetened soft	Record linkages with cancer registries, boards of health, and death indices, active follow-up	Basic model: Total energy intake (kcal per day) and stratified by age, EPIC (European Prospective Investigation into Cancer and Nutrition)	Lowest: <1 glass/month Highest: ≥2 glass/day	Total soft drinks: Basic model: 1.26 (1.20-1.32) Multivariable model: 1.17 (1.11-1.22)	8

	<p>e Investigation into Cancer and Nutrition (EPIC)</p>	<p>Research; Danish Cancer Society; Health Research Fund (FIS) of the Spanish Ministry of Health, Spanish Regional Governments of Andalusia, Asturias, Basque Country, Murcia and Navarra; ISCIII RCESP exp. C03/09, Spain; Cancer Research UK; Medical Research Council, United Kingdom; Stroke Association, United Kingdom; British Heart Foundation; Department of Health, United Kingdom;</p>							<p>drinks, Sugar- sweetene d soft drinks</p>		<p>center, and sex</p> <p>Multivariabl e model: Body mass index, physical activity index , educational status, alcohol consumptio n, smoking status and intensity , smoking duration , ever use of contraceptiv e pill , menopausal status , ever use of menopausal hormone therapy and intakes of total energy , red and processed meat, fruits and vegetables, coffee, and fruit and vegetable</p>	<p>Artifici ally sweete ned soft drinks: Basic model: 1.35 (1.25- 1.45) Multiva riable model: 1.26 (1.16- 1.35)</p> <p>Sugar- sweete ned soft drinks: Basic model: 1.16 (1.08- 1.25) Multiva riable model: 1.08 (1.01- 1.16)</p>	
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		<p>Food Standards Agency, United Kingdom; Wellcome Trust, United Kingdom; the Hellenic Health Foundation and the Stavros Niarchos Foundation; Italian Association for Research on Cancer (AIRC); Italian National Research Council, Fondazione-Istituto Banco Napoli, Italy; Dutch Ministry of Public Health, Welfare and Sports (VWS), Netherlands Cancer Registry (NKR), LK Research Funds, Dutch</p>								<p>juice, and stratified by age, EPIC center, and sex.</p>			
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		Prevention Funds, Dutch ZON (Zorg Onderzoek Nederland), World Cancer Research Fund (WCRF), Statistics Netherlands (The Netherlands); Swedish Cancer Society; Swedish Scientific Council; Regional Government of Skåne, Sweden; Nordforsk the Norwegian Cancer Society; French League against Cancer (LNCC); National Institute for Health and Medical Research (INSERM), France;												
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		Mutuelle Générale de l'Éducation Nationale (MGEN), France; 3M Co, France; Gustave Roussy Institute (IGR), France; and General Councils of France.												
Odegaard, 2015 (29)	Singapore, Singapore Chinese Health Study	National Institutes of Health	45–74	Men and women; asian	52.584	10.029	16.3 years	Past-year semiquantitative FFQ	Sugar-sweetened beverages (soft drinks)	Nationwide registry of birth and death in Singapore	Age, sex, dialect, education, year of interview, smoking, moderate and vigorous activity, sleep, BMI, hypertension (except for cancer), non beverage vegetable-fruit-soy-rich dietary pattern score, and energy intake.	Lowest: none Highest: $\geq 1/d$	0.92 (0.81, 1.04)	9

Pagani ni- Hill, 2007 (30)	USA, Leisure World Cohort Study	National Institutes of Health, Earl Carroll Trust Fund, the Al and Trish Nichols Chair in Clinical Neuroscience, and Wyeth- Ayerst Laboratories	44- 101 (median 74 years)	Men and women; mostly Caucasian	13.97 8	11.38 6	23 years	Question naire	Non- alcoholic beverages (Cola with sugar, Cola artificially sweetened, Other soft drinks with sugar, Other soft drinks artificially sweetened), chocolate	Search of death indexes and ascertainment of death certificates	Model 1: adjusted for age and sex. Model 2: adjusted for age, sex, smoking, exercise, body mass index, alcohol intake, and histories of hypertension, angina, heart attack, stroke, diabetes, rheumatoid arthritis, and cancer.	Lowest: None Highest: >1 cans/week	Cola with sugar: Model 1: 1.00 (0.90– 1.11) Model 2: 1.02 (0.92– 1.13) Cola artificially sweetened: Model 1: 1.24 (1.12– 1.36) Model 2: 1.18 (1.07– 1.30) Other soft drinks with sugar: Model 1: 1.00 (0.89– 1.12) Model 2: 1.03 (0.92– 1.16) Other soft	9
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													drinks artificially sweetened: Model 1: 1.11 (1.01–1.23) Model 2: 1.07 (0.97–1.19)	
Pan, 2012 (31)	USA, Health Professionals Follow-up study (HPFS), Nurses' Health study (NHS)	National Institutes of Health	HPFS: 40–75 NHS: 30–55	Men and women; whites, non-whites	121.342	23.926	HPFS: 22 years NHS: 28 years	Food frequency questionnaire	Processed red meat (bacon, hot dog, sausage, salami, bologna, and other processed red meats)	Reports from the next of kin, postal authorities, or by searching National Death Index	Multivariate model: adjusted for age, body mass index category, alcohol consumption, physical activity level, smoking status, race, menopausal status and hormone use in women, family history of diabetes, myocardial infarction, or cancer, history of	Lowest: First quintile Highest: Fifth quintile	Processed foods Multivariate model: 1.23 (1.16–1.30)	8

											diabetes, hypertension, or hypercholesterolemia, quintiles of total energy intake, whole grains, fruits, and vegetables			
Ramne, 2019 (32)	Sweden; the Malmö Diet and Cancer Study, Northern Swedish Health and Disease Study	Swedish Research Council, the Swedish Society for Medical Research, the Albert Pahlsson Foundation, the Crafoord Foundation, and the Swedish Heart and Lung Foundation	MDC S= 57.6 (44–73) NSH DS= 48.6 (36–64)	Men and women, N/A	48.747	9.190	MD CS= 19.9y NSH DS= 20.1y	FFQ	The added sugar intake (the basis of his or her total intake of sucrose and monosaccharides (glucose and fructose) from their whole diet); SSB	The Swedish National Tax Agency, Statistics in Sweden, and the National Board of Health and Welfare	Basic adjusted: Age, sex, and energy intake Fully adjusted: Energy intake, age, sex, educational level, leisure-time physical activity, smoking status, alcohol habits, dietary habits and BMI	Highest: ≥20% TE Lowest: <5% TE	added sugar: MDCS Basic adjusted: 1.62 (1.41, 1.87) Fully adjusted: 1.30 (1.12, 1.51) NSHDS Basic adjusted: 1.49 (1.16, 1.91) Fully adjusted: 1.31 (1.01, 1.70) SSB: MDCS	8

													Fully adjusted: 1.14 (1.03,1.26) NSHD S Fully adjusted: 1.10 (0.90, 1.35)	
Rico-Campà, 2019 (33)	Spain; Seguimien to Universidad de Navarra (SUN)	Spanish Government-Instituto de Salud Carlos III, and the European Regional Development Fund (FEDER)	20-91	Men and women; N/A	19.899	335	10.4 years	136 item food frequency questionnaire	Ultra-processed foods from NOVA classification	Reports from next of kin, work associates, and authority postal service, medical records, Spanish National Death Index and the National Statistics Institute	Multivariate adj: age, sex, marital status, physical activity, smoking status, snacking, special diet at baseline, body mass index, total energy intake, alcohol consumption, family history of cardiovascular disease, diabetes at baseline, hypertension at	Lowest: First quarter (<2 servings/day) Highest: Fourth quarter (>4 servings/day)	Age-sex adj.: 1.72 (1.22 - 2.43) Multivariable adj: 1.62 (1.13 - 2.33)	8

											baseline, self reported hypercholesterolaemia at baseline, CVD at baseline, cancer at baseline, depression at baseline, education level and lifelong smoking; stratified by recruitment period, deciles of age, sedentary index and television viewing			
Rohmann, 2013 (34)	France, Italy, Spain, The Netherlands, United Kingdom, Greece, Germany, Sweden, Norway, and Denmark; European Prospective	Europe Against Cancer Program of the European Commission, Deutsche Krebshilfe, Deutsches Krebsforschungszentrum, German Federal Ministry of Education and	35-69	Men and women; N/A	448.568	26.344	12.7 years	Food frequency questionnaire (FFQ)	Processed meat (all meat products, including ham, bacon, sausages; small part of minced meat that has been bought as	Cancer registries, Boards of Health, and death indices or active follow-up	Stratified by age, sex, study center, adjusted for education, body weight, body height, total energy intake, alcohol consumption, physical activity, smoking	Lowest: 0 to 9.9 g/day Highest: 160+ g/day	Ref: 10-19.9 g/day 1.43 (1.24, 1.64)	8

	Investigati on into Cancer and Nutrition (EPIC)	Research; Danish Cancer Society; Health Research Fund (FIS) of the Spanish Ministry of Health, Spanish Regional Governments of Andalusia, Asturias, Basque Country, Murcia and Navarra; ISCIH RCESP exp. C03/09, Spain; Cancer Research UK; Medical Research Council, United Kingdom; Stroke Association, United Kingdom; British Heart Foundation; Department of Health, United Kingdom;							a ready- toeat product)		status, smoking duration, meat intake mutually adjusted for each other			
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		Food Standards Agency, United Kingdom; Wellcome Trust, United Kingdom; the Hellenic Health Foundation and the Stavros Niarchos Foundation; Italian Association for Research on Cancer (AIRC); Italian National Research Council, Fondazione-Istituto Banco Napoli, Italy; Dutch Ministry of Public Health, Welfare and Sports (VWS), Netherlands Cancer Registry (NKR), LK Research Funds, Dutch												
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		Prevention Funds, Dutch ZON (Zorg Onderzoek Nederland), World Cancer Research Fund (WCRF), Statistics Netherlands (The Netherlands); Swedish Cancer Society; Swedish Scientific Council; Regional Government of Skåne, Sweden; Nordforsk the Norwegian Cancer Society; French League against Cancer (LNCC); National Institute for Health and Medical Research (INSERM), France;												
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		Mutuelle Générale de l'Éducation Nationale (MGEN), France; 3M Co, France; Gustave Roussy Institute (IGR), France; and General Councils of France.												
Schnabel, 2019 (35)	France, French NutriNet-Santé Study	University of Paris 13	56.7 ±7.5	Men and women; N/A	44.551	602	7.1 years	Web-based 24-hour dietary records	Ultra-processed foods from NOVA classification	CépiDC, the French national registry of specific causes of mortality.	Model 1: Adjusted for sex and age. Model 2: Adjusted for model 1 + income level, education level, marital status, residence, BMI, physical activity, smoking status, energy intake, alcohol intake, season of food	Lowest: First quartile Highest: Fourth quartile	Model 1: 1.25 (1.00-1.56) Model 2: 1.26 (1.00-1.58)	8

											records, 1st degree family history of cancer or cardiovascular diseases, number of food records.			
Sheehy, 2020 (36)	USA; BHWS	NIH, R01CA058420, UM1CA164974, U01CA164974, R01MD015085.	38	Black women	56,314	5054	22 years	National Cancer Institute Block FFQ	Processed red meats included sausage, bacon, hot dogs, ham, bologna, salami, and other lunch meats	National Death Index? the Social Security Administration Death Master File, and the US Postal Service	Adjusted for age, questionnaire cycle. BMI, education level, geographic region, neighborhood SES, physical activity level, cigarette smoking, family history of myocardial infarction, family history of cancer, history of diabetes, history of hypertension, history of hypercholesterol.	Lowest: 0.01 servings/d; highest: 1.2 servings/d	1.40 (1.28;1.55)	8

											erolemia, total energy intake, and modified 2010 Alternative Healthy Eating Index without red meat.			
Sinha, 2009 (37)	USA; National Institutes of Health–AARP Diet and Health Study	Intramural Research Program of the NIH, National Cancer Institute (NCI)	50-71	Men and women; non-Hispanic white, non-Hispanic black, Hispanic/Asian/Pacific Islander/American Indian/Alaskan native	545.653	71.252	10 years	Food frequency Questionnaire	Processed meat (bacon, red meat sausage, poultry sausage, luncheon meats (red and white meat), cold cuts (red and white meat), ham, regular hotdogs and low-fat hotdogs made from poultry)	Annual linkage of the cohort to the Social Security Administration Death Master File in the US verification of vital status	Basic model: age, race, and total energy intake Adjusted model: basic model plus education, marital status, body mass index, smoking status, time since quitting for former smokers, and smoking dose, frequency of vigorous physical activity, alcohol intake,	Lowest: First quintile Highest: Fifth quintile	Basic model: 1.30 (1.26-1.34) Adjusted model: 1.16 (1.12-1.20)	8

											vitamin supplement user, fruit consumption, and vegetable consumption			
Steffen, 2003 (38)	USA; Atherosclerosis Risk in Communities (ARIC) Study	National Heart, Lung, and Blood Institute	45–64	Men and women; white and African American	15.792	867	11 years	Semiquantitative food-frequency questionnaire	Whole grain were dark bread and whole-grain cold breakfast cereal; refined grain included cold breakfast cereals containing < 25% whole grain or bran by weight, cooked cereals, white bread, bagels, donuts, pastry, muffins, biscuits, cookies,	Local and national death-certificate registries	Model 1: age at baseline, race, sex, and time-dependent energy intake Model 2: Model 1+ education, smoking status, pack-years of smoking, physical activity, alcohol intake, and hormone replacement in women. Model 3: Model 2+ BMI, waist-to-hip ratio, systolic blood pressure, and use of	Whole-grain intake: Lowest: First quintile (0.1 servings/d) Highest: Fifth quintile (3.0 servings/d) Refined-grain intake: Lowest: First quintile (0.5 servings/d) Highest: Fifth quintile (5.0	Whole-grain intake: Model 1: 0.52 (0.41, 0.65) Model 2: 0.75 (0.59, 0.95) Model 3: 0.77 (0.61, 0.97) Refined-grain intake: Model 1: 1.34 (1.04, 1.72) Model 2: 1.09 (0.84, 1.42)	9

									cake, brownies, pasta, and rice		antihypertensive medications	servings /d)	Model 3: 1.08 (0.83, 1.40)	
Streppel, 2008 (39)	Netherlands, Zutphen Study	Inspectorate for Health Protection and Veterinary Public Health	49 ± 6	Men; N/A	1373	1130	40y	FFQ	Dietary fiber from bread & cereal products	Follow-up records	-Crude -Adjusted: total energy, saturated fat, trans unsaturated fatty acid, and cis polyunsaturated fat intakes; alcohol intake; wine use; fish intake; prescribed diet; the number of cigarettes smoked; duration of cigarette smoking; cigar or pipe smoking; BMI; and socioeconomic status	per 10-g/d increment	Crude: 0.80 0.69, 0.94 Adjusted: 0.90, 0.77, 1.05	9
Tasevska, 2014 (40)	USA, NIH-AARP Diet and Health Study	Intramural Research Program of the National Cancer Institute, NIH,	50-71	Men and women; white, black, Hispanic/Asian/Pacific Islander/Am	353.751	15.062	13 years	NIH Diet History Questionnaire	Sugars from beverages, sugars from solid foods	US Social Security Administration Death Master File	Age, BMI, marital status, smoking, race, education,	Lowest: First quintile Highest: Fifth quintile	Women Sugars from solid foods	8

		Department of Health and Human Services		erican Indian/Alaskan native, or unknown/missing							physical activity, and intake of energy, vegetables, alcohol		0.99 (0.94, 1.06) Sugars from beverages 1.05 (1.00, 1.11) Men Sugars from solid foods 1.01 (0.97, 1.06) Sugars from beverages 0.99 (0.95, 1.03)	
van Den Brandt, 2019 (41)	Netherlands; The Netherlands Cohort Study	The Netherlands Cancer Foundation and the Ministry of Welfare, Public Health and Cultural Affairs	55–69	Men and women; N/A	120852	12.386	10 years	Semi-quantitative food-frequency questionnaire (FFQ)	Processed meat (ham, bacon, smoked beef or pork loin roll, and other sliced cold meats (e.g.,	Dutch Central Bureau of Genealogy and Statistics Netherlands	Multivariable adj.: Age at baseline, sex, cigarette smoking status, number of cigarettes smoked per day, and years of smoking, history of	Lowest: First quintile Highest: Fifth quintile	Age-sex adj: 1.18 (1.02–1.37) Multivariable adj: 1.21 (1.02–1.44)	8

									sausages))		physician-diagnosed hypertension and diabetes, body height, BMI, non-occupational physical activity, highest level of education, intake of alcohol, vegetables and fruit, energy, use of nutritional supplements ;, in women, postmenopausal HRT			
Wang, 2020 (42)	USA, Cancer Prevention Study-II Nutrition Cohort	American Cancer Society, Centers for Disease Control and Prevention's National Program of Cancer Registries, National Cancer	Pre-diagnosis: 69.2 (5.4) Post-diagnosis: 72.1 (6.1)	Men; white, black, other	Pre-diagnosis: 9,286 Post-diagnosis: 4,882	Pre-diagnosis: 4,682 Post-diagnosis: 2,768	N/A	FFQ	Processed meat: sausages, hot dogs, bacon, ham, and luncheon meats	National Death Index	Age at diagnosis; calendar year of diagnosis; tumor extent; Gleason score; nodal involvement ; education; family history of	Prediagnosis Highest: Fourth quartile (5.2 servings /week) Lowest: First quartile (0.2 servings /week)	Pre-diagnosis is: 1.08 (0.98–1.18) Post-diagnosis is: 1.12 (0.80–1.57)	7

		Institute's Surveillance, Epidemiology, and End Results Program									prostate cancer; history of PSA testing; BMI; smoking status; physical activity; history of diabetes, cardiovascular disease history, and other cancer; total fruit and vegetable intake; and energy intake	Postdiagnosis Highest: Fourth quartile (5.1 servings/week) Lowest: First quartile (0.6 servings/week)		
White man, 1999 (43)	UK; OXCHECK study	Imperial Cancer Research Fund	35–64	Men and women; N/A	11090	598	9 years	Simple food frequency questions modified from a 'health and lifestyle survey'	Biscuits, cakes, puddings, sweets, Processed meat (e.g. pies, burgers, sausages, etc.), Chips, Hard margarine	Office for National Statistics	Gender, smoking and age group	Lowest: <1 day/week Highest: 4–7 days/week	Biscuits, cakes, puddings, sweets: 0.68 (0.54–0.85) Processed meat: 1.05 (0.62–1.76) Chips:	7

													1.17 (0.71– 1.92)	
													Hard margarine vs. butter: 1.23 (0.94– 1.60)	
Xu, 2015 (44)	USA; National Institutes of Health (NIH)– AARP Diet and Health Study	NutraSource	50- 71	Men and women; non- Hispanic white, non- Hispanic black, Hispanic/ Asian/Pacific Islander/American Indian/Alaskan native	3674 42	46.06 7	14 years	Self administered 124-item food frequency questionnaire	Ready-to- Eat Cereal	Social Security Administration Death Master File and National Death Index Plus	Multivariate model 1: Age, gender, smoking status, smoking dose, and time since quitting smoking. Model 2: Model 1+ race/ethnicity, education, marital status, self- rated health status, body mass index, physical activity, use of menopausal hormone therapy, and	Lowest: Zero intake Highest: Fourth quartile	Age- adjusted: 0.67 (0.65, 0.69) Model 1: 0.80 (0.77, 0.82) Model 2: 0.85 (0.83, 0.88)	8

											intake of alcohol, red meat, fruits, vegetables, and total energy.			
Zhang, 2020 (45)	USA NHANES	Department of health and human services, Food and drug administration, Health resources and services administration, National Institutes of Health, Substance abuse and mental health services administration, social security administration, department of agriculture, environmental protection agency, department of commerce	18+	Men and women; Non-hispanic white, Non-hispanic black, Mexican-American, Other	31,402	3878	7.9y	24-h dietary recalls	SSBs (sodas, fruit-flavored drinks, sugar-added fruit juices, sweetened coffees and teas, sport and energy drinks, and other sweetened drinks) ASBs (sugarfree soft drinks and carbonated water)	National Death Index	Age, sex, family income-poverty ratio level, race, education level, marital status, alcohol consumption, smoking, and leisure-time physical activity, body mass index, prevalent high cholesterol level, hypertension, and diabetes, and history of cardiovascular disease and cancer, healthy eating index	≥ 2 servings/d vs. 0 servings/d	SSB: 1.17 (0.98–1.38) ASB: 0.86 (0.69–1.06)	9

											score-2015 and total energy intake			
Zheng, 2019 (46)	USA, Health Professionals Follow-up study (HPFS), Nurses' Health study (NHS)	National Institutes of Health	HPFS: 40-75 NHS: 30-55	Men and women; whites, non-whites	81.469	14.019	12 years	Semiquantitative food frequency questionnaire	Processed red meat included bacon (one serving, two slices, 13 g), hot dogs (one serving, one hot dog, 45 g), and sausage, salami, bologna, and other processed red meats (one serving, one piece, 28 g)	State vital statistics records, the national death index, or reported by families and the postal system	Model 1: age and calendar year Model 2: Model 1 + race, initial consumption of red meat, initial body mass index, family history of myocardial infarction, diabetes, and cancer; updated aspirin use and multivitamin use; menopause and hormone therapy status in women and simultaneous changes in other lifestyle	Lowest: >0.5 servings/day decrease in consumption in 8 years Highest: >0.5 servings/day increase in consumption in 8 years Ref. group: no change	Model 1: 1.19 (1.10 to 1.30) Model 2: 1.13 (1.04 to 1.23)	8

											factors: smoking status, initial and changes in physical activity, alcohol consumption, total energy intake, and other food groups, that is, vegetables, fruits, whole grains, and sugar-sweetened beverages (all in fifths).			
Zhong, 2020 (47)	USA, ARIC (Atherosclerosis Risk in Communities) study, CARDIA (Coronary Artery Risk Development in Young Adults)	Northwestern University Feinberg School of Medicine	53.7 ± 15.7	Men and women; Non-Hispanic white, Non-Hispanic black, Hispanic, Chinese, mixed	29.682	8.875	19.0	Validated food frequency questionnaire or diet history	Processed meat	N/A	Model1: Age, sex, race/ethnicity and educational level. Model 2: Model 1 +total energy, smoking status, smoking pack-years, cohort-	Additonal 2 servings/week	Model 1: 1.07 (1.05-1.08) Model 2: 1.04 (1.02-1.05) Model 3: 1.03 (1.02-1.05)	8

<p>study, CHS (Cardiovascular Health Study), FHS (Framingham Heart Study), FOS (Framingham Offspring Study), and MESA (Multi-Ethnic Study of Atherosclerosis)</p>									<p>specific physical activity z score, alcohol intake and hormone therapy Model 3: fruits, legumes, potatoes, other vegetables excluding legumes and potatoes, nuts and seeds, whole grains, refined grains, low-fat dairy products, high-fat dairy products, sugar-sweetened beverages, eggs, unprocessed red meat, poultry, and fish</p>			
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Web Table 2. The Newcastle Ottawa Scale to evaluate the quality of prospective cohort studies included in meta-analysis of the ultra-processed foods and all-cause mortality.

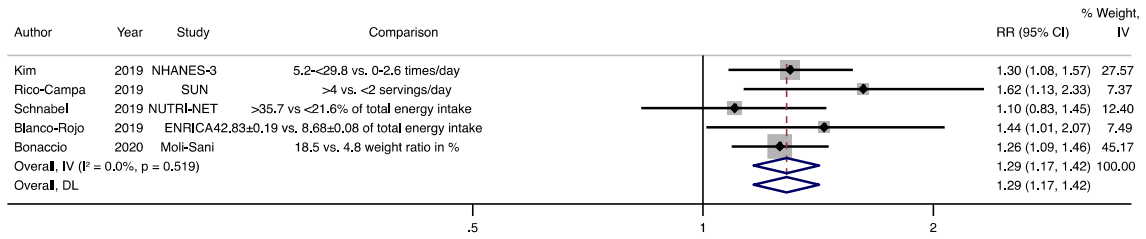
Author, year (Reference No)	Selection				Comparability	Outcome/Exposure			Total Score
	1	2	3	4	1	1	2	3	9
Alshahrani, 2019 (1)	*	*		*	**	*	*	*	8
Anderson, 2020 (2)	*	*		*	**	*	*	*	8
Argyridou, 2019 (3)	*	*		*	**	*	*	*	8
Baer, 2010 (4)	*	*		*	**	*	*	*	8
Barrington, 2016 (5)	*	*		*	**	*	*	*	8
Bellavia, 2014 (6)	*	*		*	**	*	*	*	8
Blanco-Rojo, 2019 (7)	*	*	*	*	**	*	*	*	9
Bonaccio, 2020 (8)	*	*	*	*	**	*	*	*	9
Burke, 2007 (9)		*	*		**	*	*		6
Chuang, 2012 (10)	*	*		*	**	*	*	*	8
Collin, 2019 (11)	*	*		*	**	*	*	*	8
Dominguez, 2017 (12)	*	*		*	**	*	*	*	8
Etemadi, 2017 (13)	*	*		*	**	*	*	*	8

Fortes, 1999 (14)		*	*	*	*	*	*	*	6
González, 2008 (15)		*	*	*	**	*	*	*	8
He, 2010 (16)	*	*			**	*	*	*	7
Huang, 2015 (17)	*	*		*	**	*	*	*	8
Johnsen, 2015 (18)	*	*		*	**	*	*	*	8
Kahn, 1984 (19)	*	*		*	*	*	*		6
Kappeler, 2013 (20)	*	*	*	*	**	*	*	*	9
Kim, 2019 (21)	*	*	*	*	**	*	*	*	9
Lee, 1998 (22)	*	*		*	*				4
Li, 2014 (23)	*	*			**	*	*	*	7
Liu, 2018 (24)	*	*		*	**	*	*	*	8
Liu, 2003 (25)	*	*		*	**	*	*	*	8
Malik, 2019 (26)	*	*		*	**	*	*	*	8
Mejborn, 2020 (27)	*	*		*	**	*	*	*	8
Mossavar-Rahmani, 2019 (48)	*	*		*	**	*	*	*	8
Mullee, 2019 (28)	*	*		*	**	*	*	*	8

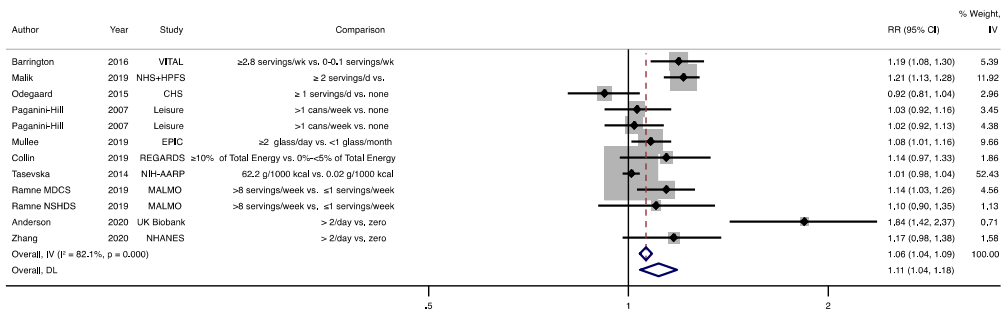
Odegaard, 2015 (29)	*	*	*	*	**	*	*	*	9
Paganini-Hill, 2007 (30)	*	*	*	*	**	*	*	*	9
Pan, 2012 (31)	*	*		*	**	*	*	*	8
Ramne, 2018 (32)	*	*		*	**	*	*	*	8
Rico-Campà, 2019 (33)	*	*		*	**	*	*	*	8
Rohrmann, 2013 (34)	*	*		*	**	*	*	*	8
Schnabel, 2019 (35)	*	*		*	**	*	*	*	8
Sheehy, 2020 (36)	*	*		*	**	*	*	*	8
Sinha, 2009 (37)	*	*		*	**	*	*	*	8
Steffen, 2003 (38)	*	*	*	*	**	*	*	*	9
Streppel, 2008 (39)	*	*	*	*	**	*	*	*	9
Tasevska, 2014 (40)	*	*		*	**	*	*	*	8
van den Brandt, 2019 (41)	*	*		*	**	*	*	*	8
Wang, 2002 (42)	*	*			**	*	*	*	7
Whiteman, 1999 (43)	*	*		*	*	*	*	*	7
Xu, 2015 (44)	*	*		*	**	*	*	*	8

Zhang, 2020 (45)	*	*	*	*	**	*	*	*	9
Zheng, 2019 (46)	*	*		*	**	*	*	*	8
Zhong, 2020 (47)	*	*		*	**	*	*	*	8

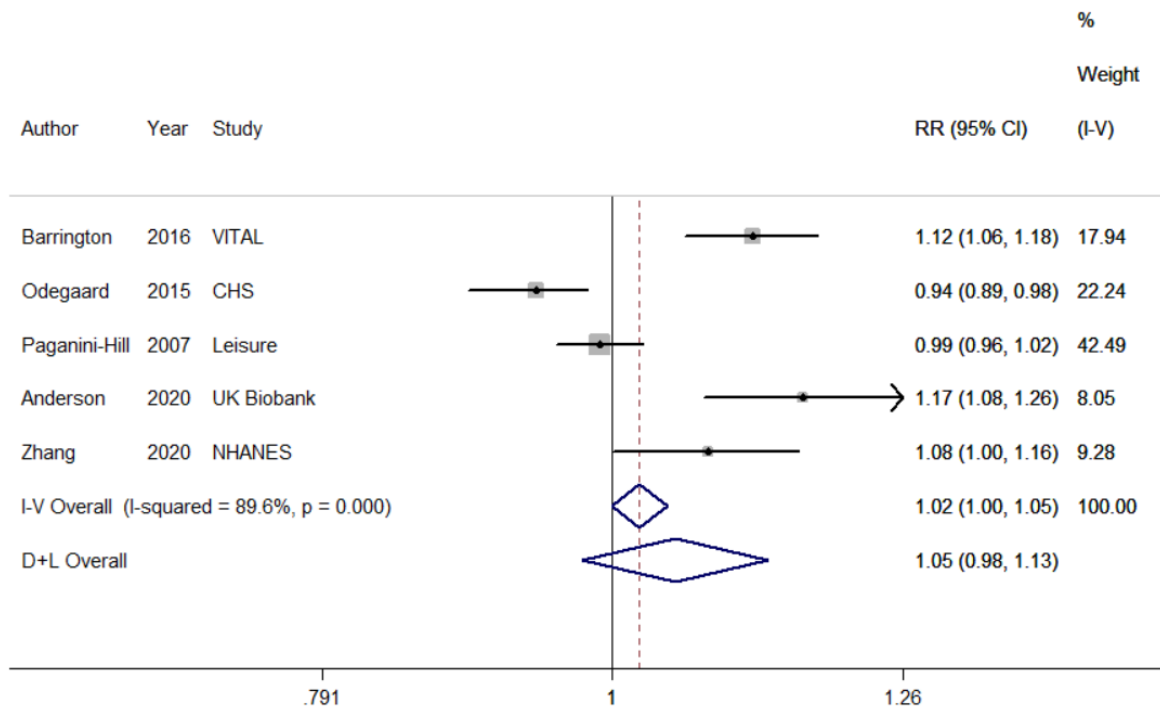
Web Figure 1. Forest plot of prospective studies investigating the association between UPF consumption and all-cause mortality (highest vs. lowest)



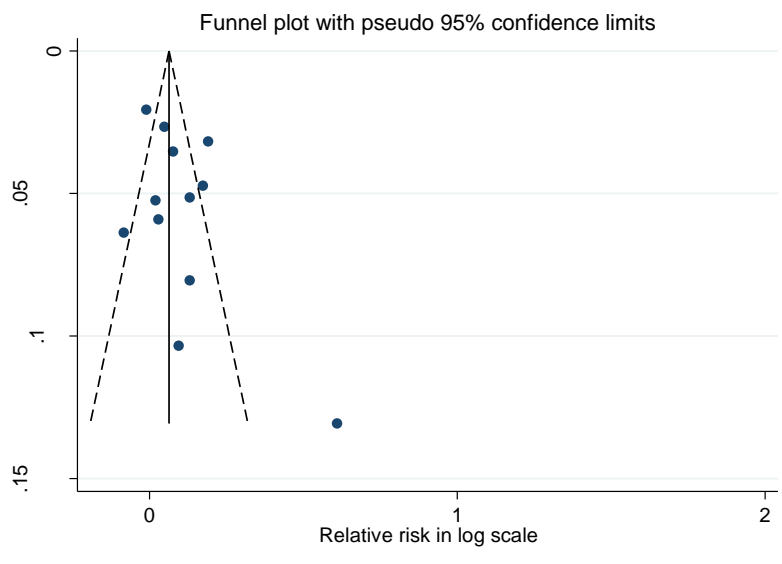
Web Figure 2. Forest plot of prospective studies investigating the association between SSB consumption and all-cause mortality (highest vs. lowest)



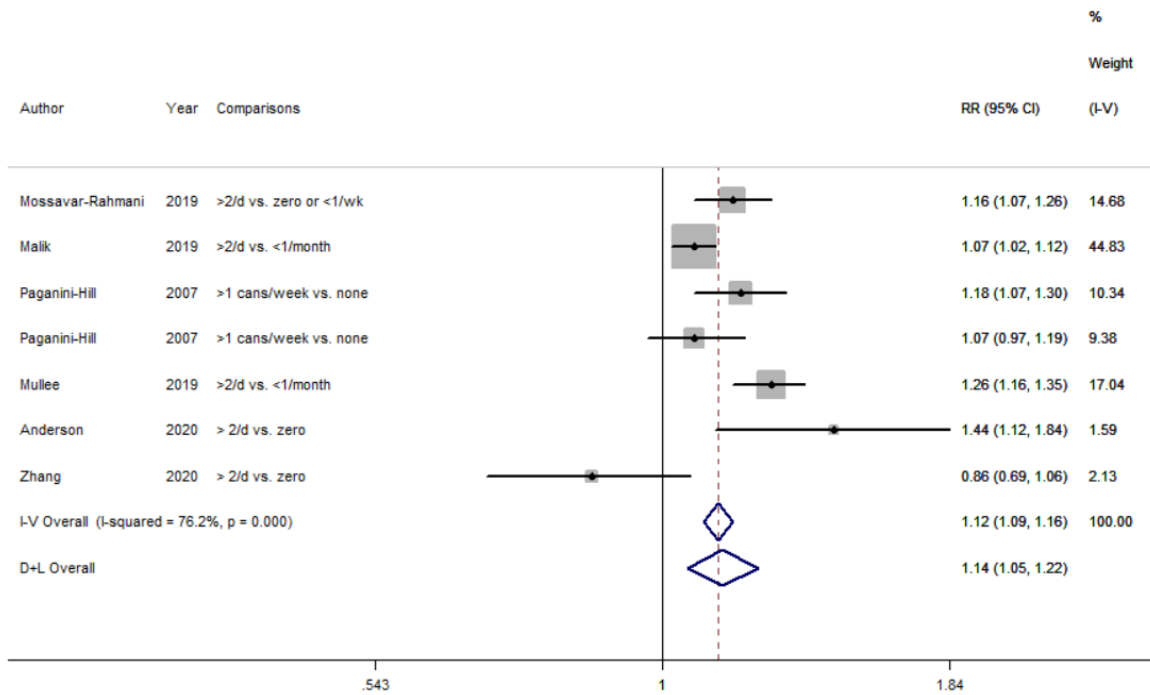
Web Figure 3. Forest plot of prospective studies investigating the association between SSB consumption and all-cause mortality (consumption vs. no consumption)



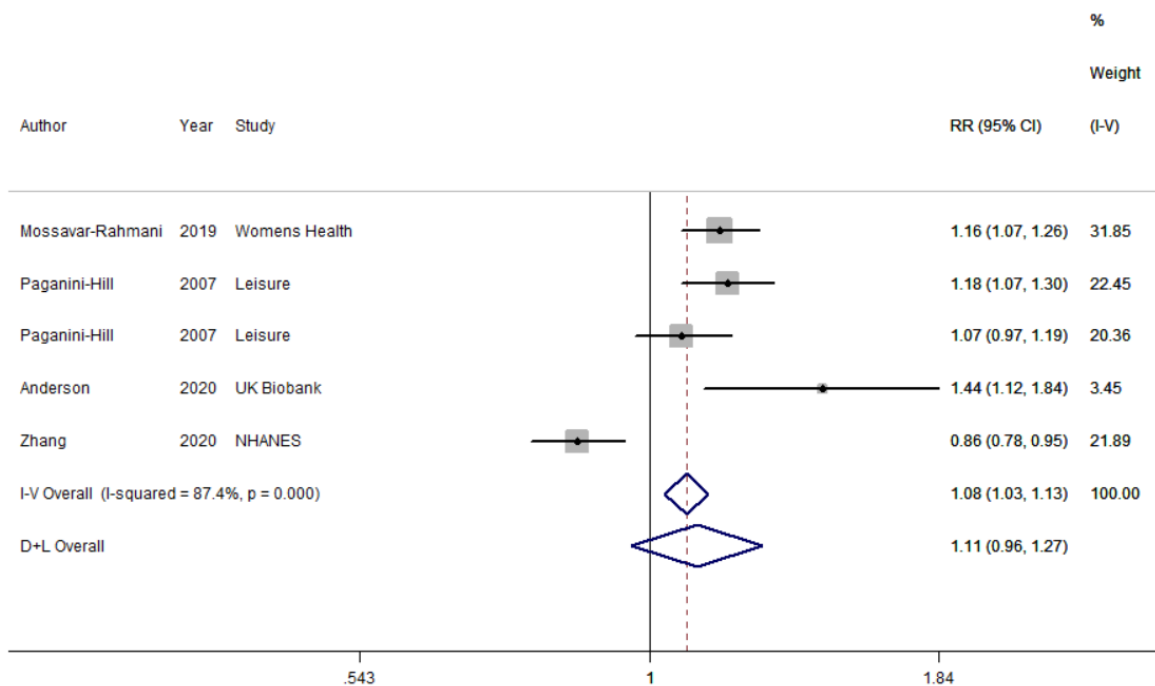
Web Figure 4. Funnel plot of prospective studies investigating the association between SSB consumption and all-cause mortality



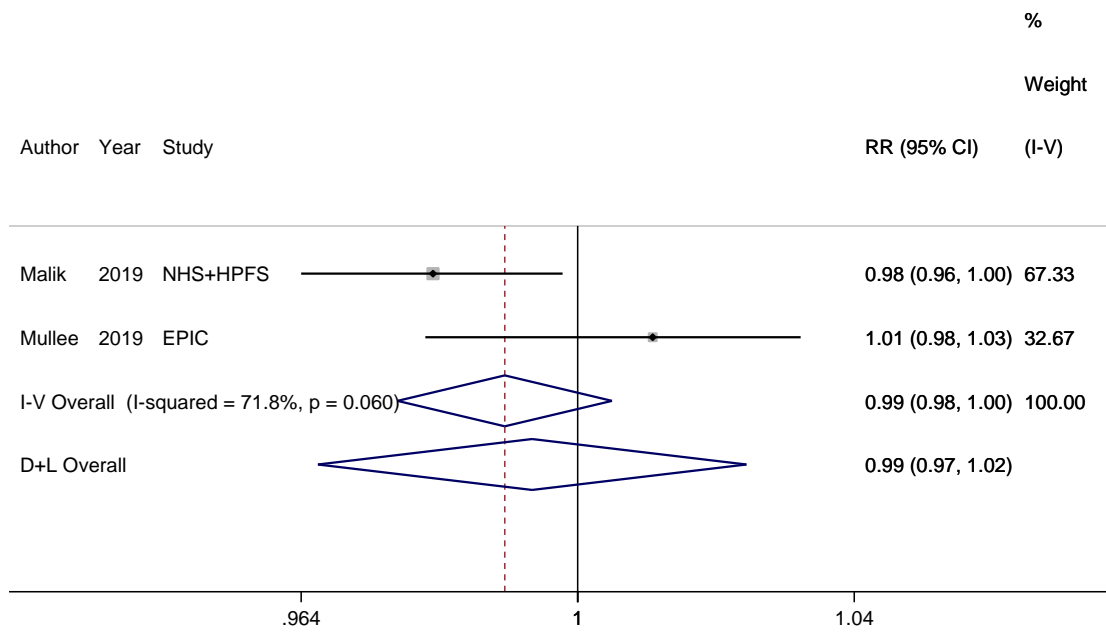
Web Figure 5. Forest plot of prospective studies investigating the association between ASB consumption and all-cause mortality (highest vs. lowest)



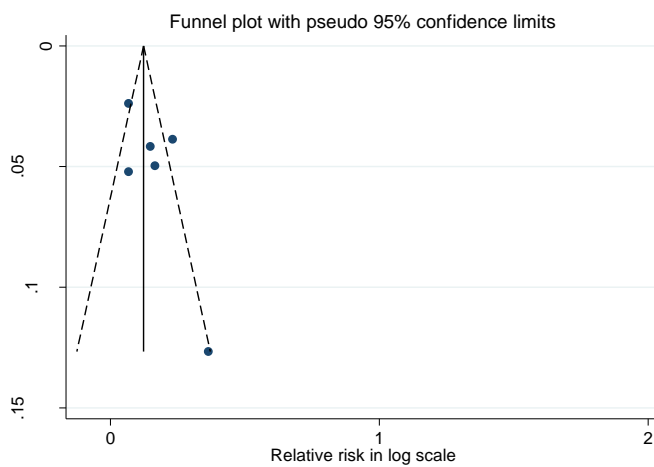
Web Figure 6. Forest plot of prospective studies investigating the association between ASB consumption and all-cause mortality (consumption vs. no consumption)



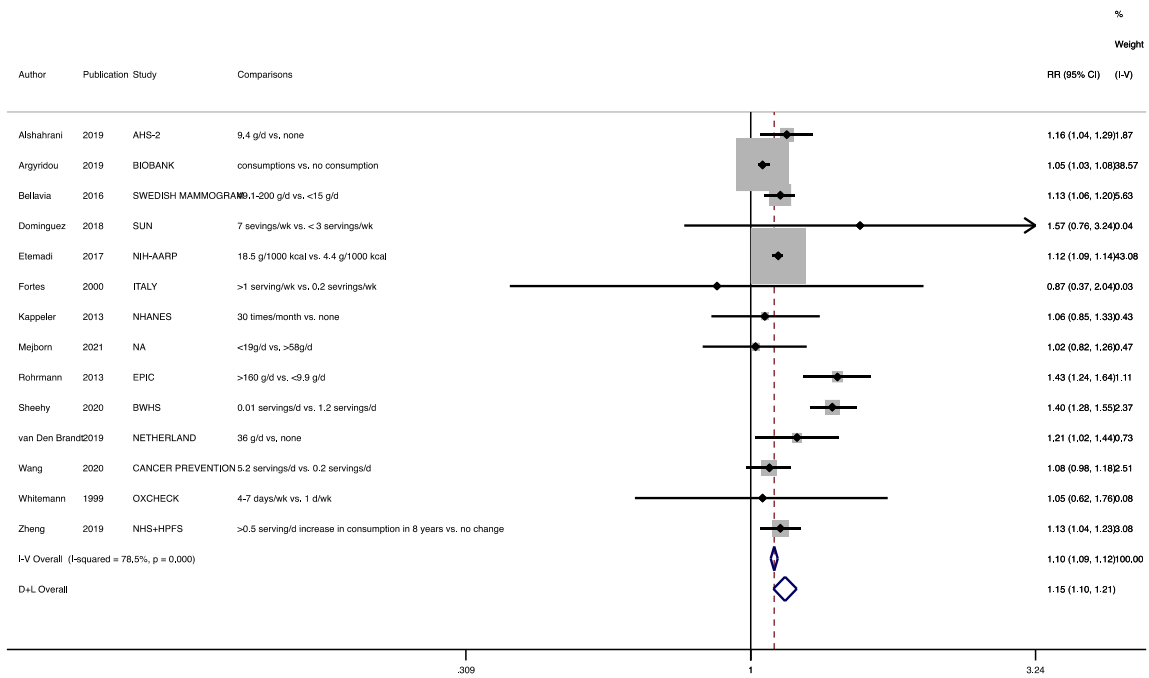
Web Figure 7. Forest plot of prospective studies investigating the association between ASB consumption and all-cause mortality (drinking more than 1 serving/month vs. lower)



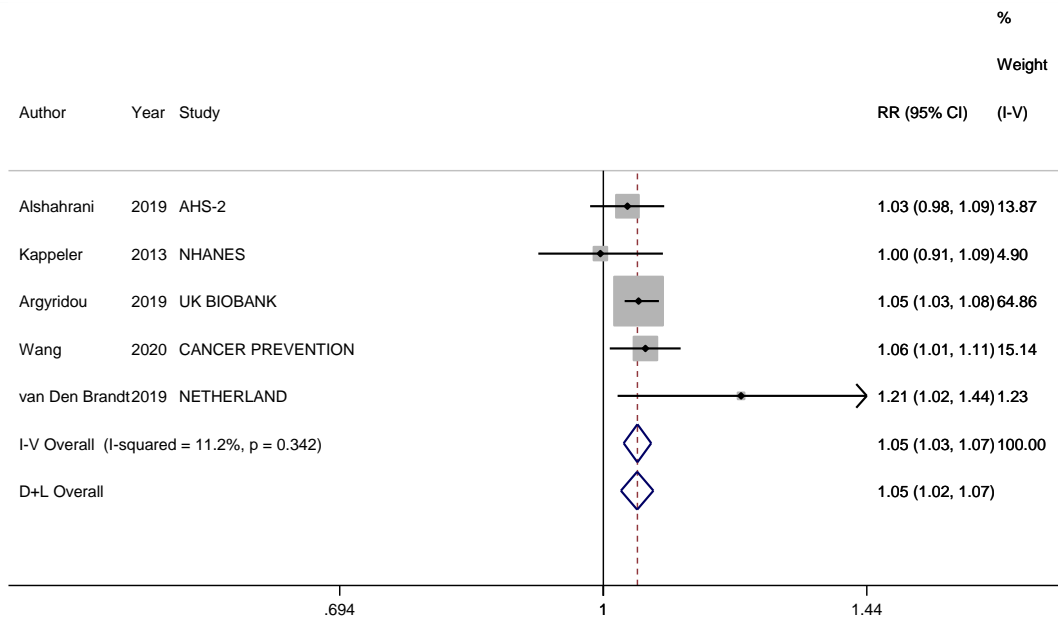
Web Figure 8. Funnel plot of prospective studies investigating the association between ASB consumption and all-cause mortality



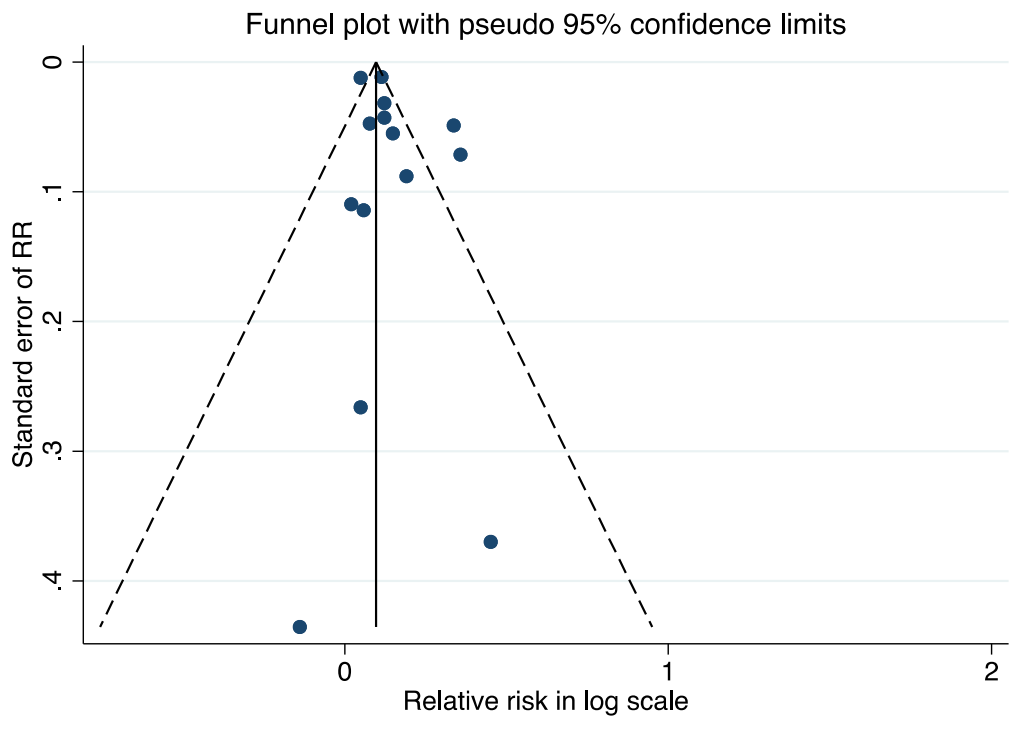
Web Figure 9. Forest plot of prospective studies investigating the association between processed meat consumption and all-cause mortality (highest vs. lowest)



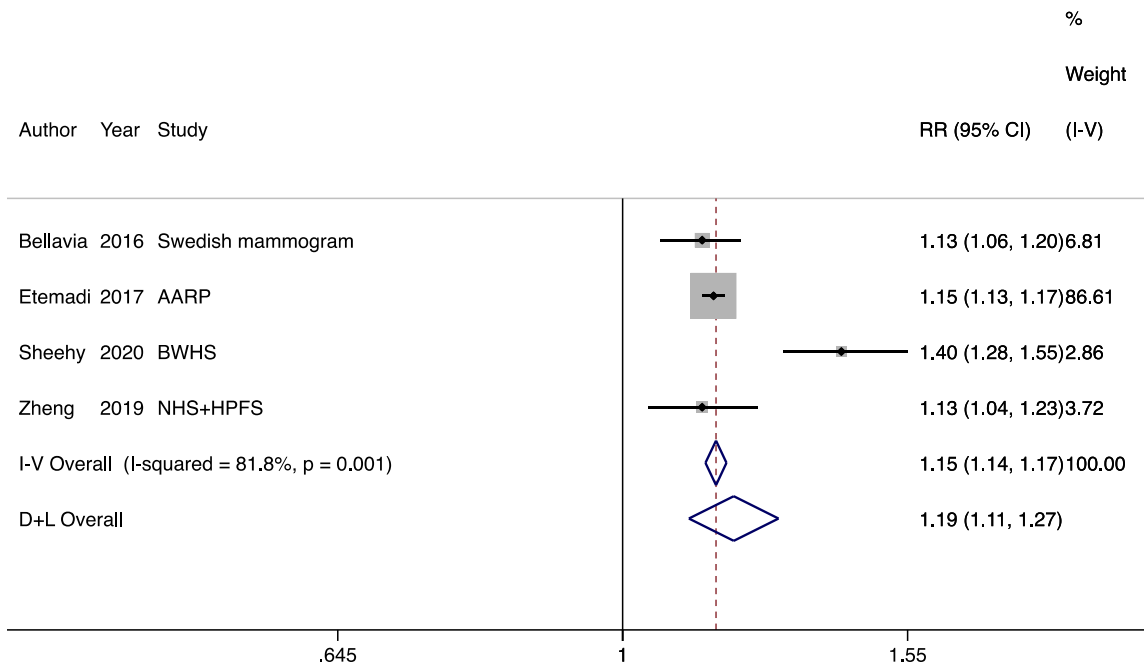
Web Figure 10. Forest plot of prospective studies investigating the association between processed meat consumption and all-cause mortality (consumption vs. no consumption)



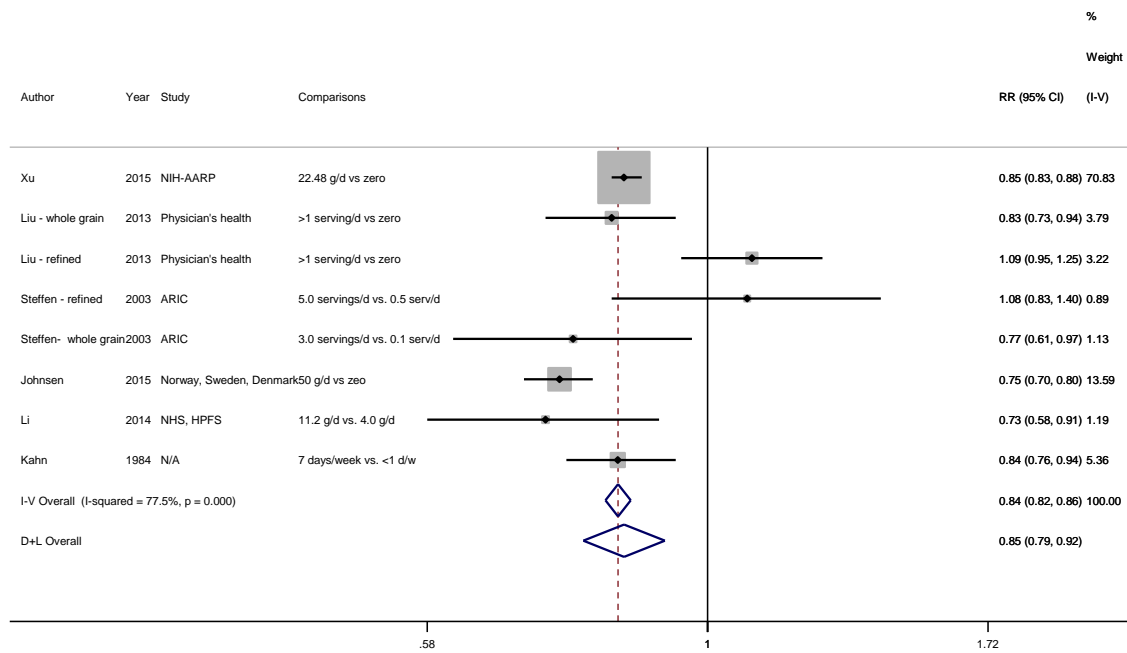
Web Figure 11. Funnel plot of prospective studies investigating the association between processed meat consumption and all-cause mortality



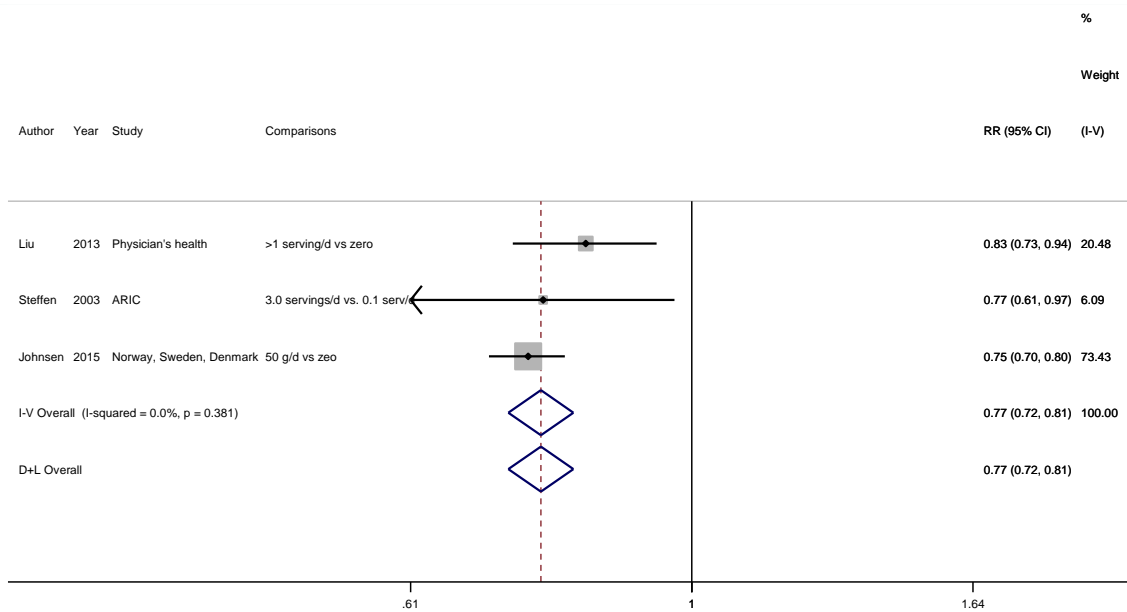
Web Figure 12. Forest plot of prospective studies investigating the association between processed red meat consumption and all-cause mortality (highest vs. lowest)



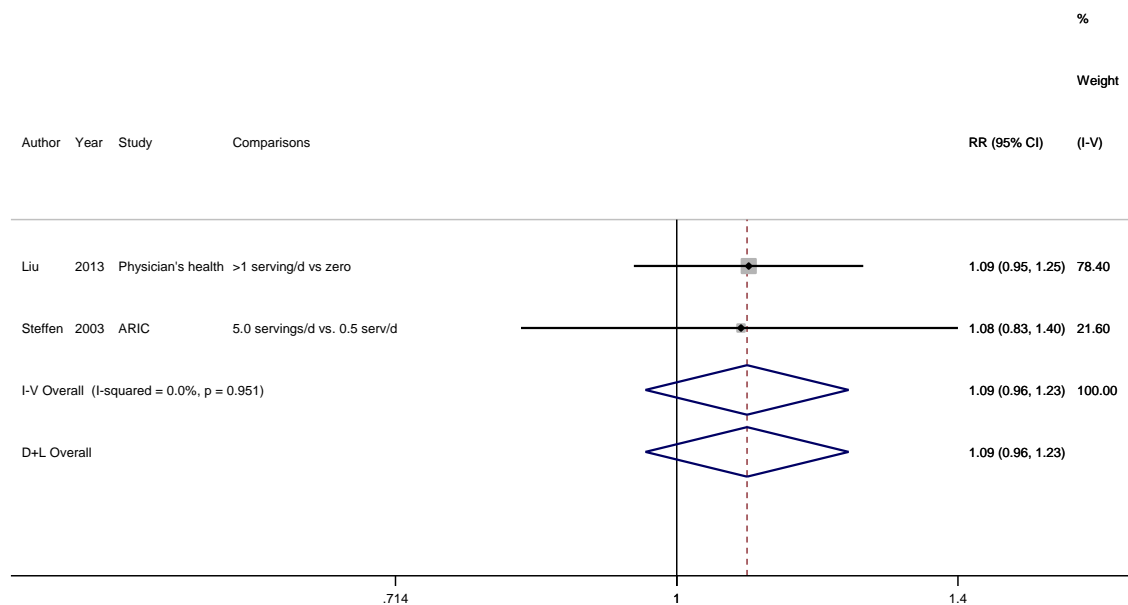
Web Figure 13. Forest plot of prospective studies investigating the association between cereal consumption and all-cause mortality (highest vs. lowest)



Web Figure 14. Forest plot of prospective studies investigating the association between whole grain cereal consumption and all-cause mortality (highest vs. lowest)



Web Figure 15. Forest plot of prospective studies investigating the association between refined grain cereal consumption and all-cause mortality (highest vs. lowest)



References:

1. Alshahrani SM, Fraser GE, Sabaté J, Knutsen R, Shavlik D, Mashchak A, et al. Red and processed meat and mortality in a low meat intake population. *Nutrients*. 2019;11(3):622.
2. Anderson JJ, Gray SR, Welsh P, Mackay DF, Celis-Morales CA, Lyall DM, et al. The associations of sugar-sweetened, artificially sweetened and naturally sweet juices with all-cause mortality in 198,285 UK Biobank participants: a prospective cohort study. *BMC medicine*. 2020;18:1-12.
3. Argyridou S, Zaccardi F, Davies MJ, Khunti K, Yates T. Relevance of physical function in the association of red and processed meat intake with all-cause, cardiovascular, and cancer mortality. *Nutrition, Metabolism and Cardiovascular Diseases*. 2019;29(12):1308-15.
4. Baer HJ, Glynn RJ, Hu FB, Hankinson SE, Willett WC, Colditz GA, et al. Risk factors for mortality in the nurses' health study: a competing risks analysis. *American journal of epidemiology*. 2011;173(3):319-29.
5. Barrington WE, White E. Mortality outcomes associated with intake of fast-food items and sugar-sweetened drinks among older adults in the Vitamins and Lifestyle (VITAL) study. *Public health nutrition*. 2016;19(18):3319-26.
6. Bellavia A, Stilling F, Wolk A. High red meat intake and all-cause cardiovascular and cancer mortality: is the risk modified by fruit and vegetable intake? *The American journal of clinical nutrition*. 2016;104(4):1137-43.
7. Blanco-Rojo R, Sandoval-Insausti H, López-García E, Graciani A, Ordovás JM, Banegas JR, et al., editors. Consumption of ultra-processed foods and mortality: a national prospective cohort in Spain. *Mayo Clinic Proceedings*; 2019: Elsevier.
8. Bonaccio M, Di Castelnuovo A, Costanzo S, De Curtis A, Persichillo M, Sofi F, et al. Ultra-processed food consumption is associated with increased risk of all-cause and cardiovascular mortality in the Moli-sani Study. *The American journal of clinical nutrition*. 2021;113(2):446-55.

9. Burke V, Zhao Y, Lee A, Hunter E, Spargo R, Gracey M, et al. Health-related behaviours as predictors of mortality and morbidity in Australian Aborigines. *Preventive medicine*. 2007;44(2):135-42
10. Chuang S-C, Norat T, Murphy N, Olsen A, Tjønneland A, Overvad K, et al. Fiber intake and total and cause-specific mortality in the European Prospective Investigation into Cancer and Nutrition cohort. *The American journal of clinical nutrition*. 2012;96(1):164-74.
11. Collin LJ, Judd S, Safford M, Vaccarino V, Welsh JA. Association of sugary beverage consumption with mortality risk in US adults: a secondary analysis of data from the REGARDS study. *JAMA network open*. 2019;2(5):e193121-e.
12. Dominguez LJ, Bes-Rastrollo M, Basterra-Gortari FJ, Gea A, Barbagallo M, Martínez-González MA. Should we recommend reductions in saturated fat intake or in red/processed meat consumption? The SUN prospective cohort study. *Clinical Nutrition*. 2018;37(4):1389-98.
13. Etemadi A, Sinha R, Ward MH, Graubard BI, Inoue-Choi M, Dawsey SM, et al. Mortality from different causes associated with meat, heme iron, nitrates, and nitrites in the NIH-AARP Diet and Health Study: population based cohort study. *Bmj*. 2017;357.
14. Fortes C, Forastiere F, Farchi S, Rapiti E, Pastori G, Perucci CA. Diet and overall survival in a cohort of very elderly people. *Epidemiology*. 2000:440-5.
15. González S, Huerta JM, Fernández S, Patterson ÁM, Lasheras C. Differences in overall mortality in the elderly may be explained by diet. *Gerontology*. 2008;54(4):232-7.
16. He M, van Dam RM, Rimm E, Hu FB, Qi L. Whole grain, cereal fiber, bran, and germ intake and the risks of all-cause and CVD-specific mortality among women with type 2 diabetes. *Circulation*. 2010;121(20):2162.
17. Huang T, Xu M, Lee A, Cho S, Qi L. Consumption of whole grains and cereal fiber and total and cause-specific mortality: prospective analysis of 367,442 individuals. *BMC medicine*. 2015;13(1):59.
18. Johnsen NF, Frederiksen K, Christensen J, Skeie G, Lund E, Landberg R, et al. Whole-grain products and whole-grain types are associated with lower all-cause and cause-specific mortality in the Scandinavian HELGA cohort. *British Journal of Nutrition*. 2015;114(4):608-23.
19. Kahn HA, Phillips RL, Snowdon DA, CHOI W. Association between Reported Diet and All-Cause Mortality: Twenty-One-Year Follow-Up on 27, 530 Adult Seventh-Day Adventists. *American Journal of Epidemiology*. 1984;119(5):775-87.
20. Kappeler R, Eichholzer M, Rohrmann S. Meat consumption and diet quality and mortality in NHANES III. *European journal of clinical nutrition*. 2013;67(6):598-606.
21. Kim H, Hu EA, Rebholz CM. Ultra-processed food intake and mortality in the USA: results from the Third National Health and Nutrition Examination Survey (NHANES III, 1988–1994). *Public Health Nutrition*. 2019;22(10):1777–85.
22. Lee I-M, Paffenbarger Jr RS. Life is sweet: candy consumption and longevity. *Bmj*. 1998;317(7174):1683-4.
23. Li S, Flint A, Pai JK, Forman JP, Hu FB, Willett WC, et al. Dietary fiber intake and mortality among survivors of myocardial infarction: prospective cohort study. *Bmj*. 2014;348.
24. Liu S, Sesso HD, Manson JE, Willett WC, Buring JE. Is intake of breakfast cereals related to total and cause-specific mortality in men? *The American journal of clinical nutrition*. 2003;77(3):594-9.

25. Liu Z-m, Tse SLA, Chen B, Chan D, Wong C, Woo J, et al. Dietary sugar intake does not pose any risk of bone loss and non-traumatic fracture and is associated with a decrease in all-cause mortality among Chinese elderly: Finding from an 11-year longitudinal study of Mr. and Ms. OS Hong Kong. *Bone*. 2018;116:154-61.
26. Malik VS, Li Y, Pan A, De Koning L, Schernhammer E, Willett WC, et al. Long-term consumption of sugar-sweetened and artificially sweetened beverages and risk of mortality in US adults. *Circulation*. 2019;139(18):2113-25.
27. Mejbørn H, Møller SP, Thygesen LC, Biloft-Jensen A. Dietary Intake of Red Meat, Processed Meat, and Poultry and Risk of Colorectal Cancer and All-Cause Mortality in the Context of Dietary Guideline Compliance. *Nutrients*. 2021;13(1):32.
28. Mullee A, Romaguera D, Pearson-Stuttard J, Viallon V, Stepien M, Freisling H, et al. Association between soft drink consumption and mortality in 10 European countries. *JAMA internal medicine*. 2019;179(11):1479-90.
29. Odegaard AO, Koh W-P, Yuan J-M, Pereira MA. Beverage habits and mortality in Chinese adults. *The Journal of nutrition*. 2015;145(3):595-604.
30. Paganini-Hill A, Kawas CH, Corrada MM. Non-alcoholic beverage and caffeine consumption and mortality: the Leisure World Cohort Study. *Preventive medicine*. 2007;44(4):305-10.
31. Pan, A., Sun, Q., Bernstein, A. M., Schulze, M. B., Manson, J. E., Stampfer, M. J., Willett, W. C., & Hu, F. B. Red meat consumption and mortality: results from 2 prospective cohort studies. *Archives of internal medicine*, 172(7), 555–563.
32. Ramne S, Alves Dias J, González-Padilla E, Olsson K, Lindahl B, Engström G, et al. Association between added sugar intake and mortality is nonlinear and dependent on sugar source in 2 Swedish population-based prospective cohorts. *The American journal of clinical nutrition*. 2019;109(2):411-23.
33. Rico-Campà A, Martínez-González MA, Alvarez-Alvarez I, de Deus Mendonça R, de la Fuente-Arrillaga C, Gómez-Donoso C, et al. Association between consumption of ultra-processed foods and all cause mortality: SUN prospective cohort study. *Bmj*. 2019;365.
34. Rohrmann S, Overvad K, Bueno-de-Mesquita HB, Jakobsen MU, Egeberg R, Tjønneland A, et al. Meat consumption and mortality-results from the European Prospective Investigation into Cancer and Nutrition. *BMC medicine*. 2013;11(1):63.
35. Schnabel L, Kesse-Guyot E, Allès B, Touvier M, Srour B, Hercberg S, et al. Association between ultraprocessed food consumption and risk of mortality among middle-aged adults in France. *JAMA internal medicine*. 2019;179(4):490-8.
36. Sheehy S, Palmer JR, Rosenberg L. High Consumption of Red Meat Is Associated with Excess Mortality Among African-American Women. *The Journal of Nutrition*. 2020;150(12):3249-58
37. Sinha, R., Cross, A. J., Graubard, B. I., Leitzmann, M. F., & Schatzkin, A. (2009). Meat intake and mortality: a prospective study of over half a million people. *Archives of internal medicine*, 169(6), 562–571.
38. Steffen LM, Jacobs Jr DR, Stevens J, Shahar E, Carithers T, Folsom AR. Associations of whole-grain, refined-grain, and fruit and vegetable consumption with risks of all-cause mortality and incident coronary artery disease and ischemic stroke: the Atherosclerosis Risk in Communities (ARIC) Study. *The American journal of clinical nutrition*. 2003;78(3):383-90.
39. Stoppel MT, Ocké MC, Boshuizen HC, Kok FJ, Kromhout D. Dietary fiber intake in relation to coronary heart disease and all-cause mortality over 40 y: the Zutphen Study. *The American journal of clinical nutrition*. 2008;88(4):1119-25.

40. Tasevska N, Park Y, Jiao L, Hollenbeck A, Subar AF, Potischman N. Sugars and risk of mortality in the NIH-AARP Diet and Health Study. *The American journal of clinical nutrition*. 2014;99(5):1077-88.
41. van den Brandt PA. Red meat, processed meat, and other dietary protein sources and risk of overall and cause-specific mortality in The Netherlands Cohort Study. *European journal of epidemiology*. 2019;34(4):351-69.
42. Wang Y, Jacobs EJ, Shah RA, Stevens VL, Gansler T, McCullough ML. Red and Processed Meat, Poultry, Fish, and Egg Intakes and Cause-Specific and All-Cause Mortality among Men with Nonmetastatic Prostate Cancer in a U.S. Cohort. *Cancer Epidemiology Biomarkers & Prevention*. 2020;29(5):1029-38.
43. Whiteman D, Muir J, Jones L, Murphy M, Key T. Dietary questions as determinants of mortality: the OXCHECK experience. *Public health nutrition*. 1999;2(4):477-87
44. Xu M, Huang T, Lee AW, Qi L, Cho S. Ready-to-eat cereal consumption with total and cause-specific mortality: Prospective analysis of 367,442 individuals. *Journal of the American College of Nutrition*. 2016;35(3):217-23.
45. Zhang Y-B, Chen J-X, Jiang Y-W, Xia P-F, Pan A. Association of sugar-sweetened beverage and artificially sweetened beverage intakes with mortality: an analysis of US National Health and Nutrition Examination Survey. *European Journal of Nutrition*. 2020:1-11.
46. Zheng Y, Li Y, Satija A, Pan A, Sotos-Prieto M, Rimm E, et al. Association of changes in red meat consumption with total and cause specific mortality among US women and men: two prospective cohort studies. *Bmj*. 2019;365.
47. Zhong, V. W., Van Horn, L., Greenland, P., Carnethon, M. R., Ning, H., Wilkins, J. T., Lloyd-Jones, D. M., & Allen, N. B. (2020). Associations of Processed Meat, Unprocessed Red Meat, Poultry, or Fish Intake With Incident Cardiovascular Disease and All-Cause Mortality. *JAMA internal medicine*, 180(4), 503–512.
48. Mossavar-Rahmani Y, Kamensky V, Manson JE, Silver B, Rapp SR, Haring B, et al. Artificially sweetened beverages and stroke, coronary heart disease, and all-cause mortality in the Women's Health Initiative. *Stroke*. 2019;50(3):555-62.