



RED MEAT AND PROCESSED MEAT

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TO HUMANS

International Agency for Research on Cancer



Table 2.6.2 Cohort studies: Processed meat and cancer of the breast (web only)

Reference, location enrolment/follow-up period, study design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/deaths	Risk estimate (95% CI)	Covariates controlled
Voorrips et al. (2002) the Netherlands 1986–1992 (mean follow-up 6.3 years) Cohort	62 573 cohort/941 cases; the Netherlands Cohort Study on Diet and Cancer (NLCS) included 62 573 women aged 55–69 y at the beginning of the study, originating from 204 municipalities with computerized population registries. Exposure assessment method: Questionnaire; 150-item FFQ. Red meat, which was presented as ‘fresh meat’, included beef and pork and did not include processed meat.	Breast	Processed meat: Category 1 Category 2 Category 3 Category 4 Trend-test p-value: 0.59	128 330 189 136	1 0.93 (0.71–1.23) 0.91 (0.68–1.23) 0.93 (0.67–1.29)	Age, history of benign breast disease, maternal breast cancer, breast cancer in one or more sisters, age at menarche, age at menopause, oral contraceptive use, parity, age at first childbirth, Quetelet index, education, alcohol use, current cigarette smoking, and energy intake
Holmes et al. (2003) USA Follow-up 1980–1998 Cohort	Cohort 88 647/4107 cases; In 1976, the Nurses’ Health Study (NHS) cohort was established when 121 700 female registered nurses from across the United States, aged 30–55 years, answered a mailed questionnaire on risk factors for cancer and cardiovascular disease. Exposure assessment method: Questionnaire; In 1980, a 61-item food-frequency questionnaire designed to assess dietary intake was used. In 1984, 1986, 1990 and 1994, an expanded food-frequency questionnaire was used. The validity and reproducibility of the food frequency questionnaires have been documented.	Breast	Processed meat, All women: ≤ 0.10 servings/d 0.11–0.18 0.19–0.28 0.29–0.45 ≥ 0.46 Trend-test p-value: 0.12	NR NR NR NR NR	- 1.03 (0.94–1.13) 1.01 (0.92–1.11) 0.96 (0.87–1.06) 0.94 (0.85–1.05)	Age, total energy intake, alcohol intake, parity and age at first birth, body mass index at age 18, weight change since age 18, height, family history of breast cancer, history of benign breast disease, age at menarche, menopausal status, age at menopause and hormone replacement therapy use, duration of menopause
		Breast	Premenopausal women: ≤ 0.10 servings/d 0.11–0.18 0.19–0.28 0.29–0.45 ≥ 0.46 Trend-test p-value: 0.25	NR NR NR NR	- 0.99 (0.78–1.25) 1.08 (0.87–1.35) 0.99 (0.79–1.25) 0.86 (0.67–1.09)	Same as above

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		Breast	Postmenopausal women: ≤ 0.10 servings/d	NR	-	Same as above
			0.11–0.18	NR	1.05 (0.94–1.17)	
			0.19–0.28	NR	1.02 (0.91–1.14)	
			0.29–0.45	NR	0.95 (0.84–1.06)	
			≥ 0.46	NR	1 (0.88–1.13)	
			Trend-test p-value: 0.45			
van der Hel et al. (2004) Amsterdam, Maastricht and Doetinchem, the Netherlands Enrollment 1987–1991: follow-up 1987–1997 Nested Case-Control	Cases: 229; Women enrolled at age 20–55 in the Monitoring Project on Cardiovascular Disease Risk Factors, with first incident breast cancer and with blood sample. Controls: 264; Random sample from the same cohort, with blood samples, matched to the cases on age, menopausal status, and residence. Exposure assessment method: Questionnaire; Meat consumption was recorded at baseline by use of a validated self-administered FFQ. Portion sizes of every meat type were derived from a Dutch national reference book on portion sizes and food coding. Processed meat intake in grams per day was calculated by adding up intake of all processed meat items.	Breast	Processed Meat < 20 g/day	88	1	Age, menopausal status, town, energy intake, smoking, alcohol, age at menarche and BMI
			20–34 g/day	64	0.95 (0.6–1.49)	
			≥ 35 g/day	77	1.08 (0.6–1.7)	

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Taylor et al. (2007) England, Wales, Scotland Enrollment 1995–1998; median follow-up 8 years Cohort	Cohort 35 372/678 cases; Participants of United Kingdom Women's Cohort Study, aged 35–69 y, living in England, Wales and Scotland. The cohort was constructed to have similar, large numbers of three groups: vegetarians, meat-eaters and fish-eaters. Exposure assessment method: Questionnaire; Diet was assessed between 1995 and 1998 using a 217-item postal FFQ developed from that of the EPIC study. Red meat consisted of beef, pork, lamb and other red meats included in mixed dishes, for example, meat lasagne, moussaka, ravioli and filled pasta with sauce. Processed meat consisted of bacon, ham, corned beef, spam, luncheon meats, sausages, pies, pasties, sausage rolls, liver pate, salami and meat pizza.	Breast	Processed Meat, Postmenopausal: 0 g/day	66	1	Age, energy intake, BMI, physical activity, smoking status, HRT use, OCP use, parity, total fruit and vegetable intake
			< 10 g/day	105	1.48 (1.04–2.12)	
			10–20 g/day	116	1.6 (1.12–2.29)	
			> 20 g/day	108	1.64 (1.14–2.37)	
			Trend-test p-value: 0.003			
		Breast	Processed Meat, Premenopausal: 0 g/day	109	1	Same as above
			< 10 g/day	55	0.94 (0.65–1.36)	
			10–20 g/day	56	1.04 (0.72–1.51)	
			> 20 g/day	63	1.2 (0.85–1.7)	
			Trend-test p-value: 0.09			
		Breast	Processed meat, Combined pre- and postmenopausal breast cancer: 0 g/day	175	1	Same as above
			< 10 g/day	160	1.19 (0.94–1.53)	
			10–20 g/day	172	1.3 (1.02–1.66)	
			> 20 g/day	171	1.39 (1.09–1.78)	
			Trend-test p-value: < 0.001			

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Egeberg et al. (2008) Copenhagen and Aarhus, Denmark Enrollment 1993–1997; median follow-up 4.2 years Nested Case-Control	Cases: 378; Participants of 'Diet, Cancer, and Health' cohort study, postmenopausal at baseline (age 50–64), with incident breast cancer before end of year 2000. Controls: 378; Cohort participant postmenopausal women free of cancer at the exact age at diagnosis of the case. Matched on age at inclusion into the cohort. Exposure assessment method: Questionnaire; Meat consumption was estimated from a validated 192-item FFQ completed at baseline covering the participants' habitual diet during the preceding 12 months. Intake of processed meat in grams per day was calculated by adding up intake of processed red meat, including bacon, smoked ham, salami, frankfurter, Cumberland sausage, cold cuts and liver pâté and processed fish that is fish prepared by pickling, salting or smoking. NAT1 and NAT2 genotyping was performed blinded to case-control and exposure status.	Breast	Processed Meat: < 20 g/day 20 < 35 g/day 35 < 45 g/day > 45 g/day Trend-test p-value: 0.02	72 131 70 105	1 1.24 (0.83–1.86) 1.59 (0.99–2.55) 1.59 (1.02–2.47)	Parity (parous/nulliparous and number of births), age at first birth, education, duration of hormone replacement therapy use, intake of alcohol and body mass index

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Ferrucci et al. (2009) USA Enrollment 1993–2001/ mean follow-up 5.5 years Cohort	Cohort 52 158/1205 cases; Members of the PLCO Cancer Screening Trial cohort to evaluate screening methods for the early detection of prostate, lung, colorectal, and ovarian cancer: women aged 55–74 years, recruited from 10 centres in the US. Exposure assessment method: Questionnaire; 124 food item FFQ. Estimated haem iron from meat using the NCI heme iron database based on the measured values of haem iron from meat samples cooked by a range of methods to varying doneness levels. Red meat included bacon, beef, cheeseburgers, cold cuts, ham, hamburgers, hot dogs, liver, pork, sausage, veal, venison, and red meat from mixed dishes. Processed meat included bacon, cold cuts, hams, hot dogs, and sausage.	Breast	Processed meat: ≤ 2.4 g/1000 kcal > 2.4–4.3 > 4.3–6.9 > 6.9–11.6 > 11.6–124.1 Trend-test p-value: 0.66	218 250 251 255 231	1 1.17 (0.98–1.41) 1.2 (0.99–1.45) 1.23 (1.02–1.49) 1.12 (0.92–1.36)	Age, race, education, study centre, randomization group, family history of breast cancer, age at menarche, age at menopause, age at first birth and number of live births, history of benign breast disease, number of mammograms during past 3 years, menopausal hormone therapy use, body mass index, alcohol intake, total fat intake, total energy intake
Kabat et al. (2009) USA Enrollment 1995–1996; follow-up 8 years Cohort	Cohort 120 755/3,818 cases; AARP cohort members, women aged 50–71 years, residing in six US states (California, Florida, Louisiana, New Jersey, North Carolina, and Pennsylvania) and two metropolitan areas (Atlanta, GA, and Detroit, MI), who completed questionnaires. Exposure assessment method: Questionnaire; Self-administered validated NCI FFQ with 124 food items. Red meat included bacon, beef, cold cuts, ham, hamburgers, hot dogs, liver, pork, sausage, and steak. Processed meat included bacon, red meat sausage, poultry sausage, luncheon meat (red and white meat), cold cuts (red and white meat), ham, regular hot dogs, and low-fat hot dogs made from poultry.	Breast	Processed meat: Q1 Q2 Q3 Q4 Q5 Trend-test p-value: 0.55	752 790 722 817 737	1 1.02 (0.92–1.13) 0.95 (0.86–1.06) 1.09 (0.98–1.21) 1 (0.9–1.12)	Age, BMI, age at menarche, age at first birth, family history of breast cancer, hormone replacement therapy, education, race, total energy intake, saturated fat intake, alcohol intake, physical activity, age at menopause, number of breast biopsies

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Pala et al. (2009) Denmark, France, Germany, Greece, Italy, Norway, Spain, Sweden, Netherlands, United Kingdom Enrollment 1992– 2003/median follow-up 8.8 years Cohort	Cohort 319 826/7119 cases; EPIC cohort members: cancer free women aged 20–70 years. In most centres, participants came from the general population. Exposure assessment method: Questionnaire; Diet was assessed by using country-specific (in Italy and Sweden centre- specific) validated FFQs designed to capture habitual consumption of food over the preceding year. Red meat consisted of fresh, minced, and frozen beef, veal, pork, and lamb. Processed meats were mostly pork and beef preserved by methods other than freezing, such as salting, smoking, marinating, air-drying, or heating and included ham, bacon, sausages, blood sausages, liver paté, salami, mortadella, tinned meat, and others.	Breast	Processed Meat, Postmenopausal: 1.7 g/d 11.0 g/d 20.1 g/d 32.3 g/d 56.5 g/d Trend-test p-value: 0.06	542 846 771 776 738	1 1.08 (0.96–1.2) 1.01 (0.9–1.14) 1.09 (0.97–1.23) 1.13 (1–1.28)	Energy, height, weight, years of schooling, alcohol intake, and smoking; stratified by centre and age
		Breast	Processed Meat, Premenopausal: 1.7 g/d 11.0 g/d 20.1 g/d 32.3 g/d 56.5 g/d Trend-test p-value: 0.72	274 307 368 363 387	1 0.97 (0.81–1.16) 1.07 (0.9–1.28) 0.99 (0.82–1.18) 0.99 (0.82–1.19)	Same as above
		Breast cancer	Processed meat, all women, intake by quintile: 1.7 g/day 11.0 g/day 20.1 g/day 32.3 g/day 56.5 g/day Trend-test p-value: 0.07	1016 1489 1553 1555 1506	1 1.04 (0.96–1.14) 1.08 (0.99–1.17) 1.09 (1–1.19) 1.1 (1–1.2)	Same as above

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Loh et al. (2010) Norfolk, East Anglia, United Kingdom Enrollment 1993–1997, follow-up till end of 2006 Nested Case-Control	Cases: 276; Women aged 40–79 years at baseline from EPIC-Norfolk cohort, diagnosed with breast cancer. Controls: 1498; Women, members of EPIC cohort, cancer free and had genotyping data for the specific gene polymorphism studied. Exposure assessment method: Questionnaire; Dietary data using a 7-day diary of all food and drink consumed. The diary booklet contains colour food portion photographs and detailed instructions in which the description, preparation and amounts of foods eaten at main meals, snacks and between meals over a week can be recorded. The first day of the food diary was an interviewed 24-hour recall. Red meat (beef, lamb/mutton, pork, veal, rabbit and venison including all muscle cuts and meats in composite dishes, excluding offal), processed meat (meat that has undergone smoking, curing, salting or the addition of chemical preservatives, including bacon, fresh and dried sausage and ham).	Breast	Red and Processed Meat, MGMT Ile/Ile: < 46 g/d Ile/Ile, ≥ 46 g/d Ile/Val + Val/Val, < 46 g/d Ile/Val + Val/Val, ≥ 46 g/d	98 95 41 37	1 1 (0.73–1.38) 1.43 (0.94–2.18) 0.75 (0.45–1.24)	Trend-test p-value: 0.33 Age, date of entry to study, cigarette smoking status, BMI

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Genkinger et al. (2013) USA, > 17 states Enrollment 1995; follow-up 12 years Cohort	Cohort 52 062/1268 cases; Participants of the Black Women's Health Study, African-American women aged 21–69 years at baseline in 1995. Women were subscribers to Essence magazine, members of several professional organizations, and friends and relatives of early respondents enrolled by completing health questionnaires on diet, lifestyle factors, medical and reproductive history, and medication use. Study participants reside in more than 17 states. Exposure assessment method: Questionnaire; Diet during the past year was estimated from a 68-item modified Block FFQ including 13 meat items, completed at baseline in 1995. In 2001, a modified version asked about 85 food items including 15 meat items was administered to collect updated dietary information.	Breast Total breast cancer	Processed meat: < 100 g/wk 100–199.9 g/wk ≥ 200 g/wk	851 265 152	1 1.01 (0.87–1.17) 0.99 (0.82–1.2)	Energy intake (quintiles), age at menarche (< 12, 12–13, ≥ 14 years), body mass index (< 25, 25–29, ≥ 30 kg/m ²), family history of breast cancer (mother or sister), education (≤ 12, 13–15, ≥ 16 years), parity and age at first live birth (nulliparous, parity 1–2 and age at first birth < 25 years, parity 1–2 and age at first birth 25–29 years, parity 1–2 and age at first birth ≥ 30 years, parity ≥ 3 and age at first birth < 25 years, parity ≥ 3 and age at first birth 25–29 years, parity ≥ 3 and age at first birth ≥ 30 years), oral contraceptive use (yes/no), menopausal status (postmenopausal, premenopausal, and uncertain), age at menopause (< 35, 35–39, 40–44, 45–49, 50–54, ≥ 55 years), menopausal hormone use (yes/no), vigorous physical activity (none, ≤ 2, > 2 hours/week), smoking status (never, former, current), and alcohol intake (none, 1–3, 4–6, ≥ 7 drinks/week)
Pouchieu et al. (2014) France Enrollment 1994–1995; mean follow-up 11.3 years Cohort	Cohort 4684/190 cases; Women aged 35–60 years from the general population, participating in SU.VI.MAX randomized, placebo-controlled prevention trial of antioxidant vitamins and minerals. Exposure assessment method: other; During the follow-up period, participants completed a 24h dietary record every 2 months. Dietary records from the first 2 years of follow-up were used in the analysis. Total daily intake of red meat and processed meat in g/day were measured. Red meat consisted of fresh, minced	Breast	Whole population, processed meat: < 16.4 g/d 16.4 < 28.6 g/d 28.6 < 43.5 g/d ≥ 43.5 g/d	NR NR NR NR	1 1 (0.64–1.56) 1.53 (1.02–2.32) 1.45 (0.92–2.27)	Trend-test p-value: 0.03 Age, intervention group, number of dietary records, smoking status, educational level, physical activity, height, BMI, family history of breast cancer, menopausal status, use of HTM, number of live births, without-alcohol energy intake, alcohol intake, total lipid intake, red meat intake

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Farvid et al. (2015) USA 1998; follow-up 13 years Cohort	Cohort 44 231/1132 cases; Women aged 33–52 years, members of the Nurses' Health Study II cohort who in 1998 completed a questionnaire about diet during adolescence. Exposure assessment method: Questionnaire; Adolescent diet was measured using a 124-item validated high-school FFQ. Total red meat intake included unprocessed red meat (hamburger, beef, lamb, pork and meatloaf) and processed red meat items (hot dog, bacon and other processed meat such as sausage, salami and bologna).	Breast	Placebo group, processed meat: < 16.4 g/d	NR	1	Same as above
			16.4 < 28.6 g/d	NR	1.31 (0.68–2.52)	
			28.6 < 43.5 g/d	NR	2.51 (1.38–4.57)	
			≥ 43.5 g/d	NR	2.46 (1.28–4.72)	
			Trend-test p-value: 0.001			
			Antioxidant-supplemented group, processed meat: < 16.4 g/d	NR	1	Same as above
			16.4 < 28.6 g/d	NR	0.8 (0.43–1.47)	
			28.6 > 43.5 g/d	NR	0.92 (0.51–1.66)	
			> 43.5 g/d	NR	0.86 (0.45–1.63)	
			Trend-test p-value: 0.7			
	All women, processed meat: Q1	Breast	249	1	Age, race, family history of breast cancer in mother or sisters, history of benign breast disease, smoking, height, weight gain since age 18, BMI at age 18 years, age at menarche, parity and age at first birth, oral contraceptive use, adolescent alcohol intake, adult alcohol intake, and adolescent energy intake, hormone use and menopausal status, age at menopause	
			Q2	204	0.99 (0.82–1.2)	
			Q3	172	0.96 (0.79–1.17)	
			Q4	249	0.96 (0.8–1.15)	
			Q5	258	1.17 (0.96–1.41)	
			Trend-test p-value: 0.14			

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		Breast	Premenopausal women, processed meat: Q1	109	1	Same as above
			Q2	98	0.94 (0.71–1.24)	
			Q3	96	0.85 (0.64–1.13)	
			Q4	105	1.01 (0.76–1.34)	
			Q5	138	1.29 (0.98–1.7)	
			Trend-test p-value: 0.02			
		Breast	Postmenopausal women, processed meat: Q1	95	1	Same as above
			Q2	100	0.99 (0.74–1.32)	
			Q3	105	0.92 (0.69–1.23)	
			Q4	78	0.91 (0.66–1.24)	
			Q5	105	0.98 (0.72–1.33)	
			Trend-test p-value: 0.85			

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