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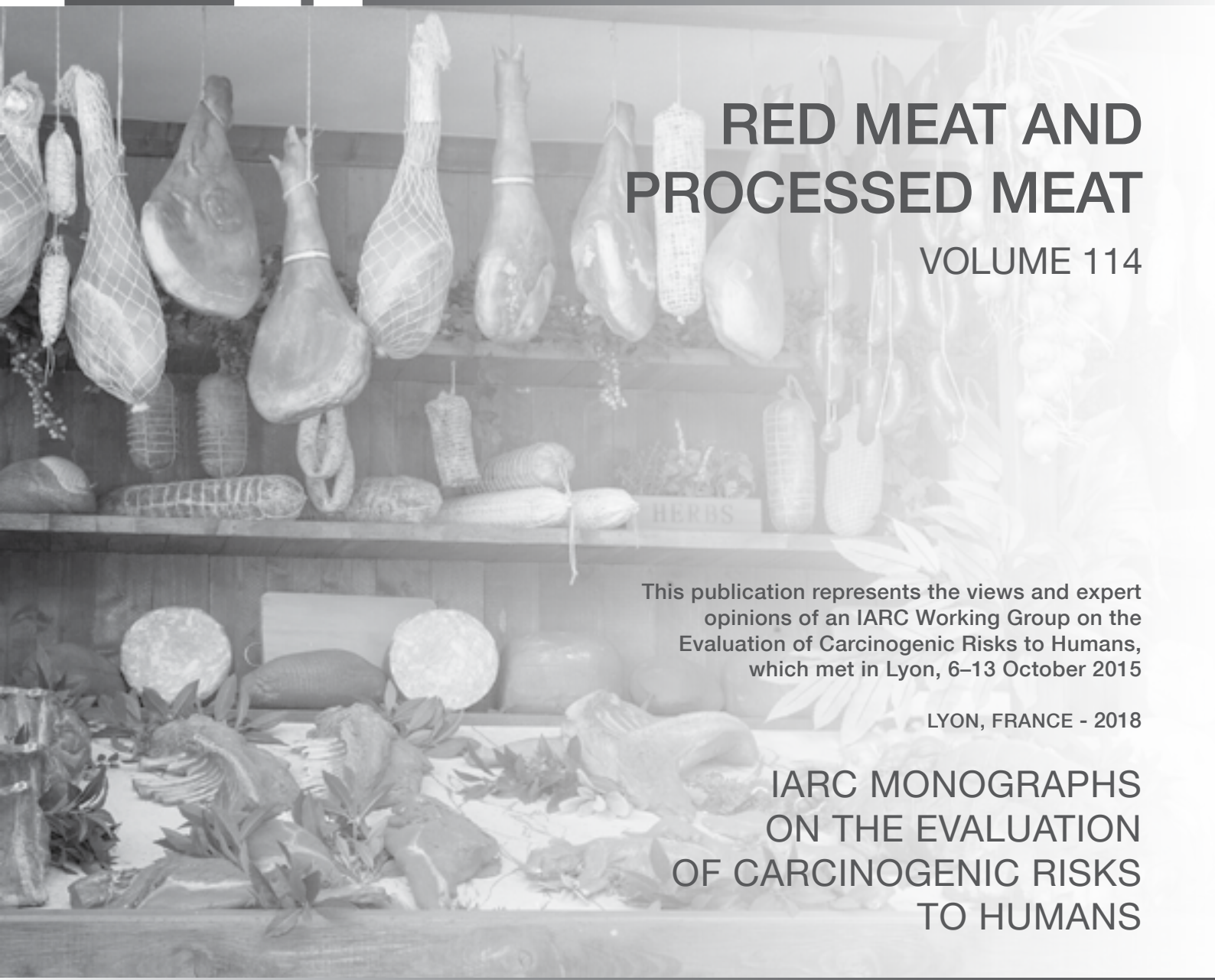

RED MEAT AND PROCESSED MEAT

VOLUME 114

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IARC MONOGRAPHS ON THE EVALUATION OF CARCINOGENIC RISKS TO HUMANS

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2.3 Cancer of the stomach

The Working Group focused their review on studies that clearly defined red meat or processed meat (see Section 1 and Section 2.1). Studies were excluded if: (1) risk estimates were presented for total meat (red and processed meat combined) intake; (2) the type of meat was not defined or included white meat; (3) fewer than 100 cases were reported, due to the limited statistical power, as a large database of high-quality studies were available; (4) a more recent report from the same study was available; (5) risk estimates, adjusted for important confounders, were not available (crude estimates were not considered to be informative); (6) dietary patterns were the focus; and (7) outcomes were assessed using mortality data.

Several cohort and case–control studies, conducted in areas all over the world, have reported on the association between red and processed meat intake and cancer of the stomach. Important confounders for the assessment of this association are age, tobacco smoking, socioeconomic status (or education), and energy intake. Infection with *Helicobacter pylori* is a risk factor for cancer of the stomach, although its role in the association between intake of red or processed meat and cancer of the stomach is unclear. Salt intake may also be a confounder, as there is evidence that it increases the risk of cancer of the stomach, and it is also present in preserved or salted (processed) meat; however, it is difficult to distinguish the effect of salt from that of preserved meat.

2.3.1 Cohort studies

(a) Red meat

See Table 2.3.1 (web only; available at: http://publications.iarc.fr/564)

Of the publications on cohort studies that reported on the association between red meat and gastric cancer in the USA, Europe, Japan, and China, positive associations were reported in two studies: the EPIC cohort, which followed up 521 457 participants (González et al., 2006), and a case–control study of 226 gastric non-cardia cancer (GNCA) cases and 451 controls nested within the Shanghai Men's Health Study (SMHS) cohort (Epplein et al., 2014). [The Working Group noted that the strengths of the EPIC study (González et al., 2006) were its large size and analysis by subsite, histological type, and *H. pylori* infection. For the study nested within the Shanghai cohort (Epplein et al., 2014), the Working Group noted that this population had over 90% prevalence of CagA-positive *H. pylori* infection. In addition, socioeconomic status (or education) was not included as a covariate, and the items included in red meat were not detailed.]

Several other studies reported no association, or relative risks greater than one, but with wide confidence intervals that included the null value, between red meat consumption and gastric cancer. These studies included a cohort of 13 250 people older than 15 years from the Fukuoka Prefecture in Japan (Ngoan et al., 2002); a population-based cohort of 61 433 Swedish women (Larsson et al., 2006); the Japan Collaborative Cohort Study for Evaluation of Cancer (JACC Study), which included 42 513 men and 57 777 women (Iso et al., 2007); the NIH-AARP study cohort of 494 979 individuals Cross et al. (2011); and a cohort of 120 852 men and women in the NLCS (Keszei et al., 2012). [The Working Group noted that processed meat was included in the definition of red meat in the NIH-AARP study.]

(b) Processed meat

See Table 2.3.2

Studies investigating the association between consumption of total processed meat, specific processed meat are presented below. Of the reviewed papers, we excluded papers reporting fewer than 100 cases (e.g. Kneller et al., 1991; Knekt et al., 1999; Khan et al., 2004). Studies focusing on dietary pattern (e.g. Pham et al., 2010), studies

from mortality data (e.g. McCullough et al., 2001, Ngoan et al.., 2002; Tokui et al., 2005; Iso et al., 2007), studies that were overlapping or updated (Cross et al., 2007) were excluded. Finally, seven studies were included.

Among 7990 American men of Japanese ancestry in a cohort study in which 150 cases of gastric cancer were observed, Nomura et al. (1990) reported an age-adjusted relative risk of 1.3 (95% CI, 0.9–2.0) for the highest versus the lowest frequency of intake of ham and sausage. [The Working Group noted that only age was adjusted. Smoking status was related to gastric cancer, but was not adjusted for. No subsite analysis was conducted.]

In a cohort of 11 907 randomly selected Japanese residents of Hawaii, USA, with an average follow-up period of 14.8 years, 108 observed cases of gastric cancer (44 women, 64 men) were identified, and no association was observed between processed meat consumption and incidence of gastric cancer (Galanis et al., 1998). The adjusted odds ratios for the highest frequency compared with the lowest frequency of consumption were 1.0 (95% CI, 0.5–1.9; 20 exposed cases) and 1.2 (95% CI, 0.6–2.4; 15 exposed cases) for men and women, respectively. [The Working Group noted that the case number was small, especially for women. An FFQ was used with only 13 items. No subsite analysis was conducted.]

González et al. (2006) examined the association between processed meat consumption and risk of gastric cancer in the EPIC study. The adjusted hazard ratio for the association with processed meat intake (highest vs lowest quintile) was 1.62 (95% CI, 1.08–2.41; P_{trend} = 0.02), which was more apparent in non-cardia cancer (HR, 1.92; 95% CI, 1.11–3.33; P_{trend} = 0.01) than in cardia cancer (HR, 1.14; 95% CI, 0.52–2.49; P_{trend} = 0.91). No difference was seen by histological type. When *H. pylori* infection was considered in the case–control data set nested in the present study, *H. pylori* antibody status did not appear to modify the association. [The Working Group noted that it was defined that white meat was not included. The population size was large, and detailed information on subsite, histological type, and *H. pylori* was available.]

In a population-based cohort of 61 433 Swedish women, Larsson et al. (2006) found a positive association between long-term processed meat consumption (using two surveys 10 years apart) and gastric cancer risk. During 18 years of follow-up, 156 incident cases of gastric cancer were diagnosed. The multivariate-adjusted hazard ratio for the highest versus the lowest serving per week of total processed meat was 1.66 (95% CI, 1.13–2.45; 67 exposed cases). [The Working Group noted that using a survey from two time points enabled the effect of long-term exposure to be seen. The number of cases was small. No subsite analysis was conducted.]

In the NIH-American Association of Retired Persons (NIH-AARP Diet and Health Study cohort of 494 979 individuals, aged 50–71 years, Cross et al. (2011) investigated intake of processed meat and meat cooking by-products with accrued 454 gastric cardia cancers (GCAs) and 501 GNCAs. After adjusting for important confounders, no association was observed between processed meat consumption and GCA and GNCA. For the highest versus the lowest quintile, the hazard ratios were 0.82 (95% CI, 0.59–1.14; P_{trend} = 0.285) and 1.09 (95% CI, 0.81–1.48; P_{trend} = 0.329), respectively. Nitrate and nitrite were not associated with gastric cancer. [The Working Group noted that this was a large study with a large number of cases, both for GCA and GNCA.]

In the Netherlands Cohort Study (NLCS), Keszei et al. (2012) reported on the association between intake of processed meat and gastric cancer risk in both men and women, after adjusting for important confounders. The case–cohort study consisted of 120 852 men and women, and after 16.3 years of follow-up, 163 GCAs and 489 GNCAs were observed. The

definition of processed meat included all meat items that had undergone some form of preservation, including cold cuts, croquettes, and all types of sausages. For the highest compared with the lowest category, the relative risks of intake of processed meat for GCA and GNCA were 1.49 (95% CI, 0.81–2.75; P_{trend} = 0.34; 32 exposed cases) and 1.19 (95% CI, 0.78–1.79; P_{trend} = 0.36; 77 exposed cases), respectively, in men. [The Working Group noted that the number of cases for gastric cancer of the cardia was small. A detailed FFQ with 150 items was used.]

Epplein et al. (2014) investigated the interaction between preserved meat, comprising intake of smoked meat, salted meat, and "Chinese" sausage, and *H. pylori* infection among 226 GNCA cases and 451 controls nested within the Shanghai Men's Health Study (SMHS prospective cohort. Overall, after adjusting for important confounders, including age, education, smoking, and total energy, preserved meat intake was not associated with gastric cancer. For the highest compared with the lowest category of intake, the relative risk of preserved meat was 1.01 (95% CI, 0.66–1.55; P_{trend} = 0.99). An effect modification by *H. pylori* was not apparent ($P_{interaction}$ = 0.09). [The Working Group noted that information on *H. pylori* infection was available. This was a study in a population with over 90% prevalence of CagA-positive *H. pylori* infection. Socioeconomic status or education was not adjusted for. Processed meat intake was low in the study population.]

2.3.2 Case–control studies

(a) Red meat

See Table 2.3.3 (web only; available at: http://publications.iarc.fr/564)

The Working Group reviewed 20 reports from case–control studies of gastric cancer reporting on the association with consumption of red meat (La Vecchia et al., 1987; Kono et al., 1988; Ward et al., 1997; De Stefani et al., 1998; Ji et al., 1998; Tavani et al., 2000; Palli et al., 2001; Takezaki et al., 2001; Chen et al., 2002; Huang et al., 2004; Lissowska et al., 2004; Wu et al., 2007; Hu et al., 2008; Navarro Silvera et al., 2008; Pourfarzi et al., 2009; Gao et al., 2011; Wang et al., 2012, 2014; Ward et al., 2012; Zamani et al., 2013). Although odds ratios greater than one were reported in all but three studies (Kono et al., 1988; Ji et al., 1998; Huang et al., 2004), the studies had several methodological limitations, including low precision power resulting from a small number of cases, use of an FFQ that may not have been validated, lack of adjustment for important confounders (e.g. smoking, total energy intake), inclusion of processed meat in the definition of red meat, and issues with the selection of hospital-based controls. Few studies reported analyses by subsite. The Working Group put more emphasis on two well-designed population-based case–control studies from the USA (Wu et al., 2007) and Canada (Hu et al., 2008) that used validated FFQs and adjusted for important confounders.

(b) Processed meat

The Working Group reviewed several case–control studies of gastric cancer that reported on the association with consumption of processed meat. Few studies were hospital-based (Lee et al., 1990; Boeing et al., 1991b; De Stefani et al., 1998, 2012; Huang et al., 2004), and the majority were population-based (Risch et al., 1985; La Vecchia et al., 1987; Sanchez-Diez et al., 1992; Ward & López-Carrillo, 1999; Palli et al., 2001; Takezaki et al., 2001; Chen et al., 2002; Nomura et al., 2003; Lissowska et al., 2004; Wu et al., 2007; Navarro Silvera et al., 2008; Pourfarzi et al., 2009; Hu et al., 2011; Ward et al., 2012).

(i) Hospital-based case–control studies

See Table 2.3.4

Several hospital-based case–control studies of gastric cancer were conducted in Taipei, Taiwan, China (Lee et al., 1990), Germany (Boeing et al., 1991a, b), Uruguay (De Stefani et al., 1998, 2012), and Japan (Huang et al., 2004). All but two

studies (Huang et al., 2004; De Stefani et al., 1998) reported increased risks of gastric cancer associated with processed meat consumption in multivariable models. The possibility of selection bias (due to the selection of hospital-based controls that may have been admitted for conditions leading to modifications in diet), recall bias, and confounding (due to inadequate adjustment for potential confounding variables) could not be ruled out.

(ii) Population-based case–control studies

See Table 2.3.5

Several population-based case–control studies of gastric cancer that reported on processed meat consumption were identified from Canada (Risch et al., 1985; Hu et al., 2011), Italy (La Vecchia et al., 1987; Palli et al., 2001), Poland (Boeing et al., 1991a; Lissowska et al., 2004), Spain (Sanchez-Diez et al., 1992), Mexico (Ward & López-Carrillo, 1999), China (Takezaki et al., 2001), the Islamic Republic of Iran (Pourfarzi et al., 2009), and the USA, specifically Nebraska (Chen et al., 2002; Ward et al., 1997, 2012), Hawaii (Nomura et al., 2003), Los Angeles (Wu et al., 2007), Connecticut, New Jersey, and western Washington state (Navarro Silvera et al., 2008).

Nearly all the studies reported odds ratios above one, although chance, bias, and confounding could not be ruled out as possible explanations for the observed excesses due to study limitations, including inadequate adjustment for potential confounders (e.g. tobacco smoking, total energy intake), recall bias, and information bias (e.g. large amount of information obtained from proxy respondents).

However, no association between processed meat and gastric cancer was reported in a population-based case–control study from 1988 to 1994 in Nebraska, USA (Ward et al., 2012): the multivariate odds ratio for the highest versus the lowest quartile of processed meat consumption was 0.97 (95% CI, 0.51–1.85; P_{trend} = 0.87; 46 exposed cases). Although, in a previous study, Ward et al. (1997) reported a positive association between processed meat and gastric cancer based on servings per day (P_{trend} = 0.06). The 2012 publication conducted a more accurate analysis, estimating grams per day and considering adequate confounding factors. [The Working Group noted that the response rate was high. No subsite analysis was conducted.]

2.3.3 Meta-analyses

(a) Red meat

Among the meta-analyses published on gastric cancer and meat consumption, Song et al. (2014) was the most recent and comprehensive, including 18 studies (4 cohort studies, 14 case–control studies) and 1 228 327 subjects, published between 1997 and 2013. Two case–control studies, Wang et al. (2012) and Navarro Silvera et al. (2008) were not included in the meta-analysis. [Therefore, the Working Group did not place great weight on the meta-analysis.] In the meta-analysis, high–red meat intake was found to be associated with an increased risk of gastric cancer. The summary relative risk of gastric cancer for the highest compared with the lowest categories was 1.37 (95% CI, 1.18–1.59; $P_{heterogeneity}$ < 0.001; I^2 = 67.6%). A significant association was also observed with population-based case–control studies (RR, 1.58; 95% CI, 1.22–2.06; $P_{heterogeneity}$ < 0.001; I^2 = 73.0%) and hospital-based case–control studies (RR, 1.63; 95% CI, 1.38–1.92; $P_{heterogeneity}$ = 0.284; I^2 = 19.1%), but not with cohort studies (RR, 1.00; 95% CI, 0.83–1.20; $P_{heterogeneity}$ = 0.158; I^2 = 33.9%). A significant association was also shown in the subgroup analysis by geographical area (Asia, Europe), publication year (≥ 2000), sample size (< 1000, ≥ 1000), and study quality score. The dose–response analysis revealed that gastric cancer was associated with a 17% increased risk per 100 g/day increment of red meat intake (RR, 1.17; 95% CI, 1.05–1.32). [The Working Group noted that the dose–response

analysis did not distinguish between cohort and case–control studies.]

(b) Processed meat

The most recent and comprehensive meta-analysis on the association between processed meat and gastric cancer was reported by Larsson et al. (2006). The meta-analysis included seven prospective cohort studies and 14 case–control studies. The summary relative risks of gastric cancer for the highest compared with the lowest categories of red meat intake were 1.24 (95% CI, 0.98–1.56; $P_{\text{heterogeneity}} = 0.04$) for cohort studies and 1.63 (95% CI, 1.31–2.01; $P_{\text{heterogeneity}} = 0.06$) for case–control studies. In an exposure–response analysis, the meta-relative risks for gastric cancer were 1.15 (95% CI, 1.04–1.27) for cohort studies and 1.38 (95% CI, 1.19–1.60) for case–control studies per 30 g/day increment of processed meat intake. An elevated risk was also observed for the highest compared with the lowest categories of intake of specific items of processed meat. For bacon, the relative risks were 1.38 (1.12–1.71) for cohort studies and 1.37 (1.06–1.78) for case–control studies, and for sausage, the relative risks were 1.26 (0.92–1.72) for cohort studies and 1.49 (1.09–2.03) for case–control studies. [The Working Group noted that one case–control study in Paraguay (Rolón et al., 1995) was not included. Specific items of processed meat such as ham, bacon, or sausage were analysed separately from processed meat.]

Table 2.3.2 Cohort studies on consumption of processed meat and cancer of the stomach

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
Nomura et al. (1990) Hawaii, USA 1965–October 1986 Cohort study	7990; men of Japanese ancestry, born between 1919–1990, residing on the Hawaiian island of Oahu Exposure assessment method: questionnaire; FFQ for food and 24-h dietary recall for nutrients	Stomach	Risk by frequency for ham, bacon, and sausage			Age
			≤ 1 time/wk	71	1.0	
			2–4 times/wk	43	1.0 (0.7–1.4)	
			≥ 5 times/wk	36	1.3 (0.9–2.0)	
Galanis et al. (1998) Hawaii, USA (Japanese residents) 1975–1994 Cohort study	11 907 (5610 men, 6297 women); randomly selected Japanese residents of Hawaii Exposure assessment method: questionnaire; FFQ	Stomach	Risk by frequency for processed meats			Age, years of education, Japanese place of birth, sex
			Men and women:			
			None	34	1.0	
			1–2 times/wk	39	0.9 (0.6–1.4)	
			≥ 3 times/wk	35	1.0 (0.6–1.7)	
			Trend-test *P* value: 0.37			
		Stomach	Risk by frequency for processed meats			Age, years of education, Japanese place of birth, cigarette smoking, alcohol intake status
			Men:			
			None	18	1.0	
			1–2 times/wk	26	1.1 (0.6–2.0)	
			≥ 3 times/wk	20	1.0 (0.5–1.9)	
			Trend-test *P* value: 0.58			
		Stomach	Risk by frequency for processed meats			Age, years of education, Japanese place of birth
			Women:			
			None	16	1.0	
			1–2 times/wk	13	0.7 (0.3–1.4)	
			≥ 3 times/wk	15	1.2 (0.6–2.4)	
			Trend-test *P* value: 0.77			

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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
González et al. (2006) Ten European countries: Denmark (Aarhus, Copenhagen), France, Germany (Heidelberg, Potsdam), Greece, Italy (Florence, Turin, Varese, Naples, Ragusa), the Netherlands (Bilthoven, Utrecht), Norway, Spain (Granada, Murcia, Asturias, Navarre, San Sebastián), Sweden (Malmö, Umeå), and the United Kingdom (Norfolk, Oxford) 1992–1999/2002 (depending on the study centre) Cohort study	521 457; aged 35–70 yr, usually from the general population Exposure assessment method: questionnaire; FFQ	Stomach	Processed meat (quartiles)			Centre and age at EPIC study entry, and adjusted by sex, height, weight, education level, tobacco smoking, cigarette smoking intensity, work and leisure physical activity, alcohol intake, energy intake, vegetable intake, citrus fruit intake, and non-citrus fruit intake; red meat, poultry, and processed meat intakes were mutually adjusted
			Q1	NR	1.00	
			Q2	NR	1.10 (0.76–1.58)	
			Q3	NR	1.16 (0.79–1.69)	
			Q4	NR	1.62 (1.08–2.41)	
			Continuous, observed	NR	1.18 (0.97–1.43)	
			Continuous, calibrated	NR	1.64 (1.07–2.51)	
			Trend-test *P* value: 0.02			
		Stomach/cardia adenocarcinoma	Processed meat(quartiles)			
			Q1	NR	1.00	
			Q2	NR	1.19 (0.61–2.34)	
			Q3	NR	1.04 (0.51–2.12)	
			Q4	NR	1.14 (0.52–2.49)	
			Continuous, observed	NR	0.89 (0.59–1.34)	
			Continuous, calibrated	NR	0.76 (0.29–1.96)	
			Trend-test *P* value: 0.91			
		Stomach/ non-cardia adenocarcinoma	Processed meat (quartiles)			
			Q1	NR	1.00	
			Q2	NR	1.02 (0.60–1.71)	
			Q3	NR	1.02 (0.59–1.77)	
			Q4	NR	1.92 (1.11–3.33)	
			Continuous, observed	NR	1.36 (1.06–1.74)	
			Continuous, calibrated	NR	2.45 (1.43–4.21)	
			Trend-test *P* value: 0.01			

Table 2.3.2 Cohort studies on consumption of processed meat and cancer of the stomach

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
González et al. (2006) (cont.)		Stomach/ adenocarcinoma	Processed meat (nested case–control study)			
			H. pylori antibody status: Negative	40	0.45 (0.05–4.01)	
			Positive	201	2.00 (1.06–3.79)	
			Trend-test *P* value: 0.48			
		Stomach/cardia adenocarcinoma	Processed meat (nested case–control study)			
			H. pylori antibody status: Negative	22	0.86 (0.03–27.0)	
			Positive	47	1.62 (0.47–5.55)	
			Trend-test *P* value: 0.42			
		Stomach/ non-cardia adenocarcinoma	Processed meat (nested case–control study)			
			H. pylori antibody status: Negative	12	0.002 (0.001–62.6)	
			Positive	113	2.67 (1.20–5.93)	
			Trend-test *P* value: 0.25			
Larsson et al. (2006) Uppsala and Västmanland counties, central Sweden Recruitment, 1987–1990; end of follow-up, 2004 Cohort study	61 433; women born in 1914 and 1948 Exposure assessment method: questionnaire; FFQ, age-specific portion sizes (mean of weighed and recorded food data of 213 random samples unpublished)	Stomach	Processed meat (servings/wk)			Age, education, BMI, energy, alcohol, fruits, vegetables
			< 1.5	51	1.00	
			1.5–2.9	38	1.46 (0.95–2.25)	
			≥ 3.0	67	1.66 (1.13–2.45)	
			Trend-test *P* value: 0.01			
		Stomach	Bacon or side pork (servings/wk)			
			0	52	1.00	
			0.1–0.4	66	1.27 (0.88–1.85)	
			≥ 0.5	38	1.55 (1.00–2.41)	
			Trend-test *P* value: 0.05			
		Stomach	Sausage or hot dogs (servings/wk)			
			< 0.4	24	1.00	
			0.4–0.9	55	1.44 (0.89–2.35)	
			≥ 1.0	77	1.50 (0.93–2.41)	
			Trend-test *P* value: 0.13			
		Stomach	Ham or salami (servings/wk)			
			< 0.4	45	1.00	
			0.4–1.4	46	0.97 (0.65–1.51)	
			≥ 1.5	65	1.48 (0.99–2.22)	
			Trend-test *P* value: 0.03			

Table 2.3.2 Cohort studies on consumption of processed meat and cancer of the stomach

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
Cross et al. (2011) California, Florida, Louisiana, New Jersey, North Carolina, Pennsylvania, and two metropolitan areas (Atlanta, Georgia, and Detroit, Michigan), USA End of 2006 Cohort study	494 979; men and women aged 50–71 yr; enrolled in 1995–1996. The following individuals were excluded: duplicates and participants who died or moved before the baseline questionnaire was received or withdrew from the study, who did not return the baseline questionnaire, whose baseline questionnaire was filled in by someone else on their behalf, who had prevalent cancer according to the cancer registry or self-report, and who had extreme daily total energy intake Exposure assessment method: questionnaire; dietary intake of various food items was assessed through a 124-item FFQ (usual frequency of consumption and portion size information of foods over the previous 12 mo). Portion sizes and daily nutrient intakes were calculated from the 1994–1996 USA Department of Agriculture's Continuing Survey of Food Intakes by Individuals. "Processed meat" was bacon, red meat sausage, poultry sausage, luncheon meats (red and white meat), cold cuts (red and white meat), ham, regular hot dogs, and low-fat hot dogs made from poultry; meat added to complex food mixtures, such as pizza, chilli, lasagne, and stew, contributed to the relevant meat type	Stomach/cardia adenocarcinoma	Processed meat (quintile median, µg/1000 kcal)			Age, sex, BMI, education, ethnicity, tobacco smoking, alcohol drinking, usual physical activity at work, vigorous physical activity, daily intake of fruits, daily intake of vegetables, daily intake of saturated fat, daily intake of calories
			Q1 (1.7)	68	1.00	
			Q2 (4.5)	78	0.89 (0.64–1.24)	
			Q3 (7.8)	93	0.91 (0.66–1.26)	
			Q4 (12.6)	108	0.92 (0.67–1.28)	
			Q5 (23.2)	107	0.82 (0.59–1.14)	
			All processed meats, continuous (per 10 g/1000 kcal)	NR	1.00 (0.92–1.09)	
			Trend-test *P* value: 0.285			
		Stomach/ non-cardia adenocarcinoma	Processed meat (quintile median, µg/1000 kcal)			
			Q1 (1.7)	93	1.00	
			Q2 (4.5)	81	0.87 (0.64–1.18)	
			Q3 (7.8)	105	1.10 (0.82–1.47)	
			Q4 (12.6)	105	1.04 (0.77–1.41)	
			Q5 (23.2)	117	1.09 (0.81–1.48)	
			All processed meats, continuous (per 10 g/1000 kcal)	NR	1.02 (0.94–1.11)	
			Trend-test *P* value: 0.329			

Table 2.3.2 Cohort studies on consumption of processed meat and cancer of the stomach

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
Cross et al. (2011) California, Florida, Louisiana, New Jersey, North Carolina, Pennsylvania, and two metropolitan areas (Atlanta, Georgia, and Detroit, Michigan), USA End of 2006 Cohort study	303 156; men and women aged 5–71 yr; enrolled in 1995–1996. The following individuals were excluded: duplicates and participants who died or moved before the risk factor questionnaire was received or withdrew from the study, who did not return the risk factor questionnaire, whose risk factor questionnaire was filled in by someone else on their behalf, who had prevalent cancer according to the cancer registry or self-report, and who had extreme daily total energy intake Exposure assessment method: questionnaire; dietary intake of various food items was assessed through a 124-item FFQ (usual frequency of consumption and portion size information of foods over the previous 12 mo). Portion sizes and daily nutrient intakes were calculated from the 1994-1996 USA Department of Agriculture's Continuing Survey of Food Intakes by Individuals. A risk factor questionnaire sent 6 mo later elicited detailed information on meat intake and cooking preferences. Nitrate and nitrite intake from processed meat was estimated using a database of measured values from 10 types of processed meats, which represented 90% of processed meats consumed in the USA	Stomach/ stomach cardia adenocarcinoma	Nitrate (quintile median, µg/1000 kcal)			Age, sex, BMI, education, ethnicity, tobacco smoking, alcohol drinking, usual physical activity at work, vigorous physical activity, daily intake of fruits, daily intake of vegetables, daily intake of saturated fat, daily intake of calories
			Q1 (24.9)	39	1.00	
			Q2 (66.9)	57	1.17 (0.77–1.77)	
			Q3 (112.7)	36	0.64 (0.40–1.02)	
			Q4 (174.5	61	0.94 (0.61–1.45)	
			Q5 (298.0)	62	0.81 (0.52–1.25)	
			All nitrates, continuous (per 100 µg/1000 kcal)	NR	0.99 (0.90–1.09)	
			Trend-test *P* value: 0.259			
		Stomach/cardia adenocarcinoma	Nitrite (quintile median, µg/1000 kcal)			
			Q1 (12.1)	44	1.00	
			Q2 (34.6)	40	0.72 (0.47–1.11)	
			Q3 (61.4)	55	0.88 (0.58–1.32)	
			Q4 (102.9)	61	0.87 (0.58–1.31)	
			Q5 (199.2)	55	0.71 (0.47–1.08)	
			All nitrites, continuous (per 100 µg/1000 kcal)	NR	0.89 (0.77–1.03)	
			Trend-test *P* value: 0.25			
		Stomach/ non-cardia adenocarcinoma	Nitrate (quintile median, µg/1000 kcal)			
			Q1 (24.2)	50	1.00	
			Q2 (66.9)	48	0.90 (0.60–1.35)	
			Q3 (112.7)	50	0.89 (0.59–1.33)	
			Q4 (174.5)	56	0.91 (0.61–1.37)	
			Q5 (298.0)	73	1.04 (0.69–1.55)	
			All nitrates, continuous (per 100 µg/1000 kcal)	NR	1.01 (0.92–1.10)	
			Trend-test *P* value: 0.578			

Table 2.3.2 Cohort studies on consumption of processed meat and cancer of the stomach

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
Cross et al. (2011) (cont.)		Stomach/ non-cardia adenocarcinoma	Nitrite (quintile median, µg/1000 kcal)			
			Q1 (12.1)	54	1.00	
			Q2 (34.6)	44	0.77 (0.51–1.15)	
			Q3 (61.4)	48	0.79 (0.53–1.18)	
			Q4 (102.9)	67	1.04 (0.71–1.52)	
			Q5 (199.2)	64	0.93 (0.63–1.37)	
			All nitrite, continuous (per 100 µg/1000 kcal)	NR	1.02 (0.91–1.15)	
			Trend-test *P* value: 0.615			
Keszei et al. (2012) The Netherlands 1986–2002 Cohort study	120 852 individuals were recruited, and finally, 3923 sub-cohort members were used in the analysis (case–cohort design); the sample was selected from 204 municipal population registries throughout the Netherlands by sex-stratified random sampling Exposure assessment method: questionnaire; FFQ	Stomach/cardia adenocarcinoma	Processed meat intake			Age, smoking status, years of cigarette smoking, number of cigarettes smoked per day, total energy intake, BMI, alcohol intake, vegetable intake), fruit intake, levels of education, non-occupational physical activity
			Men:			
			Q1	23	1.00	
			Q2	34	1.51 (0.86–2.64)	
			Q3	21	0.89 (0.47–1.68)	
			Q4	29	1.26 (0.71–2.24)	
			Q5	32	1.49 (0.81–2.75)	
			Continuous (50 g/day increment)	139	1.15 (0.71–1.86)	
			Trend-test *P* value: 0.34			
		Stomach/ non-cardia adenocarcinoma	Processed meat intake (quintiles)			
			Men:			
			Q1	62	1.00	
			Q2	65	1.05 (0.71–1.56)	
			Q3	59	0.96 (0.64–1.44)	
			Q4	66	1.09 (0.73–1.63)	
			Q5	77	1.19 (0.78–1.79)	
			Trend-test *P* value: 0.36			

Table 2.3.2 Cohort studies on consumption of processed meat and cancer of the stomach

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
Keszei et al. (2012) The Netherlands 1986–2002 Cohort study (cont.)		Stomach/cardia adenocarcinoma	Processed meat intake			
			Women:			
			T1	7	1.00	
			T2	8	1.19 (0.41–3.44)	
			T3	9	1.12 (0.36–3.47)	
			Continuous (50 g/day increment)	24	0.70 (0.14–3.47)	
			Trend-test *P* value: 0.89			
		Stomach/ non-cardia adenocarcinoma	Processed meat intake (tertiles)			
			Women:			
			T1	51	1.00	
			T2	56	1.21 (0.81–1.81)	
			T3	53	1.11 (0.73–1.70)	
			Trend-test *P* value: 0.7			
Epplein et al. (2014) Shanghai, China Recruitment, 2002–2006; follow-up, 2009 Nested case–control study	Cases: 226 incident cases; permanent residents of urban Shanghai Controls: 451; permanent residents of urban Shanghai Exposure assessment method: questionnaire; validated FFQ; frequency of intake and not amount; preserved meat was smoked meat, salted meat, and Chinese sausage	Stomach/ non-cardia adenocarcinoma	Processed meat intake (times/mo), tertiles			Age, smoking, history of gastritis, regular aspirin use, total energy intake, high-risk *H. pylori* infection
			T1 (≤ 0.20)	71	1.00	
			T2 (0.21–1.42)	81	1.13 (0.74–1.72)	
			T3 (1.42)	74	1.01 (0.66–1.55)	
			Trend-test *P* value: 0.99			
		Stomach/ non-cardia adenocarcinoma	Processed meat intake (times/mo) in low risk residents (0–4 seropositive results to 6 *H. pylori* proteins), tertiles			
			T1	37	1.00	
			T2	29	0.96 (0.53–1.72)	
			T3	20	0.79 (0.41–1.51)	
			Trend-test *P* value: 0.49			
		Stomach/ non-cardia adenocarcinoma	Processed meat intake (times/mo) in high risk residents (seropositive results to 6 *H. pylori* proteins), tertiles			
			T1	34	1.00	
			T2	52	1.42 (0.80–2.52)	
			T3	54	1.34 (0.76–2.36)	
			Trend-test *P* value: 0.09			

BMI, body mass index; CI, confidence interval; EPIC, European Prospective Investigation into Cancer and Nutrition; FFQ, food frequency questionnaire; h, hour; ICD, International Classification of Diseases; mo, month; NR, not reported; wk, week; yr, year

Table 2.3.4 Case–control studies (hospital-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Lee et al. (1990) Taipei City, Taiwan, China NA	Cases: 210; serial patients with stomach cancer from four major teaching hospitals in Taipei City Controls: 810; hospital controls, group-matched to cases by hospital, age, and sex, were recruited from among ophthalmic patients in study hospitals Exposure assessment method: questionnaire	Stomach	Salted meat consumption, before age 20			Adjusted for only risk factors significantly associated with stomach cancer in univariate analysis
			< 1 meal/mo	129	1.00	
			2–5 meals/mo	50	1.24	
			≥ 6 meals/mo	31	2.90	
			Salted meat consumption, between ages 20 and 39			
			< 1 meal/mo	137	1.00	
			2–5 meals/mo	55	1.26	
			≥ 6 meals/mo	18	3.26	
			Cured meat consumption, before age 20			
			< 1 meal/mo	31	1.00	
			2–5 meals/mo	156	1.61	
			≥ 6 meals/mo	23	1.72	
			Cured meat consumption, between ages 20 and 39			
			< 1 meal/mo	23	1.00	
			2–5 meals/mo	146	2.04	
			≥ 6 meals/mo	41	2.31	
			Salted meat consumption (frequency/mo)			
			< 1 meal/mo	266	1.00	
			2–5 meals/mo	105	1.48	
			≥ 6 meals/mo	49	3.18	
Boeing et al. (1991b) Germany 1985–1988	Cases: 143; the local coordinators identified all patients younger than 80 yr with histologically confirmed incident stomach cancer admitted to hospitals, and organized interviews in the hospitals, which were conducted by trained interviewers	Stomach	Processed meat, tertile 1 (lowest)	NR	1.00	Adjusted for age, sex, hospital, raw vegetables, citrus fruit, cheese, wholemeal bread
			Processed meat, tertile 2	NR	1.37 (0.82–2.31)	
			Processed meat, tertile 3 (highest)	NR	2.21 (1.32–3.71)	
			χ^2 for trend = 9.46	NR	–	

Table 2.3.4 Case–control studies (hospital-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Boeing et al. (1991b) Germany 1985–1988 (cont.)	Controls: 579; one group of controls consisted of patients from the hospitals, usually two controls of the same sex for each case and of comparable age; patients with a history of chronic atrophic gastritis or intestinal metaplasia were not considered to be eligible as controls; another type of control group consisted of visitors to the hospitals, who were approached directly by the interviewers during their temporary stay at the hospital; the interviewers were advised to keep their selection of visitor controls within age limits similar to those of the cases Exposure assessment method: questionnaire		Smoking of meat at home, no	68	1.00	Adjusted for age, sex, hospital
			Smoking of meat at home, yes (other wood)	57	0.88 (0.59–1.34)	
			Smoking of meat at home, yes (specifying spruce)	18	3.19 (1.50–6.75)	
			Nitrate (quintiles)			Age, sex, hospital, vitamin C, carotene, calcium
			Q1	NR	1.00	
			Q2	NR	0.93 (0.53–1.64)	
			Q3	NR	0.61 (0.32–1.19)	
			Q4	NR	0.61 (0.30–1.27)	
			Q5	NR	1.26 (0.59–2.70)	

Table 2.3.4 Case–control studies (hospital-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Boeing et al. (1991a) Poland (nine university hospitals) 1986–1990	Cases: 741 (including 374 carcinoma intestinalis and 259 carcinoma of the diffuse-type cases); consecutive incident cases of gastric cancer (adenocarcinoma), histologically confirmed (histological diagnosis from the surgical excision or, if the patient was not operable, endoscopy-based diagnosis using the obtained biopsy material) Controls: 741; hospital-based controls admitted to the hospital surgical wards for other reasons, matched to the cases by sex and age (≥ 5 yr) Exposure assessment method: questionnaire; dietary intake measured by an FFQ including 43 single-food items; frequency was estimated on a scale of six categories (ranging from "never" to "everyday"), but "no efforts were made to quantify food consumption"; tertiles based on the distribution of frequency categories among the controls were used in the analysis; "processed meat" was estimated by the items "sausages" and "ham of good quality"	Stomach/ adenocarcinoma (all)	Sausages			Age, sex, occupation, education, residency, fruit and vegetable score, non-white bread, cheese score
			Tertile 1 (low)	388	1.00	
			Tertile 2	266	1.20 (0.95–1.51)	
			Tertile 3 (high)	87	1.55 (1.07–2.26)	
			Trend-test *P* value: 0.01			
		Stomach/ adenocarcinoma (intestinal type)	Sausages			
			Tertile 1 (low)	NR	1.00	
			Tertile 2	NR	1.09 (0.79–1.52)	
			Tertile 3 (high)	NR	1.74 (1.00–3.01)	
			Trend-test *P* value: 0.09			
		Stomach/ adenocarcinoma (diffuse type)	Sausages			
			Tertile 1 (low)	NR	1.00	
			Tertile 2	NR	1.19 (0.79–1.79)	
			Tertile 3 (high)	NR	1.63 (0.85–3.15)	
			Trend-test *P* value: 0.13			
		Stomach/ adenocarcinoma (all)	Ham			
			Tertile 1 (low)	313	1.00	
			Tertile 2	268	0.89	
			Tertile 3 (high)	160	0.87	
			Trend-test *P* value: 0.29			

Table 2.3.4 Case–control studies (hospital-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
De Stefani et al. (1998) Montevideo, Uruguay 1993–1996	Cases: 340; all newly diagnosed and microscopically confirmed patients with gastric cancer admitted to the four major hospitals in Montevideo Controls: 698; all controls were selected from the same hospitals and in the same period as the cases; controls were aged 25–84 yr, free of conditions related to digestive tract or nutritional disorders, and free of conditions related to tobacco and alcohol consumption Exposure assessment method: questionnaire	Stomach	Nitrite Processed meat	NR NR	0.53 (0.42–0.67) 0.96 (0.79–1.17)	Age, sex, residence, urban/rural status, tobacco duration, total alcohol consumption, mate drinking; red meat, barbecued meat, salted meat, processed meat, vegetables, and fruits were also included in the model

Table 2.3.4 Case–control studies (hospital-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Huang et al. (2004) Nagoya, Japan 1988–1998	Cases: 1988; of a total of 80 420 first-visit outpatients who visited the Aichi Cancer Center Hospital between January 1988 and June 1998; 8057 outpatients were excluded due to interviewer absence, inadmissible age (younger than 18 yr), or visit for a consultation; the questionnaire was finally administered to 72 363 subjects; among them, 71 277 (98.5%) completed the questionnaire adequately; after linkage between questionnaire data and medical data, 9032 subjects (12.7%) were excluded, as the cancer history of at least one of their parents or siblings was unknown Controls: 50 706; first-visit non-cancer subjects were regarded as the referent group Exposure assessment method: questionnaire; FFQ	Stomach	Risk by frequency for sausage			Age, sex
			≥ 3 times/wk vs < 3 times/wk, without gastric cancer family history	NR	1.03 (0.86–1.22)	
			≥ 3 times/wk vs < 3 times/wk, with gastric cancer family history	NR	0.87 (0.61–1.26)	

Table 2.3.4 Case–control studies (hospital-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
De Stefani et al. (2012) Uruguay 1996–2004	Cases: 234 274; incident cases of stomach cancer (n = 274) diagnosed in the four major hospitals in Montevideo and microscopically confirmed (C15) Controls: 2532; hospital-based controls (from the same hospitals) with conditions unrelated to tobacco smoking and alcohol drinking Exposure assessment method: questionnaire; dietary intake measured by an FFQ including 64 food items (quantities recorded as servings/wk) and tested for reproducibility with good results; "processed meat" was bacon, sausage, mortadella, salami, saucisson, hot dog, ham, and air-dried and salted lamb; intakes were energy-adjusted by the residual method	Stomach	Processed meat by type *Men*			Age, residence, BMI, smoking status, smoking cessation, number of cigarettes smoked per day among current smokers, alcohol drinking, mate consumption, total energy intake, total vegetable and fruit intake, total white meat and red meat intake.
			Bacon	NR	0.64 (0.49–0.83)	
			Sausage	NR	1.02 (0.86–1.21)	
			Mortadella	NR	0.99 (0.87–1.14)	
			Salami	NR	0.99 (0.86–1.15)	
			Saucisson	NR	1.22 (1.03–1.44)	
			Hot dog	NR	1.49 (1.30–1.70)	
			Ham	NR	0.96 (0.81–1.14)	
			Salted meat	NR	1.02 (0.87–1.19)	
			Processed meat by type *Women*			
			Bacon	NR	0.72 (0.46–1.13)	
			Sausage	NR	1.16 (0.88–1.53)	
			Mortadella	NR	1.25 (1.01–1.56)	
			Salami	NR	0.76 (0.58–0.99)	
			Saucisson	NR	1.48 (1.07–2.04)	
			Hot dog	NR	1.50 (1.23–1.83)	
			Ham	NR	1.24 (1.03–1.44)	
			Salted meat	NR	0.62 (0.36–1.07)	
			Processed meat *Men*			
			T1 (< 11.4 g/day)	NR	1.00	
			T2 (11.5–28.2 g/day)	NR	1.60 (1.02–2.49)	
			T3 (≥ 28.3 g/day)	NR	1.93 (1.25–2.98)	
			Trend-test P value: 0.003			
			Processed meat *Women*			
			T1 (< 11.4 g/day)	NR	1.00	
			T2 (11.5–28.2 g/day)	NR	3.07 (1.58–5.98)	
			T3 (≥ 28.3 g/day)	NR	4.51 (2.34–8.70)	
			Trend-test P value: 0.0001			

BMI, body mass index; CI, confidence intervals; FFQ, food frequency questionnaire; mo, month; NA, not available; NR, not reported

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Risch et al. (1985) Toronto, Winnipeg, and St John's, Canada 1979–1982	Cases: 246; aged 35–79 yr with newly diagnosed gastric cancer; all cases were histologically verified Controls: 246; randomly selected population controls; individually matched by age, sex, and area of residence Exposure assessment method: questionnaire	Stomach	Smoked meats (per 100 g/day increase)	246	2.22 (1.19–4.15)	Total food consumption and ethnicity
			Nitrite (1 mg/day)	246	1.71 (1.24–2.37)	
			Nitrate (100 g/day)	246	0.66 (0.54–0.81)	
			Dimethylnitrosamine (10 µg/day)	246	0.94 (0.14–6.13)	
			Smoked meats (per 100 g/day increase)	246	3.92 (1.76–8.75)	Matched by age, sex, area of residence, and adjusted for total food consumption, ethnicity, and consumption of grains, chocolate, fibrous foods, eggs, and public water supply

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
La Vecchia et al. (1987) Greater Milan area, Italy January 1985–June 1986	Cases: 206; incident cases of histologically confirmed gastric cancer diagnosed within the year preceding the interview and admitted to the National Cancer Institute, to several university clinics (chiefly surgery), and to the Ospedale Maggiore in Milan Controls: 474; hospital-based controls who were admitted to the Ospedale Maggiore in Milan and to several university clinics; patients admitted for malignant disorders, any disease of the digestive tract, or any condition related to consumption of alcohol or tobacco that might have resulted in modification of the diet were excluded Exposure assessment method: questionnaire; dietary intake was based on an FFQ including 29 food items; individuals were asked to indicate the frequency of consumption of these items per week before the onset of the disease that led to hospital admission and to recall any major change in frequency of intake of the same foods during the 10-yr period preceding the diagnosis; items related to processed meat were "raw ham", "ham", "salami and other sausages", and "canned meat"	Stomach	Raw ham intake (frequency)			Age, sex
			Low	75	1.00	
			Intermediate	37	0.62	
			High	94	1.04	
			Salami and other sausages intake (frequency)			
			Low	114	1.00	
			Intermediate	31	0.56	
			High	61	1.27	
			Canned meat intake (frequency)			
			Low	187	1.00	
			Intermediate	15	0.95	
			High	4	0.77	

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Sanchez-Diez et al. (1992) Province of León, Spain 1975–1986	Cases: 109; total cases diagnosed between 1975 and 1986 at a specific study site Controls: 123; all people born locally or who had been living in the area for the past 10 yr; one control was randomly selected and matched by year of birth, sex, and municipality of residence Exposure assessment method: questionnaire	Stomach	Homemade sausages, not consumed	13	1.00	Matched by year of birth, sex, municipality of residence
			Homemade sausages, daily consumption	42	3.34 (1.51–7.37)	
			Smoked sausages, not consumed	9	1.00	
			Smoked sausages, daily consumption	40	3.55 (1.59–7.94)	
Ward & López-Carrillo (1999) Mexico City, Mexico 1989–1990	Cases: 220; 267 newly diagnosed cases of gastric cancer in patients aged 20 yr and older were identified between 1989 and 1990 at 15 metropolitan area hospitals in Mexico City; these cases represented approximately 80% of those reported to the Mexican Cancer Registry in the same period; 22 (8.2%) of the identified cases were unavailable for interview; a further 20 cases (7.5%) were excluded because the pathology material could not be obtained, and five cases (1.9%) were excluded because their tumours were not adenocarcinomas of the stomach Controls: 752; controls were an age-stratified random sample of Mexico City metropolitan area residents selected from the 1986–1987 household sampling frame of the Mexican National Survey for Health and Nutrition Exposure assessment method: questionnaire	Stomach/ adenocarcinoma	Processed meat intake (times/wk)			Age, sex, total calories, chilli pepper consumption, added salt, history of peptic ulcer, cigarette smoking, socioeconomic status
			< 1	25	1.0	
			1–2	67	2.0 (1.0–3.8)	
			3–5	68	2.8 (1.4–5.7)	
			≥ 6	60	3.2 (1.5–6.6)	
			Trend-test *P* value: 0.002			
		Stomach/ adenocarcinoma (intestinal)	Processed meat intake (times/wk)			
			< 1	NR	1.0	
			1–2	NR	2.2 (0.9–5.2)	
			3–5	NR	2.6 (1.0–6.4)	
			≥ 6	NR	2.6 (1.0–7.0)	
		Stomach/ adenocarcinoma (diffuse)	Processed meat intake (times/wk)			
			< 1	NR	1.0	
			1–2	NR	1.1 (0.5–2.8)	
			3–5	NR	1.8 (0.7–4.6)	
			≥ 6	NR	2.2 (0.8–6.0)	

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Palli et al. (2001) Florence, Italy 1985–1987	Cases: 382; all gastric cancer cases were histologically confirmed and originally classified according to the Lauren classification by review of all available surgical pathology specimens Controls: 561; computerized lists of residents were used to identify a random sample of eligible population controls Exposure assessment method: questionnaire	Stomach	Cured and canned meat intake, MSI+ Tertile 1 Tertile 2 Tertile 3 Trend-test *P* value: 0.1 Cured and canned meat intake, MSI– Tertile 1 Tertile 2 Tertile 3 Trend-test *P* value: 0.05	 NR NR NR NR NR NR 	 1.0 1.0 (0.5–2.4) 1.0 (0.4–2.6) 1.0 1.2 (0.6–2.3) 1.9 (1.0–3.7) 	Adjusted for non-dietary variables (age, sex, social class, family history of gastric cancer, area of residence, BMI), total energy, consumption tertiles of each food of interest (reference, lowest tertile)
Takezaki et al. (2001) Pizhou, Jiangsu Province, China 1996 (1995 for controls)–2000	Cases: 187 stomach cancer; incident cases of histopathologically confirmed cases of stomach cancer who visited the Pizhou City Municipal Hospital Controls: 333; healthy residents of Pizhou, matched to cases by sex, ethnicity, and age (≤ 2 yr); controls came from three different sources: individuals from a population-based ecological study conducted in 1995–1996; individuals selected between 1995 and 1998 in the general population; individuals selected between 1998 and 2000 Exposure assessment method: questionnaire; food consumption frequency was measured at the time of the interview and 10 yr previously; among the available items, only "salted meat" could be used to estimate "processed meat" consumption; previously used in a case–control and ecological study	Stomach	Salted meat, < 1 time/mo Salted meat, 1–3 times/mo Salted meat, ≥ 1 time/wk Trend-test *P* value: 0.001	NR NR NR	1.00 3.82 (2.24–6.50) 2.36 (1.08–5.15)	Age, sex, smoking, drinking

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Chen et al. (2002) Eastern Nebraska, USA 1 July 1988–31 June 1993	Cases: 124 (distal stomach); incident, histologically confirmed cases of stomach adenocarcinoma, identified from the Nebraska Cancer Registry or 14 participating hospitals covering > 90% of the study population Controls: 449; population-based controls selected from the control group of a previous case–control study conducted in 1986–1987 in the same base population; frequency-matched to the whole distribution of cases by age, sex, and vital status Exposure assessment method: questionnaire; dietary assessment was based on a modified version of the short HHHQ, with the addition of several food items (e.g. for processed meat); subjects were asked to recall frequency of consumption of 54 dietary items before 1985; "processed meat" was bacon; sausage, including breakfast sausage; processed or smoked ham bought from the store; meat that was cured or smoked at home; sandwich meats, such as bologna or salami; and hot dogs	Stomach/distal adenocarcinoma	Processed meat (times/day), quartiles			Age, sex, energy intake, respondent type, BMI, alcohol use, tobacco use, education, family history, vitamin supplement use
			Q1	NR	1.00	
			Q2	NR	1.70 (0.77–3.70)	
			Q3	NR	1.20 (0.55–2.70)	
			Q4	NR	1.70 (0.72–3.90)	

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Nomura et al. (2003) Hawaii, USA 1993–1999	Cases: 658; from eight major hospitals on the Hawaiian Islands and identified by the rapid reporting system of the Hawaii Tumor Registry Controls: 446; controls identified from lists of Oahu residents interviewed by the Health Surveillance Program, which identifies a 1% representative random sample of all households in the state Exposure assessment method: questionnaire	Stomach	Processed meat *Men* T1 T2 T3 Trend-test *P* value: 0.19 Processed meat, Tertiles *Women* T1 T2 T3 Trend-test *P* value: 0.43 Bacon, Tertiles *Men* T1 T2 T3 Trend-test *P* value: 0.36 Bacon *Women* T1 T2 T3 Trend-test *P* value: 0.4	 NR NR NR NR NR NR NR NR NR NR NR NR	 1.0 1.8 (1.0–3.3) 1.7 (0.9–3.3) 1.0 0.6 (0.3–1.3) 0.7 (0.3–1.5) 1.0 1.3 (0.7–2.2) 1.3 (0.7–2.4) 1.0 0.6 (0.3–1.3) 1.1 (0.5–2.3)	Age, ethnicity, smoking, education, history of gastric ulcer, NSAID use, family history of gastric cancer, total calories, intake of other foods and food groups
Lissowska et al. (2004) Warsaw, Poland 1994–1996	Cases: 274; cases consisted of Warsaw residents newly diagnosed with stomach cancer; identified by collaborating physicians in each of the 22 hospitals Controls: 463; controls randomly selected from the general population in Warsaw Exposure assessment method: questionnaire	Stomach	Sausages ,Quartiles (frequency/wk) Q1 Q2 Q3 Q4 Trend-test *P* value: 0.81	 NR NR NR NR	 1.00 1.13 (0.74–1.71) 0.75 (0.48–1.17) 1.23 (0.79–1.93)	Age, sex, education, smoking, calories from food

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Wu et al. (2007) Los Angeles, USA 1992–1997	Cases: 829; all incident cancers were identified by the Los Angeles Cancer Surveillance Program, a population-based tumour registry Controls: 1308; control subjects were individually matched to interviewed case patients by sex, race, and date of birth (± 5 yr) in the neighbourhoods Exposure assessment method: questionnaire	Stomach/cardia adenocarcinoma	Processed meat, quartiles (g/day)			Age, sex, race, birthplace, education, smoking, BMI (kg/m^2), reflux, use of vitamins, total calories
			Q1	NR	1.00	
			Q2	NR	0.84 (0.60–1.30)	
			Q3	NR	0.76 (0.50–1.20)	
			Q4	NR	0.89 (0.60–1.40)	
			Trend-test *P* value: 0.57			
		Stomach/distal adenocarcinoma	Processed meat, quartiles (g/day)			
			Q1	NR	1.00	
			Q2	NR	1.54 (1.10–2.20)	
			Q3	NR	1.22 (0.80–1.80)	
			Q4	NR	1.65 (1.10–2.50)	
			Trend-test *P* value: 0.049			
		Stomach/cardia adenocarcinoma	Processed meat among subjects infected with *H. pylori*, quartiles of intake (g/day)			
			Q1	NR	1.00	
			Q2	NR	1.16 (0.60–2.40)	
			Q3	NR	0.40 (0.20–0.96)	
			Q4	NR	0.57 (0.20–1.30)	
			Trend-test *P* value: 0.08			
		Stomach/distal adenocarcinoma	Processed meat among subjects infected with *H. pylori*, quartiles of intake (g/day)			
			Q1	NR	1.00	
			Q2	NR	2.46 (1.10–5.20)	
			Q3	NR	1.40 (0.60–3.10)	
			Q4	NR	1.97 (0.90–4.50)	
			Trend-test *P* value: 0.3			

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Navarro Silvera et al. (2008) Connecticut, New Jersey and western Washington, USA 1993–early 1995	Cases: 607; incident cases of stomach adenocarcinoma (255 cardia cases, 352 non-cardia cases); this population was part of a larger population of cases also containing cases of cardia and non-cardia gastric adenocarcinoma; gastric cardia adenocarcinoma were considered as the "target cases", whereas non-cardia gastric adenocarcinoma cases were considered as the "comparison case group", which was frequency-matched to the "target group"	Stomach/cardia adenocarcinoma	High-nitrite meats, for an increase in intake of 1 serving/day	NR NR	1.19 (0.74–1.91)	Sex; site; age, "race"; proxy status; income; education; usual BMI; cigarettes per day; consumption of beer, wine, and liquor each; energy intake
		Stomach/ non-cardia adenocarcinoma	High-nitrite meats, for an increase in intake of 1 serving/day	NR NR	1.88 (1.24–2.84)	

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Navarro Silvera et al. (2008) Connecticut, New Jersey and western Washington, USA 1993–early 1995 (cont.)	Controls: 687; population-based controls frequency-matched to the expected distribution of the "target cases" by 5-yr age group, sex (in New Jersey and Washington state), "race" (in New Jersey), and study site; controls aged 30–64 yr were identified by the random digit dialling method, and controls aged 65–79 yr were identified by Health Care Financing Administration rosters Exposure assessment method: questionnaire; an expanded version of an FFQ developed and validated by investigators at the Fred Hutchinson Cancer Research Center was used to assess usual food consumption in the period 3–5 yr before diagnosis (cases) or interview (controls); processed meat was defined as " high-nitrite meats", including smoked turkey lunchmeat; cured, smoked ham lunchmeat; bologna; salami; hot dogs; sausage, not including breakfast sausage; bacon; and breakfast sausage					

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Pourfarzi et al. (2009) Ardabil Province, Iran 2004–2005	Cases: 217; identified from the Ardabil Cancer Registry; cases were eligible if they were in people who had been Ardabil residents for at least 5 yr before diagnosis, were aged older than 18 yr, had not had previous gastric surgery, and had a positive histopathological report of gastric carcinoma; in addition to the cases routinely reported to the cancer registry, active surveillance for gastric cancer was conducted by the cancer registry through all hospitals and clinics, particularly those of three gastroenterologists, to maximize the completeness of case ascertainment Controls: 394; two controls were sought for each case and frequency-matched to the case group by age (5 yr) and sex; controls had to satisfy the same residency and age criteria as cases, and were randomly selected from the community using a computer-based sampling frame that had been created for the annual household survey by the health department; this database was used to select random households, which were then visited by health professionals seeking eligible individuals; if such a person was not available or did not satisfy the inclusion criteria, the immediate neighbour to the right-hand side was visited Exposure assessment method: questionnaire	Stomach	Smoked meats, ≥ 1 time/mo Smoked meats, never Processed meats, ≥ 1 time/mo Processed meats, never	20 189 23 188	0.91 (0.40–2.09) 1.00 1.14 (0.55–2.37) 1.00	Sex, age group, education, family history of gastric cancer, citrus fruits, garlic, onion, red meat, fish, dairy products, strength and warmth of tea, preference for salt intake, *H. pylori*

Table 2.3.5 Case–control studies (population-based) on consumption of processed meat and cancer of the stomach

Reference, location, enrolment/follow-up period	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Hu et al. (2011) Canada 1994–1997	Cases: 1182; this study involved histologically confirmed cancer cases Controls: 5039; individuals without cancer were selected from a random sample of the population within each province, with an age and sex distribution similar to that of all cancer cases Exposure assessment method: questionnaire	Stomach	Processed meat (servings/wk) ≤ 0.94 0.95–2.41 2.42–5.41 ≥ 5.42 Trend-test *P* value: 0.0001	 NR NR NR NR	 1.0 1.2 (1.0–1.6) 1.3 (1.0–1.7) 1.7 (1.3–2.2)	Age, province, education, BMI, alcohol drinking, smoking, vegetable and fruit intake, total energy
Ward et al. (2012) USA (66 counties in eastern Nebraska) 1 July 1988–30 June 1993	Cases: 154 for stomach; incident cases of adenocarcinoma of the stomach, identified from the Nebraska Cancer Registry and confirmed by histological review Controls: 449; controls randomly selected from a previous population-based case–control study in the same geographical region; matched by race, age, sex, and vital status Exposure assessment method: questionnaire; dietary information was obtained using a short version of the HHHQ; "processed meat" was bacon, sausage, luncheon meats, hot dogs, ham, and home-cured meat	Stomach	Processed meat Q1 (≤ 16.1 g/day) Q2 (16.2–29.6 g/day) Q3 (29.7–52.3 g/day) Q4 (> 52.3 g/day) OR (per 10 g/day) Trend-test *P* value: 0.87	 30 38 40 46 NR	 1.00 0.81 (0.45–1.46) 1.17 (0.66–2.10) 0.97 (0.51–1.85) 1.03 (0.97–1.10)	Age, sex, smoking status,, education, vitamin C, fibre, carbohydrates, total calories

BMI, body mass index; CI, confidence intervals; FFQ, food frequency questionnaire; *H. pylori*, *Helicobacter pylori*; HHHQ, Health Habits and History Questionnaire; mo, month; MSI, microsatellite instability; NR, not reported; OR, odds ratio

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