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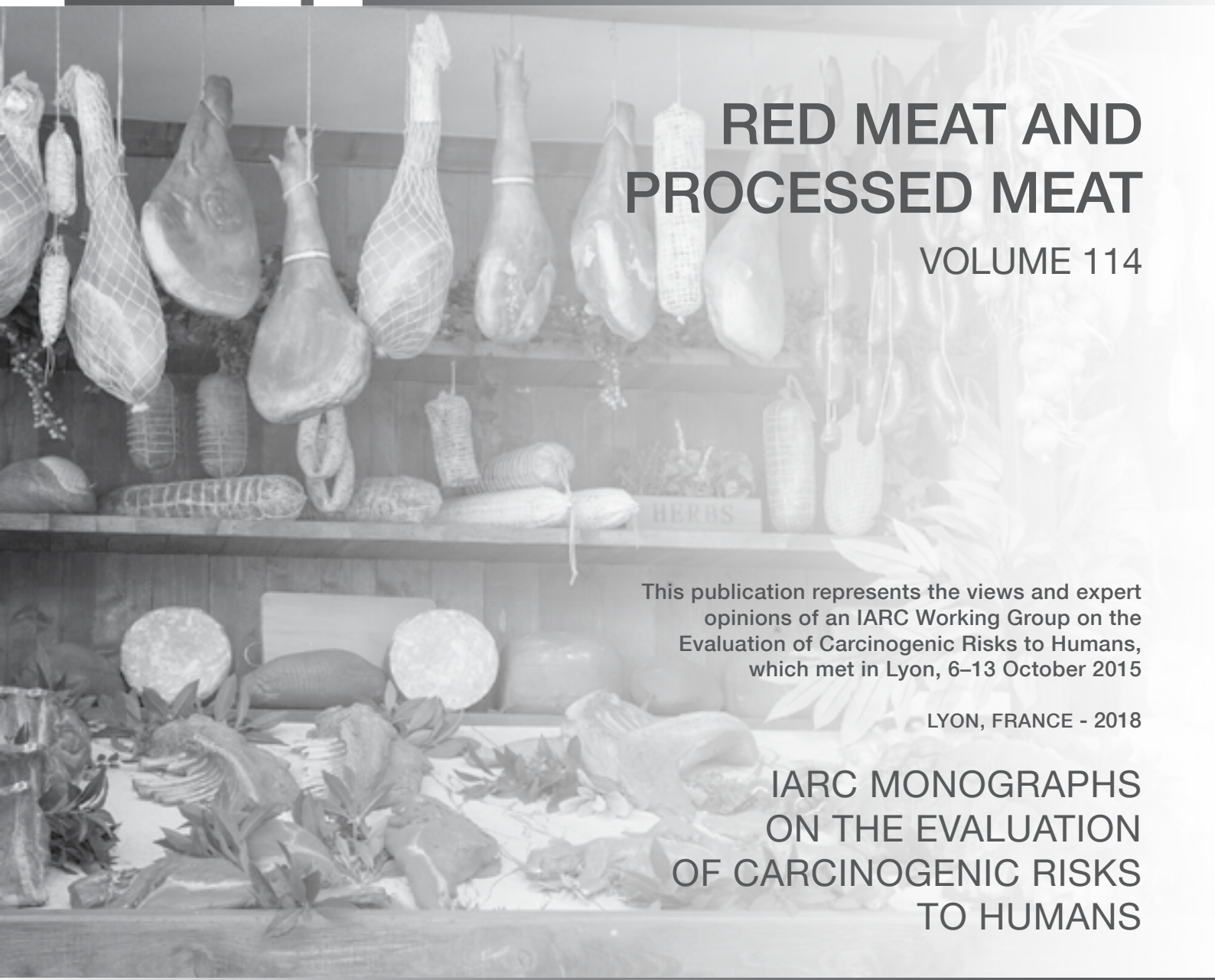

RED MEAT AND PROCESSED MEAT

VOLUME 114

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International Agency for Research on Cancer

World Health Organization

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	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) Italy – Greater Milan area January 1985 – June 1986 Case-Control	**Cases:** 206; Incident cases of histologically confirmed gastric cancer diagnosed within the year preceding the interview, 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 or which 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 and individuals were asked to indicate the frequency of consumption of these items per week before the onset of the disease which led to hospital admission and to recall any major change in frequency of intake of the same foods during the 10-year period preceding diagnosis. Items related to red meat were: 'Beef' and 'Liver'.	Stomach: (ICD-O 16)	All – Beef – Tertile 1	81	1	Age, gender
			Tertile 2	61	0.45	
			Tertile 3	64	0.86	
		Stomach: (ICD-O 16)	All – Liver – Tertile 1	169	1	Age, gender
			Tertile 2	31	0.64	
			Tertile 3	6	1.3	

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Kono et al. (1988) Northan Kyushu, Japan 1979–1982 Case-Control	**Cases:** 139; Newly diagnosed gastric cancer at the Karatsu Stomach Institute. **Controls:** 2,574 hospital controls (for red meat); 278 general population controls; Hospital controls: Subjects aged 25–75 years who were found to be free of gastrointestinal diseases were selected as hospital controls. General population controls: Two general population controls were selected for each case, matching sex and year of birth by two-stage stratified random sampling. A 10% sample of residents was first drawn by stratifying sex, year of birth and residence (10 municipalities) from the computerized file of residents as of January 1979. **Exposure assessment method:** Questionnaire; FFQ. Average frequency of food consumption in the preceding year. The uniformity of interviews between interviewers (public health nurses for population control and institute staff for hospital controls) was tested.	Stomach	Steak/hamburger steak, none	94	1	Adjusted for sex and age class.
			Steak/hamburger steak, 1–3 times/month	27	0.6	
			Steak/hamburger steak, 1–3 times/week or more	18	0.9	

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Ward et al. (1997) 66 counties of eastern Nebraska, USA 1988–1993 Case-Control	**Cases:** 124 for oesophagus, 154 for stomach; Cases were white men and women aged 21 years or older, who had been newly diagnosed with adenocarcinoma of the stomach (*n* = 176) oesophagus (ICD-O codes 150, 151) (*n* = 143). Oesophageal cancer located in the upper and cervical oesophagus (ICD-O codes 150.0, 150.3) was excluded. Cases were limited to whites. Cases were residents of 66 counties in eastern Nebraska at the time of the interview. Cases from 1988 through 1990 were identified from the Nebraska Cancer Registry. Cases from 1991 through 1993, were identified by review of discharge diagnoses and pathology records at the 14 hospitals in Omaha, Lincoln and Grand Island. **Controls:** 502; Controls were selected from controls of population-based case-control study of haematopoietic cancer and re-interviewed. Controls were identified from 66 eastern counties of Nebraska and were frequency-matched to the haematopoietic cancer cases by their gender, age (in 5 year groups) and vital status in a 3:1 ratio. Controls under the age of 65 years were selected from the general population (in 1985–1986) by random digit dialing. Subjects aged 65 years and over were identified from Health Care Financing Administration Medicare files. Controls for deceased cases were selected from Nebraska mortality records with the additional matching factor of year of death (1983–1985). A total of 502 eligible controls were-interviewed. Deceased cases and controls were not matched on year of death. **Exposure assessment method:** Questionnaire; Modified version of the Health Habits and History Questionnaire(HHHQ)	Stomach	Beef (steaks/roasts, hamburgers), times/week, < 3	30	1	Adjusted for gender and year of birth.
			Beef (steaks/roasts, hamburgers), times/week, 3–4	65	1.5 (0.9–2.6)	
			Beef (steaks/roasts, hamburgers), times/week, 5	22	1.8 (0.9–3.7)	
			Beef (steaks/roasts, hamburgers), times/week, 6+	37	1.6 (0.9–3)	
			Trend-test p-value: 0.06			
		Stomach	Beef cooking method, baked/roasted/boiled	14	1	Same as above
			Beef cooking method, fried/broiled	128	1.1 (0.6–2.1)	
			Beef cooking method, grilled/barbecued	8	1.9 (0.6–5.6)	
			Trend-test p-value: 0.37			
		Stomach	Doneness preference for beef, rare/medium rare	7	1	Adjusted for gender, year of birth and weekly red meat intake.
			Doneness preference for beef, medium	21	2.4 (0.9–6.2)	
			Doneness preference for beef, medium well	25	2.4 (0.9–6.1)	
			Doneness preference for beef, well	93	3.2 (1.4–7.6)	
			Trend-test p-value: 0.004			

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	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 Case-Control	**Cases:** 340; All newly diagnose 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. 1) 25–84 year of age, 2) free of conditions related to the digestive tract or nutritional disorders, 3) free of conditions related to tobacco and alcohol consumption. **Exposure assessment method:** Questionnaire	Stomach	Continuous			Adjusted for 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 into the model.
			Red meat	NR	1.34 (1.06–1.68)	
			Barbecued meat	NR	2.16 (1.76–2.64)	
			NDMA	NR	1.58 (1.25–2)	
			PhIP	NR	1.54 (1.24–1.91)	
		Stomach	Risk by quartile			Same as above
			NDMA; Q1 (≤ 0.14)	45	1	
			Q2 (0.15–0.18)	79	2.07 (1.36–3.18)	
			Q3 (0.19–0.26)	105	3.23 (2.13–4.89)	
			Q4 (≥ 0.27)	111	3.62 (2.38–5.51)	
			PhIP; Q1 (≤ 8.5)	34	1	
			Q2 (8.6–13.9)	70	2.07 (1.36–3.18)	
			Q3 (14.0–17.7)	110	3.1 (1.92–5.01)	
			Q4 (≥ 17.8)	126	3.86 (2.34–6.37)	
		Stomach	Risk by combination			Same as above
			NDMA low PhIP low	27	1	
			NDMA high PhIP low	77	3.07 (1.87–5.03)	
			NDMA low PhIP high	97	4.36 (2.68–7.08)	
			NDMA high PhIP high	139	12.73 (7.67–21.15)	

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Ji et al. (1998) 10 urban districts of Shanghai, China December 1, 1988-November 30, 1989 Case-Control	**Cases:** 1124; Newly diagnosed stomach cancer patients, aged 20–69, were identified among permanent residents of the 10 urban districts of Shanghai. Of the 1,722 eligible patients, 353 (20.5%) died before interview, 153 (8.9%) moved away, 19 (1.1%) refused to participate and 73 (4.2%) were excluded because only clinical diagnostic information was available. Of the 1,124 (770 men and 354 women) patients (65.3%) included in the analysis, 52.1% were confirmed by histology and 47.9% by other diagnostic methods including surgery, endoscopy, X-ray and ultra-sound. **Controls:** 1451; Controls were selected among permanent residents of Shanghai, frequency matched to the expected distributions of cases by age (5-year category) and sex. Of the 1,692 eligible controls randomly selected from the Shanghai Resident Registry files, 1,451(819 men and 632 women) were interviewed, yielding a response rate of 85.8%. **Exposure assessment method:** Questionnaire; 84-item FFQ. It is mentioned as 'Standardized' questionnaire but the validity is unknown. To minimize the effect of recall bias, diet consumption of 10 years before the diagnosis/interview was asked.	Stomach	Fresh red meats, men Q1 (low),	NR	1	Adjusted for age, income, education, smoking and alcohol drinking.
			Fresh red meats, men Q2	NR	0.9 (0.7–1.2)	
			Fresh red meats, men Q3	NR	1.1 (0.8–1.4)	
			Fresh red meats, men Q4	NR	0.9 (0.6–1.2)	
			Trend-test p-value: 0.61			
		Stomach	Fresh red meats, women Q1 (low),	NR	1	Adjusted for age, income, and education.
			Fresh red meats, women Q2	NR	0.9 (0.6–1.3)	
			Fresh red meats, women Q3	NR	0.9 (0.6–1.3)	
			Fresh red meats, women Q4	NR	0.8 (0.6–1.2)	
			Trend-test p-value: 0.35			
		Stomach	Organ meats, Men Q1 (low),	NR	1	Adjusted for age, smoking, alcohol, income, and education.
			Organ meats, Men Q2	NR	1.1 (0.8–1.4)	
			Organ meats, Men Q3	NR	1.1 (0.8–1.3)	
			Trend-test p-value: 0.7			
		Stomach	Organ meats, Women Q1 (low),	NR	1	Adjusted for age, income, and education.
			Organ meats, Women Q2	NR	0.8 (0.6–1.2)	
			Organ meats, Women Q3	NR	1.3 (0.9–1.7)	
			Trend-test p-value: 0.16			

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Tavani et al. (2000) Italy 1983–1996 Case-Control	**Cases:** 745; Cases included in the present analysis were patients below 75years with incident (i.e. interviewed at most 1 year after diagnosis), and histologically confirmed cancers. **Controls:** 7990; The control group comprised 7,990 patients (3,220 men and 4,770 women) younger than 75 years, admitted to the same network of hospitals as the cancer cases for a wide spectrum of acute non-neoplastic conditions. **Exposure assessment method:** Questionnaire; FFQ. All questionnaires included questions on the frequency of intake of approximately 40 foods and the same summary question on the frequency of total red meat consumption per week (beef, veal and pork) but excluding canned and preserved meat, thus making it possible to combine the relevant data from various studies. The questionnaire was not tested for validity but was satisfactorily reproducible; in particular, the correlation coefficient for meat intake was 0.61 (D'Avanzo et al., 1997).	Stomach	risk by frequency of red meat consumption, tertiles (times/week)			Age, year of recruitment, sex, education, smoking habits and alcohol, fat, fruit and vegetable intakes.
			Low (≤ 3)	196	1	
			Intermediate (4–6)	219	1.1 (0.8–1.3)	
			High (≥ 7)	330	1.6 (1.3–2)	
		Stomach	red meat consumption, increment of 1 portion per day			Same as above
			Increment 1 portion/day	745	1.7 (1.3–2.2)	
			Trend-test p-value: 1.5			
Palli et al. (2001) Florence, Italy 1985–1987 Case-Control	**Cases:** 382; All GC cases were histologically confirmed and originally classified according to Lauren's 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	Red meat (beef/pork/lamb/game), tertile 1, MSI+	NR	1	Adjusted for nondietary variables (age, sex, social class, family history of GC, area of residence, and BMI tertiles), total energy, and consumption tertiles of each food of interest (reference, lowest tertile).
			Tertile 2, MSI+	NR	1.7 (0.6–4.6)	
			Tertile 3, MSI+	NR	4.3 (1.8–10.8)	
			Other meats (offal/giblets/liver) T1, MSI+	NR	1	
			T2, MSI+	NR	1.1 (0.5–2.6)	
			T3, MSI+	NR	1 (0.4–2.2)	
			Trend-test p-value: 0.001			

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
		Stomach	Red meat (beef/pork/lamb/game), tertile 1, MSI-	NR	1	Same as above
			Tertile 2, MSI-	NR	0.9 (0.4–1.7)	
			Tertile 3, MSI-	NR	2.1 (1.2–3.7)	
			Other meats (offal/giblets/liver), T1	NR	1	
			T2, MSI-	NR	0.8 (0.4–1.5)	
			T3, MSI-	NR	1.4 (0.8–2.5)	
			Trend-test p-value: 0.008			
Takezaki et al. (2001) People's Republic of China – Pizhou City (Jiangsu Province) 1996 (1995 for controls) – 2000 Case-Control	**Cases:** 199 for oesophageal and 187 for stomach cancer; Incident cases of histopathologically confirmed cases of primary oesophageal and stomach cancer who visited Pizhou City Municipal Hospital. **Controls:** 333; Healthy residents of Pizhou, matched on sex, ethnicity and age within 2 years of each case. Controls came from three different sources: a population-based ecological study conducted in 1995–1996; individuals collected between 1995 and 1998 in the general population; individuals collected between 1998 and 2000. **Exposure assessment method:** Questionnaire; Validated (pre-tested) 152-item FFQ	Stomach	Broiled meat, < 1 time/month	NR	1	Adjusted for age, sex, smoking, and drinking habits.
			1–3 times/month	NR	5.18 (2.65–10.1)	
			1- times/week	NR	6.47 (2.45–17.1)	
			Meat, < 1 time/month	NR	1	
			Meat, 1–3 times/month	NR	0.7 (0.44–1.1)	
			Meat, 1–2 times/week	NR	1.53 (0.92–2.54)	
			Meat, ≥ 3 times/week	NR	1.56 (0.73–3.31)	
			Trend-test p-value: 0.057			

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	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) United States of America – Eastern Nebraska 1 July 1988 – 31 June 1993 Case-Control	**Cases:** 124 (oesophagus) +124 (distal stomach); Incident histologically confirmed cases of oesophageal adenocarcinoma and 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 (oesophagus + stomach + glioma) by age, sex and vital status. **Exposure assessment method:** Questionnaire; Dietary assessment was based on a modified version of the short Health Habits and History Questionnaire with the addition of several food items (e.g. for processed meat). Subjects were asked to recall their frequency of consumption of 54 dietary items before 1985. "Red meat" = beef, such as steak or roasts; beef stew or pot pie; hamburgers, cheeseburgers, or meatloaf; fresh ham, ham roast, pork chops, or pork roast; liver, including chicken liver.	Stomach: Distal stomach adenocarcinoma	All – Red meat – Q1 Q2 Q3 Q4 Trend-test p-value: 0.05	NR NR NR NR	1 0.96 (0.41–2.3) 1.5 (0.64–3.3) 2 (0.85–4.7)	Age, Sex, Energy intake, Respondent type, BMI, Alcohol use, Tobacco use, Education, Family history, Vitamin supplement use

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	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) Japan (Nagoya) 1988–98 Case-Control	**Cases:** 1988; Of a total of 80 420 first-visit outpatients, who visited ACCH between January 1988 to June 1998, 8057 outpatients were excluded due to interviewer absence, inadmissible age (younger than 18 years old), or a visit for 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, we excluded 9032 subjects (12.7%) since the cancer history of at least one of their parents or siblings was unknown **Controls:** 50 706; The 50 706 first-visit non-cancer subjects were regarded as our referent group **Exposure assessment method:** Questionnaire; FFQ	Stomach	Risk by frequency			Age, sex
			Beef; ≥ 3 times/wk versus < 3 times/wk; without gastric cancer family history	NR	1 (0.82–1.21)	
			Beef; ≥ 3 times/wk versus < 3 times/wk; with gastric cancer family history	NR	1.09 (0.77–1.53)	
			Pork; ≥ 3 times/wk versus < 3 times/wk; without gastric cancer family history	NR	1.08 (0.9–1.29)	
			Pork; ≥ 3 times/wk versus < 3 times/wk; with gastric cancer family history	NR	0.93 (0.65–1.32)	

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Lissowska et al. (2004) Warsaw, Poland 1994–1996 Case-Control	**Cases:** 274; Cases consisted of Warsaw residents newly diagnosed with stomach cancer, who were identified by collaborating physicians in each of the 22 hospitals. **Controls:** 463; Controls randomly selected from the general-population in Warsaw. (Population-based) **Exposure assessment method:** Questionnaire; 118-item FFQ	Stomach	Quartiles of weekly frequency consumption			Age, sex, education, smoking, and calories from food.
			Red meat (Q1)	NR	1	
			Red meat (Q2)	NR	1.24 (0.79–1.95)	
			Red meat (Q3)	NR	1.19 (0.73–1.92)	
			Red meat (Q4)	NR	1.51 (0.9–2.51)	
			Trend-test p-value: 0.28			
Wu et al. (2007) Los Angeles, USA 1992–1997 Case-Control	**Cases:** 206EAC, 257GCA, 366GNCA; All incident cancers were identified by the Los Angeles County Cancer Surveillance Program (CSP), a population-based tumour registry. **Controls:** 1308; Control subjects were individually matched to interviewed case patients on gender, race and date of birth (± 5 years) in the neighbourhood. **Exposure assessment method:** Questionnaire; 124 food items FFQ. Derived from the MEC Study.	Stomach: cardia adenocarcinoma (C16.0)	Quartile intake (in gram per day)			Age, sex, race, birthplace, education, smoking, BMI (kg/m2), reflux, use of vitamins, and total calories
			Red meat (Q1)	NR	1	
			Red meat (Q2)	NR	1.2 (0.8–1.9)	
			Red meat (Q3)	NR	1.7 (1.1–2.6)	
			Red meat (Q4)	NR	1.56 (0.97–2.5)	
			Trend-test p-value: 0.0031			
		Stomach: distal adenocarcinoma (C16.1-C16.9)	Quartile intake (in gram per day)			Same as above
			Red meat (Q1)	NR	1	
			Red meat (Q2)	NR	1.37 (0.9–2)	
			Red meat (Q3)	NR	1.16 (0.8–1.7)	
			Red meat (Q4)	NR	1.57 (1–2.4)	
			Trend-test p-value: 0.1			
		Stomach: cardia adenocarcinoma (C16.0)	Quartile intake (in gram per day)			Same as above
			Further adjusted for *H. pylori*: Red meat (Q1) among subjects infected with *H. pylori*	NR	1	
			Red meat (Q2) among subjects infected with *H. pylori*	NR	0.85 (0.4–2)	

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
			Red meat (Q3) among subjects infected with *H. pylori*	NR	2.36 (1–5.6)	
			Red meat (Q4) among subjects infected with *H. pylori*	NR	1.84 (0.8–4.5)	
			Trend-test p-value: 0.058			
		Stomach: distal adenocarcinoma (C16.1-C16.9)	Quartile intake (in gram per day)			Age, sex, race, birthplace, education, smoking, BMI (kg/m2), reflux, use of vitamins, total calories, and *H. pylori*.
			Red meat (Q1) among subjects infected with *H. pylori*	NR	1	
			Red meat (Q2) among subjects infected with *H. pylori*	NR	1.19 (0.6–2.5)	
			Red meat (Q3) among subjects infected with *H. pylori*	NR	1.35 (0.6–3)	
			Red meat (Q4) among subjects infected with *H. pylori*	NR	1.1 (0.5–2.7)	
			Trend-test p-value: 0.81			
Hu et al. (2008) Canada 1994–1997 Case-Control	**Cases:** 1182; 19 732 (15 sites including stomach) histologically confirmed cancer cases as defined by ICDO-2. (population based) **Controls:** 5039; 5039 completed questionnaires. **Exposure assessment method:** Questionnaire; 69-item validated FFQ	Stomach: (ICD-O-2)	risk by servings per week)			Age, province, education. BMI, sex, alcohol use, smoking, total of vegetable and fruit intake, and total energy intake
			Red meat (servings per week) (Q1)	NR	1	
			Q2	NR	1.1 (0.9–1.3)	
			Q3	NR	1.1 (0.9–1.4)	
			Q4	NR	1.2 (1–1.5)	
			Trend-test p-value: 0.1			

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

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Navarro Silvera et al. (2008) United States of America – Connecticut, New Jersey and western Washington state 1993 – early 1995 Case-Control	**Cases:** 206, 282, 255, 352; Incident cases of oesophageal cancer (206 cases of squamous cell cancer and 282 cases of adenocarcinoma) and stomach adenocarcinoma (255 cases of cardia and 352 cases of non-cardia). In fact, this population is part of a larger population of cases containing also cases of cardia and non-cardia gastric adenocarcinoma. Oesophageal adenocarcinomas and gastric cardia adenocarcinoma were considered as the "target cases" whereas oesophageal squamous cell carcinoma and non-cardia gastric adenocarcinoma cases were considered as a "comparison case group" frequency-matched to the "target group." **Controls:** 687; Population-based controls frequency-matched to the expected distribution of the "target cases" (i.e. cases of oesophageal adenocarcinoma and gastric cardia adenocarcinoma) by five-year age group, sex (in New Jersey and Washington state), "race" (in New Jersey), and study site. Controls aged 30–64 were identified by the random digit dialing method and controls aged 65–79 were identified by Health Care Financing Administration rosters. **Exposure assessment method:** Questionnaire; An expanded version of a food frequency questionnaire developed and validated by investigators at the Fred Hutchinson Cancer Research Center, was used to assess usual food consumption in the period 3–5 years before diagnosis (cases) or interview (controls). Processed meat was defined as " High-nitrite meats" = Smoked turkey lunchmeat; cured, smoked ham lunchmeat; bologna; salami; hot dogs; sausage, not including breakfast sausage; bacon; breakfast sausage.	Stomach: cardia Stomach: non-cardia	Red meats – For an increasing intake of one serving/day Red meats – For an increasing intake of one serving/day	NR NR	1.39 (0.8–2.42) 1.37 (0.83–2.25)	Sex, site, age, "race," proxy status, income, education, usual body mass index, cigarette/day, consumption of beer, consumption of beer, wine and liquor each, energy intake

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

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Pourfarzi et al. (2009) Ardabil Province, Islamic Republic of Iran 2004–2005 Case-Control	**Cases:** 217; Ardabil Cancer Registry; Cases were eligible if they were in people who had been Ardabil residents for at least 5 years before diagnosis, were aged more than 18 years, had not had previous gastric surgery and had a positive histopathologic 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 3 gastroenterologists, to maximize completeness of case ascertainment. **Controls:** 394; Two controls were sought for each case, frequency matched to the case group by 5-year age groups and gender. 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; There is no description of which items are included in Red meat. Poultry	Stomach: (ICD-O 16.0–16.9)	Red meat, ≥ once/day 3–4/week ≤ 2 times/week P for trend < 0.01	67 76 70 NR	3.4 (1.79–6.46) 2.2 (1.26–3.85) 1 -	Adjusted for gender, age group, education, family history of GC, citrus fruits, garlic, onion, fish, dairy products, strength and warmth of tea, preference for salt intake and *H. pylori*.

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Gao et al. (2011) Shanxi Province, China NR Case-Control	**Cases:** 600 ESCC, 599 GCA, 316 GNCA; (1) Males or females over 20 years old; (2) Residents from Taiyuan, Linfen, Jinzhong, Changzhi, and Xinzhou; (3) Recently diagnosed for cancer of the oesophagus or stomach without previous treatment; (4) Had surgical treatment for tumour at the Shanxi Cancer Hospital; (5) Diagnoses were histologically confirmed by pathologists at the Shanxi Cancer Hospital and the National Cancer Institute in the United States. **Controls:** 1514; One control was recruited for each case matched on age (5 years), gender, and neighbourhood of residence. Interviews for controls were completed within six months of matched cases. **Exposure assessment method:** Questionnaire; 39-item (summed up from the text) FFQ. Not validated. To capture the impact of the Chinese economic reformation in the late 1970s on food and drink consumption, we asked about frequency of alcohol and dietary intake before and after 1984.	Stomach: cardia adenocarcinoma	Frequency (i.e. daily, weekly, monthly, seldom, not at all) of dietary intake before illness (pork, beef, lamb)			Age (continuous), geographic region (5 classes)
			Red meat (Monthly, seldom, never) after 1984	204	1	
			Red meat (weekly) after 1984	214	1.21 (0.95–1.55)	
			Red meat (> weekly) after 1984	181	1.54 (1.15–2.07)	
			Trend-test p-value: 0.01			
		Stomach: non-cardia adenocarcinoma	Frequency (i.e. daily, weekly, monthly, seldom, not at all) of dietary intake before illness (pork, beef, lamb)			Same as above
			Red meat (monthly, seldom, never) after 1984	101	1	
			Red meat (weekly) after 1984	126	1.62 (1.18–2.24)	
			Red meat (> weekly) after 1984	89	1.77 (1.21–2.58)	
			Trend-test p-value: 0.03			

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Wang et al. (2012) Xi'an, China 2008–2010 Case-Control	**Cases:** 257; Aged 30 to 79 years, with pathologically confirmed non-cardia gastric cancer diagnosed at 1 of the 3 AAA-level comprehensive hospitals in Xi'an. The cases were confirmed to be free of diabetes and gastrointestinal disorders. **Controls:** 514; For each case, 2 controls were randomly selected from the same residential community and were matched individually by sex and age (± 5 years). The control subjects were confirmed to be free of cancer, diabetes, and gastrointestinal disorders. **Exposure assessment method:** Questionnaire	Stomach: non-cardia	Risk by tertile			Education, smoking, alcohol consumption, family history, total vegetable intake, total fruit intake, pickled food, soya products, total energy intake, and *H. pylori*.
			Red meat, tertile 1	95	1	
			Tertile 2	70	1 (0.2–2.7)	
			Tertile 3	92	1.3 (0.6–3.5)	
			Trend-test p-value: 0.447			
Ward et al. (2012) Nebraska, USA 1988–1994 Case-Control	**Cases:** 124 for oesophagus and 154 for stomach; White men and women age 21 years or older identified from the Nebraska Cancer Registry **Controls:** 449; Randomly selected from a previous population based case-control study in the same geographic region **Exposure assessment method:** Questionnaire; They used the short Health Habits and History Questionnaire with addition of foods high in nitrate/nitrite, meat cooking methods and doneness preferences. The full questionnaire contains foods that represented at least 90% of each of the 18 nutrients in the Second National Health and Nutrition Examination Survey (NHANES II) database.	Stomach	Total red meat, g/day			Year of birth, gender, cigarettes (never, < 30/day, 30+/day), education (< high school, high school graduate, some college/vocational school; college graduate/post–graduate), vitamin C, fibre, carbohydrate, total calories.
			≤ 73.8	25	1	
			73.9–111.3	36	1.64 (0.88–3.05)	
			111.4–157.2	44	1.95 (1.03–3.7)	
			> 157.2	49	2.16 (1.06–4.38)	
			OR per 10 g/day	NR	1.02 (0.99–1.06)	
			Trend-test p-value: 0.043			
		Stomach	Non processed red meat, g/day			
			≤ 50.4	24	1	
			50.5–75.1	42	1.46 (0.78–2.7)	
			75.2–111.2	35	1.9 (1.03–3.51)	
			> 111.2	53	1.94 (1–3.76)	
			OR per 10 g/day	NR	1.02 (0.98–1.06)	
			Trend-test p-value: 0.055			

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
		Stomach	Heme Iron µg/day			
			98- < 660	21	1	
			660- < 1038	40	2.15 (1.15–4.02)	
			1038- < 1440	47	2.38 (1.26–4.52)	
			1440+	46	1.99 (1–3.95)	
			OR per mg day	NR	1.24 (0.97–1.58)	
			Trend-test p-value: 0.17			
		Stomach	Meat iron (µg/day)			
			589- < 2489	23	1	
			2489- < 3802	44	2.32 (1.26–4.25)	
			3802- < 5309	37	1.66 (0.87–3.15)	
			5309+	50	2.26 (1.14–4.46)	
			OR per mg/day	NR	1.06 (0.98–1.16)	
			Trend-test p-value: 0.11			
		Stomach	Total iron (mg/day)			
			< 10.6	29	1	
			10.6- < 13.4	31	1.24 (0.66–2.32)	
			13.4- < 17.3	49	1.67 (0.87–3.18)	
			17.3+	45	1.71 (0.75–3.18)	
			OR per mg/day	NR	1.03 (0.98–1.08)	
			Trend-test p-value: 0.21			

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
Zamani et al. (2013) Golestan Province, Islamic Republic of Iran 2004–2011 Case-Control	**Cases:** 190; recruited at the Atrak Clinic **Controls:** 647; randomly selected from the Golestan Cohort Study (50 045 healthy inhabitants aged 40–75 y) **Exposure assessment method:** Questionnaire; Validated FFQ was used. Red meat: lamb, beef, liver and other viscera, hamburgers, hot dogs, sausage, and cold cuts.	Stomach	Red meat, Q1	65	1	Age (30–50, 51–70, > 71 years old), sex (qualitative), energy intake (kcal/day), ethnicity (qualitative), hot tea consumption (qualitative), tooth brushing (yes/no), cigarette smoking (yes/no), SES (high, average, low), literacy (literate/illiterate), opium consumption (yes/no), grains intake (quartiles), dairy consumption (quartiles), and vegetable (quartiles) and fruit (quartiles) intake.
			Q2	36	1.02 (0.53–1.96)	
			Q3	29	0.83 (0.41–1.66)	
			Q4	60	1.87 (1.01–3.47)	
			Trend-test p-value: 0.07			
Wang et al. (2014) Xi'an, China 2008–2010 Case-Control	**Cases:** 171; Aged 30 to 79 years, with pathologically confirmed non-cardia gastric cancer diagnosed at 1 of the 3 AAA-level comprehensive hospitals in Xi'an. The cases were confirmed to be free of diabetes and gastrointestinal disorders. Subjects who provided blood samples for DNA. **Controls:** 367; For each case, 2 controls were randomly selected from the same residential community and were matched individually by sex and age (± 5 years). The control subjects were confirmed to be free of cancer, diabetes, and gastrointestinal disorders.	Stomach: non-cardia	joint effects of pork (dichotomous), *H. pylori* CagA, Genotype			Age, gender, education, smoking, alcohol, and family history.
			Pork low (< 25 g/d) and *H.pylori* CagA(-)	55	-	
			TT	9	1	
			TC	11	0.42 (0.14–1.11)	
			CC	12	0.71 (0.27–2.36)	
			C carrier	23	0.45 (0.18–1.37)	
			Trend-test p-value: 0.447			

2.3.3 Case-control studies: Red meat and cancer of the stomach (web-only)

Reference, location follow-up/enrollment period, study-design	Population size, description, exposure assessment method	Organ site	Exposure category or level	Exposed cases/ deaths	Risk estimate (95% CI)	Covariates controlled
	Exposure assessment method: Questionnaire; 121-item FFQ validated previously.	Stomach: non-cardia	joint effects of pork (dichotomous), *H. pylori* CagA, Genotype			Same as above
			Pork low (< 25 g/d) and *H.pylori* CagA(+)	98	-	
			TT	16	1	
			TC	30	0.71 (0.31–1.98)	
			CC	11	0.46 (0.16–1.54)	
			C carrier	41	0.69 (0.33–1.63)	
			Trend-test p-value: 0.447			
		Stomach: non-cardia	joint effects of pork (dichotomous), *H. pylori* CagA, Genotype			Same as above
			Pork high ≥ 25 g/d) and *H. pylori* CagA(-)	85	-	
			TT	11	1	
			TC	20	1.25 (0.47–2.81)	
			CC	27	0.86 (0.29–2.35)	
			C carrier	27	1 (0.48–2.06)	
			Trend-test p-value: 0.447			
		Stomach: non-cardia	joint effects of pork (dichotomous), *H. pylori* CagA, Genotype			Same as above
			Pork high (≥ 25 g/d) and *H. pylori* CagA(+)	83	-	
			TT	5	1	
			TC	23	2.98 (0.99–11.3)	
			CC	16	3.11 (1.08–12.66)	
			C carrier	39	3.07 (1.17–10.79)	
			Trend-test p-value: 0.447			

References

Chen H, Ward MH, Graubard BI, Heineman EF, Markin RM, Potischman NA, et al. (2002). Dietary patterns and adenocarcinoma of the esophagus and distal stomach. Am J Clin Nutr. 75(1):137–44. PMID:11756071

D'Avanzo B, La Vecchia C, Katsouyanni K, Negri E, Trichopoulos D (1997). An assessment, and reproducibility of food frequency data provided by hospital controls. Eur J Cancer Prev. 6(3):288–93. https://doi.org/10.1097/00008469-199706000-00006 PMID:9306076

De Stefani E, Boffetta P, Mendilaharsu M, Carzoglio J, Deneo-Pellegrini H (1998). Dietary nitrosamines, heterocyclic amines, and risk of gastric cancer: a case-control study in Uruguay. Nutr Cancer. 30(2):158–62.http://dx.doi.org/10.1080/01635589809514656 PMID:9589435

Gao Y, Hu N, Han XY, Ding T, Giffen C, Goldstein AM, et al. (2011). Risk factors for esophageal and gastric cancers in Shanxi Province, China: a case-control study. Cancer Epidemiol. 35(6):e91–9.http://dx.doi.org/10.1016/j.canep.2011.06.006 PMID:21846596

Hu J, La Vecchia C, DesMeules M, Negri E, Mery L, Group CCRE; Canadian Cancer Registries Epidemiology Research Group (2008). Meat and fish consumption and cancer in Canada. Nutr Cancer. 60(3):313–24.http://dx.doi.org/10.1080/01635580701759724 PMID:18444165

Huang XE, Hirose K, Wakai K, Matsuo K, Ito H, Xiang J, et al. (2004). Comparison of lifestyle risk factors by family history for gastric, breast, lung and colorectal cancer. Asian Pac J Cancer Prev. 5(4):419–27. PMID:15546249

Ji BT, Chow WH, Yang G, McLaughlin JK, Zheng W, Shu XO, et al. (1998). Dietary habits and stomach cancer in Shanghai, China. Int J Cancer. 76(5):659–64.http://dx.doi.org/10.1002/(SICI)1097-0215(19980529)76:5<659::AID-IJC8>3.0.CO;2-P PMID:9610722

Kono S, Ikeda M, Tokudome S, Kuratsune M (1988). A case-control study of gastric cancer and diet in northern Kyushu, Japan. Jpn J Cancer Res. 79(10):1067–74.http://dx.doi.org/10.1111/j.1349-7006.1988.tb01528.x PMID:3143695

La Vecchia C, Negri E, Decarli A, D'Avanzo B, Franceschi S (1987). A case-control study of diet and gastric cancer in northern Italy. Int J Cancer. 40(4):484–9.http://dx.doi.org/10.1002/ijc.2910400409 PMID:3117710

Lissowska J, Gail MH, Pee D, Groves FD, Sobin LH, Nasierowska-Guttmejer A, et al. (2004). Diet and stomach cancer risk in Warsaw, Poland. Nutr Cancer. 48(2):149–59.http://dx.doi.org/10.1207/s15327914nc4802_4 PMID:15231449

Navarro Silvera SA, Mayne ST, Risch H, Gammon MD, Vaughan TL, Chow WH, et al. (2008). Food group intake and risk of subtypes of esophageal and gastric cancer. Int J Cancer. 123(4):852–60.http://dx.doi.org/10.1002/ijc.23544 PMID:18537156

Palli D, Russo A, Ottini L, Masala G, Saieva C, Amorosi A, et al. (2001). Red meat, family history, and increased risk of gastric cancer with microsatellite instability. Cancer Res. 61(14):5415–9. PMID:11454685

Pourfarzi F, Whelan A, Kaldor J, Malekzadeh R (2009). The role of diet and other environmental factors in the causation of gastric cancer in Iran–a population based study. Int J Cancer. 125(8):1953–60.http://dx.doi.org/10.1002/ijc.24499 PMID:19569234

Takezaki T, Gao CM, Wu JZ, Ding JH, Liu YT, Zhang Y, et al. (2001). Dietary protective and risk factors for esophageal and stomach cancers in a low-epidemic area for stomach cancer in Jiangsu Province, China: comparison with those in a high-epidemic area. Jpn J Cancer Res. 92(11):1157–65.http://dx.doi.org/10.1111/j.1349-7006.2001.tb02135.x PMID:11714439

Tavani A, La Vecchia C, Gallus S, Lagiou P, Trichopoulos D, Levi F, et al. (2000). Red meat intake and cancer risk: a study in Italy. Int J Cancer. 86(3):425–8.http://dx.doi.org/10.1002/(SICI)1097-0215(20000501)86:3<425::AID-IJC19>3.0.CO;2-S PMID:10760833

Wang XQ, Terry PD, Cheng L, Yan H, Wang JS, Wu WA, et al. (2014). Interactions between pork consumption, CagA status and IL-1B-31 genotypes in gastric cancer. World J Gastroenterol. 20(25):8151–7.http://dx.doi.org/10.3748/wjg.v20.i25.8151 PMID:25009387

Wang XQ, Yan H, Terry PD, Wang JS, Cheng L, Wu WA, et al. (2012). Interaction between dietary factors and Helicobacter pylori infection in noncardia gastric cancer: a population-based case-control study in China. J Am Coll Nutr. 31(5):375–84.http://dx.doi.org/10.1080/07315724.2012.10720447 PMID:23529995

Ward MH, Cross AJ, Abnet CC, Sinha R, Markin RS, Weisenburger DD (2012). Heme iron from meat and risk of adenocarcinoma of the esophagus and stomach. Eur J Cancer Prev. 21(2):134–8.http://dx.doi.org/10.1097/CEJ.0b013e32834c9b6c PMID:22044848

Ward MH, Sinha R, Heineman EF, Rothman N, Markin R, Weisenburger DD, et al. (1997). Risk of adenocarcinoma of the stomach and esophagus with meat cooking method and doneness preference. Int J Cancer. 71(1):14–9.http://dx.doi.org/10.1002/(SICI)1097-0215(19970328)71:1<14::AID-IJC4>3.0.CO;2-6 PMID:9096659

Wu AH, Tseng CC, Hankin J, Bernstein L (2007). Fiber intake and risk of adenocarcinomas of the esophagus and stomach. Cancer Causes Control. 18(7):713–22.http://dx.doi.org/10.1007/s10552-007-9014-8 PMID:17562192

Zamani N, Hajifaraji M, Fazel-tabar Malekshah A, Keshtkar AA, Esmaillzadeh A, Malekzadeh R (2013). A case-control study of the relationship between gastric cancer and meat consumption in Iran. Arch Iran Med. 16(6):324–9. PMID:23725064