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Processed meat consumption and risk of cancer: a multisite case–control study in Uruguay

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BACKGROUND: The role of processed meat in the aetiology of several cancers was explored in detail.

METHODS: In the time period 1996–2004, a multisite case–control study was conducted in Montevideo, Uruguay. The study included 6 060 participants (3 528 cases and 2 532 controls) corresponding to cancers of the oral cavity, pharynx, oesophagus, stomach, colon, rectum, larynx, lung, female breast, prostate, urinary bladder, and kidney (renal cell carcinoma only).

RESULTS: The highest odds ratios (ORs) were positively associated with cancers of the colon, rectum, stomach, oesophagus, and lung. With the exception of renal cell carcinoma, the remaining cancer sites were significantly associated with elevated risks for processed meat consumption. Furthermore, mortadella, salami, hot dog, ham, and salted meat were strongly associated with risk of several cancer sites.

CONCLUSION: It could be concluded that processed meat intake could be a powerful multiorgan carcinogen.

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Uruguay is a developing country characterised by high incidence rates of cancer (ASR 386.0 cases per 100 000 males and 303.2 cases per 100 000 females; Parkin *et al*, 2002). The leading cancer site among men is the lung, whereas the main cancer site among women is the breast, following the pattern of the developed countries. The main reasons for these elevated rates are related to the prevalence of tobacco smoking, alcohol drinking, the high consumption of red meat, and the low consumption of vegetables and fruits.

In fact, the Uruguayan population is characterised by a very high consumption of red meat (the highest in the world (Matos and Brandani, 2002)), a high consumption of processed meat, and a low intake of white meat. Several reports have suggested that processed meat is linked to the aetiology of frequent malignancies like gastric cancer and colon cancer (Larsson *et al*, 2006; Cross *et al*, 2007). In fact, the consumption of processed meat is much higher in Uruguay compared with consumption in the United States (Cross *et al*, 2007).

For this reason, we decided to conduct a multisite case–control study in order to explore the role of processed meat in 11 cancer sites in Uruguay.

MATERIALS AND METHODS

Selection of cases

In the time period 1996–2004, all newly diagnosed and microscopically confirmed cases of cancers of the oral cavity, pharynx, oesophagus, stomach, colon, rectum, larynx, lung, female breast, prostate, bladder, and kidney were considered eligible for this study (3 641 cases). One hundred and thirteen patients refused the interview, leading to a final total of 3 528 cases (2 648 men and 880 women) (response rate: 96.9%). All the cases were drawn from the four major public health hospitals of Montevideo. These hospitals admit only patients of low socioeconomic status, with a monthly income <200 US dollars.

Selection of controls

In the same time period and in the same hospitals, all patients with conditions not related to smoking and drinking were considered eligible for the study. In this period, 2 608 potential controls were approached for a possible participation and 76 patients refused the interview, leaving a final number of 2 532 controls (response rate: 97.1%). These controls presented the following diseases: eye disorders (622 patients, 24.6%), abdominal hernia (513 patients, 20.3%), fractures (258 patients, 10.2%), injuries (200 patients, 7.9%), varicose veins (178 patients, 7.0%), acute appendicitis (176 patients, 6.9%), diseases of the skin (160 patients, 6.3%), hydatid cyst (127 patients, 5.0%), urinary stones (119 patients, 4.7%), blood disorders (89 patients, 3.5%), bone disorders (50 patients, 2.0%), and prostate hypertrophy (40 patients, 1.6%).

Interviews and questionnaire

All the participants (6 060 cases and controls) were interviewed shortly after admission to the hospital by two trained social workers, unaware of the purposes of the present study. In all the instances, the interview was conducted face to face and proxy interviews were not allowed. The participants were administered a

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structured questionnaire, which included the following sections: (1) a sociodemographic section (age, sex, residence, education, monthly income), (2) an occupational history on the basis of the last four jobs and their duration, (3) self-reported height and weight, 5 years before the date of the interview, (4) a complete smoking history (age at start, age at quit, number of cigarettes smoked per day, type of tobacco, type of cigarette, inhalation practices), (5) a complete alcohol-drinking history (age at start, age at quit, number of glasses drunk per day, type of alcoholic beverage), (6) a complete history of non-alcoholic beverages (age at start, age at quit, number of cups per day, type of beverage: maté, coffee, tea, soft drinks), (7) menstrual and reproductive events, and (8) a food frequency questionnaire (FFQ) on 64 food items. This FFQ was recorded in servings per week and was previously tested for reproducibility with good results (Ronco *et al*, 2006).

Components of processed meat

The following meats were analysed in the study: bacon, sausage, *mortadella*, salami, *saucisson*, hot dog, ham, and air-dried and salted lamb. These components were energy-adjusted by the residual method (Willett, 1998).

Statistical analysis

Relative risks, approximated by the OR, were estimated by unconditional logistic multiple regression (Rothman *et al*, 2008). As the number of controls was smaller than the number of cases, we were unable to use multiple polynomial regression, and the ORs for each cancer site for processed meat intake were estimated by unconditional multiple logistic regression. We fitted the following model for each site including age (continuous), sex (when necessary), residence (urban, rural), education (categorical, 3 strata), body mass index (continuous), smoking index (smoking status, smoking cessation, number of cigarettes smoked per day among current smokers, categorical, 8 strata), alcohol drinking (categorical, 5 strata), maté consumption (categorical, 4 strata), total energy (continuous), total vegetables and fruits (continuous), total white meat (continuous), and red meat (continuous). We then included 3 terms for meat intake (red, processed and white meat) to capture the effect of total meat in each estimation. All the calculations were performed using the STATA software (Stata Corp., College Station, TX, USA), release 11 (StataCorp., 2008).

RESULTS

The distribution of cases and controls by cancer site, stratified by sex, is shown in Table 1. For both sexes, lung cancer occupied the first place (26.1%), followed by breast cancer (13.1%), colorectal cancer (10.2%), and prostate cancer (9.8%).

Cases and controls showed similar age and education, the cases being heavy smokers, and consuming more alcohol and maté than controls (Table 2).

Odds ratios of cancer sites for processed meat intake are shown in Table 3. Cancers of the colon (OR for the highest tertile *vs* the first tertile 2.75, 95% CI 1.80–4.22), rectum (OR 2.14, 95% CI 1.42–3.22), colorectum (OR 2.39, 95% CI 1.76–3.24), stomach (OR 2.60, 95% 1.83–3.70), and larynx (OR 2.37, 95% CI 1.59–3.53) showed the highest risks. With the exception of oropharyngeal cancer and renal cell carcinoma, the remaining sites displayed a significantly positive association with processed-meat consumption, including cancers of the oesophagus, lung, upper aerodigestive tract, female breast, prostate, and urinary bladder. The model fitted included white meat and red meat intakes, thus it captured total meat in the estimations.

Odds ratios of cancer sites for different types of processed meat are shown in Table 4. Curiously, bacon was inversely associated with most cancer sites and sausage was not associated with the risk of cancer. On the other hand, *mortadella* intake was positively associated with cancers of the stomach (OR 1.13, 95% CI 1.02–1.26), colon (OR 1.18, 95% 1.04–1.34), larynx (OR 1.28, 95% CI 1.14–1.42), lung (OR 1.15, 95% CI 1.07–1.23), breast (OR 1.29, 95% CI 1.16–1.43), and prostate (OR 1.29, 95% CI 1.16–1.42). Similarly,

Table 1 Number and percentages by cancer sites and controls

Cancer site	Males Number (%)	Females Number (%)	Both sexes Number (%)
Oral/pharynx	274 (10.3)	9 (1.0)	283 (8.0)
Oesophagus	184 (6.9)	50 (5.7)	234 (6.6)
Stomach	190 (7.2)	84 (9.5)	274 (7.8)
Colon	87 (3.3)	89 (10.5)	176 (5.0)
Rectum	127 (4.8)	58 (6.6)	185 (5.2)
Larynx	274 (10.3)	7 (0.8)	281 (8.0)
Lung	865 (32.7)	55 (6.3)	920 (26.1)
Breast	—	461 (52.4)	461 (13.1)
Prostate	345 (13.0)	—	345 (9.8)
Bladder	225 (8.5)	30 (3.4)	255 (7.2)
Kidney	77 (2.9)	37 (4.2)	144 (3.2)
All cases	2648 (100.0)	880 (100.0)	3528 (100.0)
All controls	1640 (100.0)	892 (100.0)	2532 (100.0)

Table 2 Means of cancer sites and controls for age, education, smoking intensity, alcohol drinking, and processed meat

	Age (years)		Education (years)		Smoking (cigarettes per day)		Alcohol (ml/ethanol per day)		Processed meat (grams per day)	
Cancer site	Men	Women	Men	Women	Men	Women	Men	Women	Men	Women
Oral/pharynx	60.0	54.9	4.3	4.4	27.6	14.0	213.1	7.0	37.0	29.1
Oesophagus	65.5	68.9	3.5	3.8	22.2	7.0	153.9	17.4	35.7	38.3
Stomach	66.1	64.3	3.6	4.7	20.3	5.9	118.9	9.1	34.5	33.8
Colon	63.9	64.6	4.7	4.3	22.0	5.5	86.3	6.0	34.5	38.6
Rectum	66.1	66.5	4.2	6.1	20.1	3.0	94.5	14.4	37.9	29.8
Larynx	62.3	53.7	4.1	5.7	32.9	18.3	198.2	30.0	36.5	32.7
Lung	62.1	59.4	4.2	5.2	32.3	20.5	144.9	17.8	32.7	33.5
Breast	—	59.7	—	5.3	—	4.1	—	12.1	—	24.8
Prostate	70.6	—	3.7	—	18.0	—	96.4	—	29.4	—
Bladder	67.2	65.7	4.4	4.5	21.1	7.2	95.4	2.4	33.2	35.9
Kidney	61.6	58.5	4.5	5.2	20.1	6.2	113.6	3.9	25.3	33.9
All cases	64.2	61.6	4.1	5.1	26.6	5.9	141.2	11.6	33.5	29.6
All controls	64.2	60.5	4.2	4.8	18.0	4.1	98.2	8.2	24.3	19.9

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Table 3 Odds ratios of cancer sites for processed meat consumption[a,b,c,d,e]

	Tertiles			
Grams per day Cancer site	**I ⩽11.4 OR (reference)**	**II 11.5–28.2 OR (95% CI)**	**III 28.3+ OR (95% CI)**	***P*-value trend**
Oral/pharynx				
b	56/844	87/844	140/844	
c	1.0	1.21 (0.79–1.87)	1.42 (0.95–2.13)	0.07
Oesophagus				
b	51/844	76/844	107/844	
c	1.0	1.25 (0.81–1.94)	1.67 (1.08–2.60)	0.02
d	1.0	2.05 (0.90–4.68)	3.02 (1.40–6.52)	0.004
Stomach				
b	53/844	95/844	126/844	
c	1.0	1.60 (1.02–2.49)	1.93 (1.25–2.98)	0.003
d	1.0	3.07 (1.58–5.98)	4.51 (2.34–8.70)	<0.0001
Colon				
b	34/844	62/844	80/844	
c	1.0	1.76 (0.94–3.28)	2.01 (1.07–3.76)	0.03
d	1.0	2.25 (1.19–4.23)	3.53 (1.93–6.46)	<0.0001
Rectum				
b	41/844	65/844	79/844	
c	1.0	1.47 (0.85–2.54)	1.76 (1.03–3.01)	0.03
d	1.0	2.44 (1.17–5.09)	3.18 (1.54–6.57)	0.001
Colon/rectum				
b	75/844	127/844	159/844	
c	1.0	1.55 (1.01–2.36)	1.88 (1.23–2.86)	0.004
d	1.0	2.33 (1.42–3.82)	3.36 (2.08–5.43)	<0.0001
Larynx				
b	47/844	85/844	140/844	
c	1.0	1.75 (1.13–2.70)	2.58 (1.71–3.89)	<0.0001
UADT				
e,b	154/844	248/844	396/844	
c	1.0	1.32 (0.99–1.76)	1.80 (1.37–2.38)	<0.0001
d	1.0	1.60 (0.78–3.31)	2.73 (1.42–5.26)	0.002
Lung				
b	176/844	310/844	434/844	
c	1.0	1.43 (1.11–1.85)	1.82 (1.42–2.33)	<0.0001
d	1.0	2.26 (0.99–5.15)	2.54 (1.12–5.79)	0.02
Breast				
b	127/844	161/844	173/844	
d	1.0	1.39 (1.04–1.86)	1.79 (1.83–2.40)	0.0001
Prostate				
b	75/844	134/844	136/844	
c	1.0	1.69 (1.22–2.37)	1.71 (1.23–2.39)	0.002
Bladder				
b	54/844	98/844	103/844	
c	1.0	1.68 (1.14–2.51)	1.71 (1.14–2.54)	0.01
d	1.0	2.40 (0.86–6.70)	1.97 (0.77–5.03)	0.12
Kidney				
b	29/844	38/844	47/844	
c	1.0	0.99 (0.53–1.85)	1.21 (0.65–2.25)	0.51
d	1.0	2.04 (0.85–4.91)	2.15 (0.90–5.13)	0.07
Urinary tract				
b	83/844	136/844	150/844	
c	1.0	1.47 (1.04–2.07)	1.56 (1.10–2.21)	0.01
d	1.0	2.13 (1.09–4.15)	2.11 (1.10–4.04)	0.02
All sites				
b	734/844	1211/844	1574/844	
c	1.0	1.42 (1.20–1.69)	1.73 (1.46–2.05)	<0.0001
d	1.0	1.72 (1.35–2.19)	2.32 (1.82–2.96)	<0.0001

Abbreviations: CI = confidence interval; OR = odds ratio. [a]Multivariate adjusted for age, residence, body mass index, smoking status, smoking cessation, number of cigarettes smoked per day among current smokers, alcohol drinking, maté consumption, total energy, total vegetables and fruits, total white meat, and red meat intakes. [b]Number of cases and controls by intake of processed meat (both sexes). [c]Men. [d]Women. [e]Cancer of the upper aerodigestive tract (oral, pharynx, oesophagus, larynx).

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salami was positively associated with the risk of laryngeal cancer, lung cancer (OR 1.16, 95% CI 1.07–1.25), breast cancer (OR 1.22, 95% CI 1.09–1.36), and prostate adenocarcinoma (OR 1.13, 95% CI 1.01–1.26). *Saucisson* consumption was directly associated only with gastric cancer (OR 1.25, 95% CI 1.09–1.44) and hot dog intake was positively associated with most cancer sites, with the exception of breast and prostate cancers. The highest risk for hot dog intake was observed for gastric cancer (OR 1.53, 95% CI 1.40–1.71). Also, ham consumption was directly associated with cancers of the stomach, colon, rectum, lung, breast, bladder, and kidney, being the highest risks associated with renal cell carcinoma (OR 1.33, 95% CI 1.13–1.55) and lung cancer (OR 1.28, 95% CI 1.18–1.40). Finally, air-dried and salted lamb intake was directly associated with cancers of the oesophagus, colon, rectum, lung, breast, prostate, bladder, and kidney. The highest risk for this food item was observed among bladder cancer (OR 1.32, 95% CI 1.19–1.46).

DISCUSSION

According to our study, processed meat intake was positively associated with cancers of the oesophagus, stomach, colon, rectum, larynx, lung, breast, prostate, and urinary bladder. Therefore, processed meat could be said to act as a multiorgan carcinogen among humans (World Cancer Research Fund/American Institute for Cancer Research, 2008).

Moreover, our study replicates the findings of previous reports (Larsson *et al*, 2006; Cross *et al*, 2007; Santarelli *et al*, 2008), which strongly suggest that processed meat consumption was associated with an increased risk of gastric and colorectal cancers.

The mechanisms of processed meat are somehow conflictive, but ham, salt (mainly for gastric cancer), aromatic amines, nitrites, and nitrosamines are strong candidates for explaining the effect of cured meats (Santarelli *et al*, 2008) in the process of carcinogenesis.

Oesophageal cancer, mainly the squamous cell histologic type, has been positively associated with the consumption of air-dried and salted lamb through the presence of nitrosamines. In our report, oesophageal carcinoma displayed an increased risk of 96%, which was highly significant.

Gastric cancer was strongly associated with intake of processed meat, mainly with *mortadella, saucisson*, hot dog, and ham. All these types of processed meat are high in salt, an enhancing chemical in gastric carcinogenesis (Correa *et al*, 1985; Chen *et al*, 1990; Nazario *et al*, 1993). The comprehensive meta-analysis by Larsson *et al* (2006) analysed all the studies dealing with stomach cancer and processed meat, both case–control and cohort, and they concluded that proccesed meat is possibly a strong carcinogen in this organ. Several studies also concluded that processed meat is a possible agent in gastric carcinogenesis (De Stefani *et al*, 2001, 2004; Boeing *et al*, 1991; Larsson *et al*, 2006).

According to the prospective study by Cross *et al* (2007), processed meat increases significantly the risk of developing colorectal cancer. Their findings have been replicated in numerous studies on colorectal cancer and processed meat intake (Goldbohm *et al*, 1994). According to a study by Goldbohm *et al* (1994), an intake of >20 g per day of processed meat was associated with an increased risk of 72% for colorectal carcinoma.

Lung cancer has been considered as directly associated with meat intake. In the present study, lung cancer displayed an increased risk of 88% for consumption of processed meat. When lung cancer risk was examined for the components of the processed meat group, there was significant increase in risk for *mortadella*, salami, hot dog, ham, and salted meat intakes. Not all studies found an increase in risk of lung cancer. In the EPIC prospective study, Linseisen *et al* (2011) only found a modest increase of lung cancer for processed meat intake. On the other hand, Lam *et al* (2009) reported a significant increase

Table 4 Odds ratios of cancer sites for types of processed meat [a,b,c,d]

Cancer site	Bacon OR (95% CI)	Sausage OR (95% CI)	Mortadella OR (95% CI)	Salami OR (95% CI)	Saucisson OR (95% CI)	Hot dog OR (95% CI)	Ham OR (95% CI)	Salted meat OR (95% CI)
Oral/pharynx								
b	0.80 (0.66–0.97)	0.91 (0.79–1.06)	1.05 (0.93–1.18)	1.14 (0.99–1.29)	0.92 (0.77–1.10)	1.28 (1.13–1.43)	1.03 (0.89–1.19)	1.07 (0.94–1.21)
Oesophagus								
b	0.85 (0.67–1.07)	0.90 (0.75–1.07)	1.09 (0.96–1.25)	1.13 (0.96–1.31)	0.84 (0.67–1.07)	1.40 (1.20–1.63)	0.92 (0.76–1.11)	1.21 (1.07–1.36)
c	0.53 (0.29–0.98)	1.30 (0.91–1.85)	1.23 (0.94–1.62)	0.74 (0.50–1.10)	0.97 (0.55–1.69)	1.27 (0.99–1.64)	1.25 0.98–1.59	1.29 (0.98–1.69)
Stomach								
b	0.64 (0.49–0.83)	1.02 (0.86–1.21)	0.99 (0.87–1.14)	0.99 (0.86–1.15)	1.22 (1.03–1.44)	1.49 (1.30–1.70)	0.96 (0.81–1.14)	1.02 (0.87–1.19)
c	0.72 (0.46–1.13)	1.16 (0.88–1.53)	1.25 (1.01–1.56)	0.76 (0.58–0.99)	1.48 (1.07–2.04)	1.50 (1.23–1.83)	1.24 (1.03–1.44)	0.62 (0.36–1.07)
Colon								
b	0.91 (0.65–1.28	1.04 (0.81–1.34)	1.17 (0.97–1.41)	0.93 (0.75–1.15)	0.93 (0.69–1.25)	1.17 (0.95–1.43)	1.02 (0.82–1.26)	1.15 (0.95–1.39)
c	0.51 (0.31–0.82)	1.41 (1.08–1.84)	0.99 (0.80–1.23)	0.93 (0.72–1.20)	0.98 (0.64–1.50)	1.36 (1.12–1.65)	1.30 (1.09–1.56)	1.41 (1.17–1.70)
Rectum								
b	0.67 (0.49–0.94)	0.91 (0.73–1.13)	1.05 (0.89–1.24)	1.19 (1.00–1.41)	0.85 (0.65–1.10)	1.34 (1.13–1.59)	0.99 (0.83–1.20)	1.23 (1.06–1.42)
c	0.82 (0.48–1.38)	1.05 (0.75–1.47)	0.90 (0.68–1.20)	0.93 (0.68–1.26)	0.91 (0.55–1.49)	1.31 (1.04–1.65)	1.35 (1.09–1.68)	1.25 (0.96–1.63)
Colon/rectum								
b	0.77 (0.60–0.99)	0.98 (0.82–1.16)	1.10 (0.97–1.25)	1.08 (0.94–1.24)	0.88 (0.72–1.08)	1.28 (1.11–1.46)	1.01 (0.87–1.17)	1.19 (1.05–1.35)
c	0.61 (0.42–0.88)	1.25 (1.01–1.56)	0.96 (0.80–1.15)	0.93 (0.76–1.14)	0.94 (0.67–1.33)	1.33 (1.15–1.57)	1.33 (1.14–1.54)	1.36 (1.15–1.61)
Larynx								
b	0.77 (0.62–0.96)	1.06 (0.90–1.35)	1.16 (1.03–1.30)	1.13 (0.99–1.30)	1.03 (0.87–1.22)	1.26 (1.10–1.44)	0.92 (0.78–1.07)	1.03 (0.90–1.17)
UADT								
d,b	0.79 (0.68–0.92)	0.94 (0.84–1.05)	1.08 (0.99–1.17)	1.11 (1.01–1.21)	0.95 (0.84–1.08)	1.30 (1.18–1.43)	0.96 (0.86–1.06)	1.08 (0.99–1.19)
c	0.53 (0.31–0.92)	1.42 (1.04–1.92)	1.28 (0.98–1.57)	0.76 (0.55–1.05)	0.81 (0.47–1.41)	1.28 (1.03–1.51)	1.10 (0.89–1.36)	1.19 (0.91–1.54)
Lung								
b	0.87 (0.75–0.99)	0.86 (0.77–0.95)	1.05 (0.97–1.14)	1.11 (1.01–1.22)	0.91 (0.80–1.03)	1.26 (1.15–1.38)	1.28 (1.16–1.41)	1.29 (1.19–1.40)
c	0.72 (0.40–1.68)	1.28 (0.90–1.82)	1.36 (1.04–1.77)	0.94 (0.69–1.29)	0.75 (0.49–1.25)	0.96 (0.74–1.25)	1.21 (0.95–1.55)	1.18 (0.89–1.56)
Breast								
c	0.94 (0.75–1.18)	0.97 (0.84–1.12)	1.27 (1.11–1.47)	1.12 (0.99–1.37)	1.05 (0.87–1.28)	0.88 (0.79–0.98)	1.12 (1.01–1.25)	1.22 (1.06–1.40)
Prostate								
b	0.84 (0.68–1.04)	1.01 (0.87–1.17)	1.27 (1.14–1.43)	1.09 (0.96–1.23)	0.80 (0.67–0.96)	0.79 (0.68–0.92)	0.98 (0.85–1.12)	1.25 (1.13–1.37)
Bladder								
b	0.62 (0.48–0.82)	1.01 (0.85–1.19)	0.91 (0.80–1.04)	1.08 (0.93–1.25)	0.64 (0.49–0.84)	1.33 (1.16–1.53)	1.23 (1.07–1.41)	1.83 (1.18–1.49)
c	0.59 (0.29–1.21)	1.70 (1.08.2.66)	0.95 (0.64–1.49)	0.56 (0.29–1.09)	1.06 (0.49–2.21)	1.07 (0.74–1.56)	1.11 (0.78–1.59)	1.69 (1.26–2.29)
Kidney								
b	0.54 (0.33–0.89)	0.85 (0.65–1.11)	1.08 (0.88–1.33)	1.02 (0.82–1.28)	0.48 (0.27–0.86)	0.90 (0.70–1.14)	1.35 (1.10–1.65)	1.22 (0.99–1.51)
c	0.51 (0.24–1.10)	1.44 (0.96–2.15)	0.65 (0.43–0.98)	1.13 (0.78–1.62)	1.55 (0.90–2.68)	1.22 (0.90–1.64)	1.28 (0.97–1.70)	1.66 (1.24–2.23)
Urinary tract								
b	0.62 (0.49–0.79)	0.94 (0.81–1.10)	0.97 (0.86–1.08)	1.05 (0.92–1.19)	0.61 (0.48–0.79)	1.21 (1.07–1.37)	1.27 (1.13–1.43)	1.30 (1.17–1.44)
c	0.58 (0.34–0.97)	1.52 (1.12–2.05)	0.80 (0.60–1.07)	0.90 (0.65–1.24)	1.17 (0.74–1.85)	1.17 (0.92–1.49)	1.18 (0.94–1.48)	1.60 (1.37–2.09)
All sites								
b	0.79 (0.71–0.87)	0.93 (0.86–1.00)	1.09 (1.03–1.15)	1.12 (1.05–1.19)	0.92 (0.85–1.01)	1.21 (1.13–1.29)	1.08 (1.01–1.15)	1.21 (1.14–1.29)
c	0.78 (0.65–0.93)	1.09 (0.97–1.22)	1.20 (1.09–1.32)	1.01 (0.91–1.12)	1.02 (0.87–1.20)	1.08 (0.99–1.17)	1.18 (1.09–1.28)	1.70 (1.16–1.46)

Abbreviations: CI = confidence interval; OR = odds ratio. [a]Multivariate adjusted for age, residence, body mass index, smoking status, smoking cessation, number of cigarettes smoked per day among current smokers, alcohol drinking, maté consumption, total energy, total vegetables and fruits, total white meat, red meat intakes, bacon, sausage, mortadella, salami, saucisson, hot dog, ham, and salted meat. [b]Men. [c]Women. [d]Cancer of the upper aerodigestive tract (oral, pharynx, oesophagus, larynx).

in the risk of lung cancer of 71% for weekly consumption of processed meat.

Female breast cancer is the higher malignancy among Uruguayan women with an ASIR of 116 persons per 100 000 (Parkin *et al*, 2002). In fact, this rate is the highest in the world (Parkin *et al*, 2002). Studies conducted in Uruguay reported elevated risks for red meat intake (Ronco *et al*, 1996; De Stefani *et al*, 1997; Ronco *et al*, 2006). In the present study, breast cancer showed an increased risk of 82% for high intake of processed meat. In a study by Pala *et al* (2009), postmenopausal women afflicted with breast cancer showed an increased risk of 13% ($P = 0.06$), whereas the study by Aune *et al* (2009) displayed an increased risk of 53% for consumption of processed meat among women afflicted with breast cancer.

Prostate cancer is the second malignancy in frequency among Uruguay men, following lung cancer (Parkin *et al*, 2002).

Epidemiology

According to the report by the World Cancer Research Fund (World Cancer Research Fund/American Institute for Cancer Research, 2008), processed meat intake has a suggestive role among those men afflicted with this malignancy. In the present study, patients with prostate cancer showed an increased risk of 72% per 28 g per day. Sinha *et al* (2009) studied the risk of advanced prostate cancer and found an increased risk of 32% per 25 g per 1000 cal. Thus, our findings replicate those reported by Sinha *et al* (2009).

In our study, bladder cancer showed a significant increased risk for both sexes with a magnitude similar to that observed for prostate cancer. In a prospective study by Michaud *et al* (2006), frequent consumption of bacon was positively associated with a relative risk of 2.1 (*P*-value for trend = 0.006). Furthermore, this association was stronger among never smokers. On the contrary, in our study bacon intake was inversely associated with the risk of bladder cancer. This difference could be explained by the low consumption of bacon among the Uruguayan population (mean intake of bacon: 1.1 g daily). On the contrary, we found rather elevated risks for bladder cancer in our study, directly associated with the intake of hot dogs, ham, and salted meat.

Like other case–control studies, the present study is subject to several potential biases, such as selection bias and recall bias. Nevertheless, the Uruguayan population is mainly unaware of the potential danger of a high consumption of processed meat. This also applies to interviewers. Our study has several strengths. In the first place, the statistical power of the study is a strength. Second, all the cases were microscopically validated by expert pathologists. Finally, the high response rate for cases and controls is another significant strength of the study.

In summary, we conducted a sizeable case–control study on the role of processed meat consumption in several cancer sites. The results were consistently associated with an elevation in risk for most cancer sites, suggesting that processed meat consumption could be a possible risk factor for various cancer sites.

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Conflict of interest

The authors declare no conflict of interest.

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