Cancers in Australia in 2010 attributable to the consumption of red and processed meat

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Abstract

Objectives: To estimate the proportion and numbers of cancers in Australia in 2010 attributable to consuming red/processed meat.

Methods: We estimated the population attributable fraction (PAF) for cancers causally associated with red/processed meat consumption (colon, rectum) using standard formulae incorporating prevalence of consumption (1995 National Nutrition Survey), relative risks associated with consumption and cancer incidence. We also estimated the proportion change in cancer incidence (potential impact fraction [PIF]) that might have occurred under two hypothetical interventions whereby Australian adults reduced their consumption of red/processed meat from prevailing levels to ≤100 g or ≤65 g per day, respectively.

Results: An estimated 2,614 cases (18%) of colorectal cancer occurring in Australians in 2010 were attributable to red/processed meat consumption (16% of colon cancers; 23% of rectal cancers). We estimated that if all Australian adults had consumed ≤65 g/day or ≤100 g/day of red/processed meat, then the incidence of colorectal cancer would have been 5.4% (798 cancers) or 1.4% (204 cancers) lower, respectively.

Conclusions: About one in six colorectal cancers in Australians in 2010 were attributable to red/processed meat consumption.

Implications: Reducing red/processed meat intake may reduce colorectal cancer incidence, but must be balanced against nutritional benefits of modest lean meat consumption.

Key words: population attributable fraction, cancer, risk factor, red/processed meat, potential impact fraction

The second expert report on Food, Nutrition, Physical Activity and the Prevention of Cancer by the World Cancer Research Fund (WCRF) and American Institute for Cancer Research (AICR) concluded that there was convincing evidence that the consumption of red meat (defined as the muscle meat from cattle, sheep, pigs and goats) and processed meat (meat preserved by smoking, curing or salting or the addition of chemical preservatives such as nitrates) increases the risk of colorectal cancer.[1] This conclusion was reiterated in the recent WCRF Continuous Update Project for Colorectal Cancer,[2] which reported a significant increase in risk for colorectal cancer (CRC) with higher consumption of red meat (relative risk [RR]=1.17 per 100 g/day) and a somewhat stronger increase in risk for processed meat, particularly for colon cancer (RR=1.24 per 50 g/day). Several mechanisms have been proposed to explain this causal association. For red meat, these include the oncogenic effects of haem iron[3] and heterocyclic amines and polycyclic aromatic hydrocarbons[4-6] that are found on the surface of well done/charred meat. For processed meats, nitrates – converted to carcinogenic nitrosamines – have been implicated.[7]

The *Australian Dietary Guidelines* recommend the consumption of no more than 455 g cooked (600–700 g raw weight) of lean red meat per week by older children, adolescents and adults, which equates to a 65 g (90–100 g raw weight, about the size of a deck of cards) serving per day.[8] Processed and cured meats are considered discretionary food choices because they are high in added salt and saturated fat. The guidelines recommend that discretionary food choices should be eaten "only sometimes and in small amounts" and the recommended serving size is no more than 50 g.[8] In this paper, we have estimated the number and fraction of cancers diagnosed in 2010 that could be attributed to the combined consumption of red and processed meat in the Australian population. We also estimated the number and proportion of cancers potentially preventable if consumption were reduced to a maximum of 65 g or 100 g/day.

Methods

Relative Risk (RR) estimates

The relative risks for colon and rectal cancers associated with consumption of red and processed meat (combined) were sourced from summary results published by the

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WCRF in the systematic literature review for the Continuous Update Project (CUP) for colorectal cancer.[9] Colon and rectal cancer were modelled separately as the risk associated with consuming red and processed meat is higher for rectal than colon cancer. For colon cancer the relative risk was derived from the WCRF CUP meta-analysis of seven cohort studies (1.21; 95%CI 1.06-1.39 per 100 g/day increase in red and processed meat consumption).[9] For rectal cancer, the relative risk was derived from the WCRF CUP meta-analysis of five cohort studies (1.31; 95% CI 1.13-1.52 per 100 g/day increase in red and processed meat consumption).[9] Although the WCRF also reported separate relative risks for red and processed meats, we did not have the relevant prevalence data to be able to analyse these food groups separately.

The increase in risk for an increase of 1 g/day of red and processed meat consumed was calculated assuming a log-linear relationship between exposure and risk (i.e. that the natural logarithm of the relative risk exhibits a linear relationship with intake), using the formula:

Increase in risk per g per day = $(lnRR_{100})/100$

where RR_{100} is the relative risk for a 100 g increase in consumption per day.

We assumed a log linear relationship because this is the model used by the studies that reported the RRs we used to calculate the PAFs and it is the method recommended by the WCRF.[10]

The increase in risk per gram of red and processed meat consumed per day for colon and rectal cancer were estimated as 1.91e-3 and 2.70e-3 respectively.

Exposure prevalence estimates

The latent period between red and processed meat consumption and development of colorectal cancer is unknown but is likely to be many years. In the updated WCRF meta-analysis undertaken for colorectal cancer, follow-up periods of the cohort studies included in the dose–response meta-analysis (when documented) ranged from 6.8 years to 16.4 years (an average of 10.7 years).[9] Data on combined red and processed meat (not available separately) consumption were therefore sourced from the 1995 National Nutrition Survey,[11,12] the most recently published nutrition survey conducted in Australia at the time this study was undertaken. We used data from three tables in the 1995 National Nutrition Survey to construct the prevalence of different levels of red and processed meat consumption.[11,12] This included information about: a) the mean daily intake of muscle meat; organ meats and offal, products and dishes; sausages, frankfurts and saveloys; processed meat; and estimated red meat from mixed dishes; b) the proportion of protein from muscle meat; sausages, frankfurts and saveloys; and mixed dishes containing lamb and beef; and c) the percentile adjusted daily protein distribution by age and sex. To account for population ageing with time since exposure, and to accommodate an assumed latent period of at least 10 years, we used prevalence data for the age category that was 10 years younger than the corresponding cancer incidence age category (for example, cancer incidence in the 29–34 year age group in 2010 was attributed to meat consumption in the 19–24 year age group in 1995). As the only data available for meat were average daily intakes by age and sex, these were combined with information on the percentile distribution of protein intake to estimate the proportions of the population (by age and sex) in different meat intake categories (see Table 1 for the calculated distributions).

Statistical analysis

Assuming a linear relationship, relative risks were calculated for each consumption category for each age group using the formula:[13]

$$RR = exp(R * G)$$

where R is the increase in risk per gram of meat and g is average consumption of red/processed meat (g) per day.

The population attributable fraction (PAF) was then calculated as:[13]

$$PAF = \frac{\Sigma(p_x \ x \ ERR_x)}{1 + \Sigma(p_x \ x \ ERR_x)}$$

where p_x is the prevalence of red and processed meat consumption for age, sex and consumption category x and ERR_x is the excess relative risk (RR_x–1) associated with each consumption level.

To estimate the number of cancers attributable to the consumption of red and processed meat, we multiplied the PAF by the number of incident colon and rectal cancers in 2010[14] for each age and sex category. The numbers of attributable cancers were then summed across all age and sex categories, and this sum was expressed as a percentage of the total number of all incident cancers (excluding basal cell and squamous cell carcinoma of the skin) recorded in Australia in 2010.

Potential impact of changing red and processed meat consumption

The reference category used to calculate the PAF in the main analyses was zero consumption of red or processed meat. As a means for developing pragmatic policies for preventing cancer, the PAF presents an absolute but unattainable target in the Australian context. The *Australian Dietary Guidelines* recommend consuming no more than ~65 g/day of lean red meat, and occasionally eating small servings (<50 g) of processed meat.[8] Based on these dietary guidelines, we modelled the impact of two potential interventions. First, we assumed that nobody consumed more than 65 g/day of red/processed meat (i.e. in or below the 60–70 g/day consumption category; this would also allow for one 35 g serving of processed meat per week). Second, we modelled a smaller reduction in consumption to a maximum of about 100 g/day. In each analysis we reduced the level of red and processed meat consumption in each category above the respective threshold to that threshold (i.e. 65 g and 100 g) and used the relative risk per gram of red and processed meat to estimate the new relative risk for those intake categories compared to the reference category (those who never eat meat). We then calculated the potential impact fraction (PIF) using the formula of Barendregt and Veerman:[15]

$$PIF = \frac{\sum_{x=1}^{n} p_x RR_x - \sum_{x=1}^{n} p_x RR_x^*}{\sum_{x=1}^{n} p_x RR_x}$$

where p_x is the proportion of population in each age and sex category x, RR_x is the relative risk for that category and RR^*_x is the new relative risk for consumption of red/processed meat of ≤100 g or ≤65 g/day compared to no consumption.

Briefly, for each cancer site, we calculated the number of cases that would have occurred in Australia in 2010, assuming that the alternative scenarios of red and processed meat consumption had prevailed. The PIF is then the proportional difference between the numbers of cancers observed and the numbers expected under the alternative exposure scenarios.

Results

On average, men (19+ years) consumed nearly twice as much red meat per day as women (Table 1). Overall, 98% of men aged ≥19 years consumed more than the recommended daily intake of ~65 g of red and processed meat, while only 50% of women did so. The proportion consuming red or processed meat in excess of guidelines was generally consistent across the younger age groups for both men and women, but in the 65+ year age group it dropped to 87% for men and 34% for women.

An estimated 1,700 colon cancer cases (PAF 16%) and 914 rectal cancer cases (PAF 23%) could be attributed to the consumption of red and processed meat (Table 2). Thus, in total, we estimate that 2,614 cases of colorectal cancer were attributable to the consumption of red and processed meat, which is 18% of all colorectal cancers and 2.3% of all cancers (2.8% in men, 1.7% in women) diagnosed in Australian adults in 2010 (excluding basal cell carcinoma and squamous cell carcinoma of the skin).

Potential impact of changing red and processed meat consumption

Table 3 shows the potential reductions in the incidence of colorectal cancer that might have been achieved if red and processed meat consumption in Australian adults had been reduced from prevailing levels to either ≤65 g or ≤100 g/day. There were 14,776 cancers of the colon or rectum diagnosed among people (aged 29 years and over) in 2010, of which 798 (5.4% of all colorectal cancers [PIF] and 30% of all those attributable to red/processed meat consumption) could potentially have been prevented if all Australians consumed meat as recommended by the guidelines. A more modest intervention achieving a maximum intake of red/processed meat of 100 g/day would have prevented 204 colorectal cancers in 2010 (PIF 1.4% of all colorectal cancers and 8% of all those attributable to red/processed meat consumption). The potential reductions were again greater for men than for women.

Table 1: Estimated distribution of meat (red and processed) consumption (g/day) by age and sex, Australia 1995.[a]

Consumption Category	Consumption of red and processed meat by age group at exposure									
	19-24 yrs		25-44 yrs		45-64 yrs		65+ yrs		19+ yrs	
	g/day	%	g/day	%	g/day	%	g/day	%	g/day	%
Males										
1 (Lowest)	0	1.5	0	0.0	0	0.3	0	4.9	0	0.8
2	61	1.6	63	0.2	66	1.1	62	8.2	63	1.7
3	72	2.8	74	0.9	78	3.5	73	18.0	75	3.8
4	83	4.5	86	3.2	91	8.3	84	19.0	86	7.5
5	94	5.6	97	8.1	103	15.6	95	16.4	98	11.7
6	105	8.9	109	16.1	115	21.2	107	15.2	109	15.4
7	116	11.0	120	21.5	127	14.7	118	10.0	121	15.6
8	127	14.0	132	14.3	139	13.5	129	1.0	132	13.1
9	138	8.1	143	13.1	151	7.4	140	4.0	144	11.0
10	149	8.9	155	9.8	163	6.7	152	2.1	155	8.1
11	160	8.0	166	4.4	175	4.0	163	0.9	167	2.5
12	171	6.8	178	4.2	187	2.1	174	0.4	178	3.9
13	182	5.5	189	2.3	199	1.0	185	0.1	190	2.3
14 (Highest)	193	12.7	200	1.9	211	0.6	196	0.1	201	2.4
Mean grams per day	134		127		121		91		121	
Females										
1 (Lowest)	0	4.5	0	1.7	0	0.2	0	6.7	0	2.2
2	39	6.8	38	5.1	43	2.2	44	14.8	40	6.3
3	48	13.3	47	13.7	52	11.5	54	28.5	49	13.0
4	57	16.4	55	29.5	61	36.1	64	16.1	58	28.6
5	65	9.1	64	12.7	71	19.1	73	16.3	67	17.4
6	74	21.3	72	16.3	80	16.7	83	10.2	76	16.1
7	83	11.3	81	9.4	90	9.5	93	4.9	85	7.6
8	91	5.3	89	6.6	99	3.6	103	1.8	94	5.5
9	100	5.5	98	3.2	109	1.0	113	0.5	103	2.4
10 (Highest)	109	6.7	106	1.8	118	0.2	122	0.1	112	1.1
Mean grams per day	65		62		68		61		64	

a: Derived from National Nutrition Survey 1995 using data from three tables: Table 1. Mean daily intake: Fine Age Group, by Sex (average grams per person) – mean daily intake of muscle meat; organ meats and offal, products and dishes; sausages, frankfurts and saveloys; processed meat; and estimated red meat from mixed dishes.[12] Table 39. Protein (g): Proportion from Selected Groups – the proportion of protein from muscle meat; sausages, frankfurts and saveloys; mixed dishes containing lamb and beef.[11] Table 66. Percentile Distribution of Adjusted Daily Protein Intake – the percentile adjusted daily protein distribution by age and sex.[11]

Discussion

Colorectal cancer was the second most common cancer diagnosed in both men and women in 2010 (behind prostate cancer in men and breast cancer in women).[16] We estimated that about one in six colon cancers (PAF 16%) and nearly one in four rectal cancers (PAF 23%) that occurred in Australians in 2010 could be attributed to consuming red and processed meat (combined PAF 18%). Although the RRs for processed meat are somewhat higher than those for red meat, this is allowed for in our calculations because the intermediate RR for red and processed meat combined that we used reflects the typical balance of red and processed meat consumption in the various study populations. Assuming this balance is representative of that in Australia – and we have no data to suggest that it is not – our estimates will accurately reflect the totality of cancer due to both red and processed meat combined. We also found that if a hypothetical intervention could reduce the consumption of red and processed meat to levels recommended by the *Australian Dietary Guidelines* (≤65 g/day), then the incidence of meat-related colorectal cancers would be reduced by about one-third. This would have equated to 798 fewer cancers in 2010, that is, 5.4% of all colorectal cancers. The more achievable target of ≤100 g/day would have prevented 204 cases in 2010, although this equates to only 1.4% of all colorectal cancers.

Our findings can be compared with those from the recent UK PAF project,[17] which yielded a similar overall PAF (21%) for colorectal cancer associated with consuming red/processed meat.[17] While the Australian and UK analyses used virtually identical analytic approaches, including an exposure threshold of no consumption of red/processed meat and a dose–response relative risk, the UK analysis used a higher relative risk (1.29 from the 2007 WCRF report) than that used in the present analysis (1.21 WCRF CUP). Moreover, the UK study did not consider colon and rectal cancer separately. In a separate study, Norat et al.[18] estimated that 19.6% and 13.6% of colorectal cancers arising in Australian and New Zealand men and women, respectively, were attributable to red meat consumption. Those estimates were based on an average intake of red meat of 125.7 g/day. Other international studies have published preventability estimates for colorectal cancer, although these used different analytical approaches and different assumptions and thus are not directly comparable with our findings. For example, the WCRF preventability estimates (17% UK, 15% US, 12% Brazil and 8% China) are based on categorical relative risks with consumption of <10 g of red meat and <10 g of processed meat per day as the reference category.[19] Despite differences in computational elements across studies, it is notable that PAF estimates from comparable industrialised nations share similar high proportions of colorectal cancers attributable to the consumption of red and processed meat.

One of the limitations of our analyses was that the consumption of red and processed meat was considered in isolation; however, it is likely that patterns of red and processed meat consumption would be associated with intakes of other dietary factors (e.g. refined sugars, alcohol, fruit, vegetables and fibre) and behavioural factors such as physical activity, overweight/obesity and smoking. The extent of possible confounding is difficult to estimate, but it is notable that most of the studies included in the pooled analysis from the WCRF CUP for colorectal cancer adjusted for smoking, alcohol consumption, body mass index and physical activity,[9] which suggests the relative risks we used are likely to be a reasonable estimate of the independent effect of meat. We believe that our PIF scenario of a maximum intake of 100 g/day is achievable. Australia and New Zealand have one of the highest per caput intakes of red meat (125.7 g/day males; 84.1 g/day females), compared to much lower levels in comparable populations like North America (85.9 g/day males; 57.7 g/day females) and North and Central Europe (even lower at 47.3 g/day males; 35.0 g/day females).[18]

In conclusion, we found that a substantial proportion of colorectal cancers diagnosed in Australia in 2010 were attributable to the consumption of red and processed meat; about one in six cases overall. Our analyses suggest that reducing consumption to the recommended Australian Dietary Guideline level of 65 g/day (which would ensure adequate nutrient intake) has the potential to prevent 30% of colorectal cancers attributable to red and processed meat. We are mindful, however, that while reducing dietary meat intake has some potential to reduce the risk of colorectal cancer, this must be balanced against the importance of lean red meat as a source of dietary iron, zinc, B12 and protein.[20]

Table 2: Population attributable fraction (PAF) and estimated number of cancers diagnosed in Australia in 2010 attributable to consumption of red and processed meat.

Age at outcome[a]	Colon (C18, C19)[b]			Rectum (C20)[b]			Colorectal (C18-C20)[b]		All Cancers[c]	
	PAF	Obs.	Exc.	PAF	Obs.	Exc.	Obs.	Exc.	Obs.	Exc.
Males										
29-34 yrs	22.9	18	4	31.0	9	3	27	7	521	7
35-54 yrs	22.1	602	133	29.9	375	112	977	245	8,845	245
55-74 yrs	21.3	3,004	640	28.9	1,453	419	4,457	1,059	3,572	1,059
75+ years	15.9	2,055	327	21.9	697	152	2,752	479	19,488	479
Total		5,679	1,104	28.5	2,534	686	8,213	1,790	64,676	1,790
PAFaw	19.4			27.1			PAFaw=	21.8	PAFaw=	2.8
Females										
29-34 yrs	12.1	20	2	16.7	8	1	28	3	701	3
35-54 yrs	11.4	556	63	15.7	263	41	819	104	11,449	104
55-74 yrs	12.4	2,254	280	17.1	668	114	2,922	394	22,115	394
75+ years	10.8	2,316	251	15.0	478	72	2,794	323	14,986	323
Total	11.7	5,146	596	16.2	1,417	228	6,563	824	49,251	824
PAFaw	11.6			16.1			PAFaw=	12.6	PAFaw=	1.7
Persons										
29-34 yrs		38	6		17	4	55	10	1222	10
35-54 yrs		1,158	196		638	153	1,796	349	20,294	349
55-74 yrs		5,258	920		2,121	533	7,379	1,453	57,907	1,453
75+ years		4,371	578		1,175	224	5,546	802	34,474	802
Total		10,825	1,700		3,951	914	14,776	2,614	113,897	2,614
PAFaw	15.7			23.1			PAFaw=	17.7	PAFaw=	2.3

Abbreviations: Obs. = observed cancers in 2010; Exc. = excess cancers in 2010 attributable to consumption of red/processed meat; PAF = population attributable fraction (expressed as a percentage); PAFaw = age-weighted population attributable fraction (expressed as a percentage)

a: Prevalence data age groups are 10 years younger than cancer incidence age groups, assuming a 10 year latent period between exposure and outcome (see text)

b: International Classification of Diseases Code (ICD-10)

c: Excluding basal cell carcinoma and squamous cell carcinoma of the skin

Table 3: Estimated number of cancers that would have occurred, and the number and percentage potentially prevented, if red and processed meat consumption were reduced to a maximum of 65 or 100 g/day.

Cancer (ICD-10 Code)	Observed cancers 2010	All consume ≤65 g/day red and processed meat			All consume ≤100 g/day red and processed meat		
		No. of cancers predicted	No. of cancers prevented	PIF%	No. of cancers predicted	No. of cancers prevented	PIF%
Males							
Colon (C18, C19)	5,679	5,269	410	7.2	5,563	116	2.0
Rectum (C20)	2,534	2,262	272	10.7	2,452	82	3.2
Total	8,213	7,531	682	8.3	8,015	198	2.4
Females							
Colon (C18, C19)	5,146	5,064	82	1.6	5,142	4	0.1
Rectum (C20)	1,417	1,383	34	2.4	1,415	2	0.1
Total	6,563	6,447	116	1.8	6,557	6	0.1
Persons							
Colon (C18, C19)	10,825	10,333	492	4.5	10,705	120	1.1
Rectum (C20)	3,951	3,645	306	7.7	3,867	84	2.1
Total	14,776	13,978	798	5.4	14,572	204	1.4

Abbreviations: PIF = potential impact fraction

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PAF Project

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