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

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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 iron2 and heterocyclic amines and polycyclic aromatic hydrocarbons4-6 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 potentially preventable if consumption were reduced to a maximum of 65 g or 100 g/day.

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

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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The increase in risk per gram 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:

$$\text{Increase in risk per g per day} = \frac{(\ln RR_{100})}{100}$$

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).13 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 sauselies; processed meat; and estimated red meat from mixed dishes; b) the proportion of protein from muscle meat; sausages, frankfurts and sauselies; 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

$$RR = \exp (R \times G)$$

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

$$\text{PAF} = \frac{\sum (p_x \times ERR_x)}{1 + \sum (p_x \times ERR_x)}$$

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 201014 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

$$\text{PIF} = \frac{\sum p_x RR_x - \sum p_x RR_x^*}{\sum p_x RR_x}$$

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 of red and processed meat (Table 3). Thus, in total, 16% of all colorectal cancers and 914 rectal cancer cases (PAF 23%) that occurred in Australians in 2010 could be attributed to consuming red and processed meat.

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 [PfP] 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 (PfP 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.

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). 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, which yielded a similar overall PAF (21%) for colorectal cancer associated with consuming red/processed meat. 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. 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.

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 | Colorectal (C18-C20) | Rectum (C20) | All Cancers |
|---------------|----------------------|--------------|-------------|
| Males         | PAF Obs. Exc. PAF Obs. Exc. PAF Obs. Exc. | PAF Obs. Exc. PAF Obs. Exc. PAF Obs. Exc. | PAF Obs. Exc. PAF Obs. Exc. PAF Obs. Exc. |
| 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+ yrs       | 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 | 21.8 PAFaw | 2.8 |
| Females       | 12.1 20 2 16.7 8 1 28 3 | 701 3 | |
| 29-34 yrs     | 11.4 556 61 15.7 263 41 819 104 | 11,449 104 | |
| 35-54 yrs     | 12.4 2,254 280 17.1 668 114 2,922 394 | 22,115 394 | |
| 55-74 yrs     | 10.8 2,361 251 15.0 478 72 2,794 323 | 14,986 323 | |
| 75+ yrs       | 11.7 5,146 596 16.2 1,417 228 6,563 824 | 49,251 824 | |
| Total         | 11.6 16.1 | 12.6 PAFaw | 1.7 |
| Persons       | 38 6 | 55 10 | 1222 10 |
| 29-34 yrs     | 1,158 196 638 153 1,796 349 20,294 349 | |
| 35-54 yrs     | 5,258 920 2,121 533 7,379 1,453 57,907 1,453 | |
| 55-74 yrs     | 4,371 578 1,175 224 5,546 802 34,474 802 | |
| 75+ yrs       | 10,825 1,700 3,951 914 14,776 2,614 113,897 2,614 | |
| PAFaw         | 15.7 23.1 | 17.7 PAFaw | 2.3 |

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 consumer ≤65 g/day red and processed meat | All consumer ≤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  |

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Attributable to consumption of meat

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