5.
Cancers attributable to dietary factors in the UK in 2010

II. Meat consumption

The current consensus based on several published meta-analyses is that consumption of red meat (all fresh, minced, and frozen beef, veal, pork and lamb), especially processed meat (any meat preserved by methods other than freezing, including marinating, smoking, salting, air-drying or heating (includes ham, bacon, sausages, pate and tinned meat)), is associated with an increased risk of bowel cancer (Department of Health, 1998; WHO/FAO, 2003; WCRF, 2007). Sandhu et al (2001) observed significant positive associations with all meat and red meat (an increased risk of around 15% per 100 g per day intake of red meat), and a stronger increase for processed meat (49% risk increase for a 25-g per day serving). Norat et al (2002) found a significant increase in risk for colorectal cancer with higher consumption of red meat (1.24 per 120 g per day) and processed meat (1.36 per 30 g per day). Larsson and Wolk (2006) considered 15 prospective studies, and found a relative risk of 1.28 for an increase of 120 g per day intake of red meat and 1.09 for an increase of 30 g per day intake of processed meat. Consumption of red meat and processed meat was positively associated with the risk of both colon and rectal cancer, although the association with red meat appeared to be stronger for rectal cancer.

There are no dietary guidelines concerning recommended levels of consumption of red and processed meat; as for alcohol, it is assumed that ‘less is better’ and that there is no threshold below which consumption presents no risk. In this section, we assume that the optimum (or target) is zero consumption. Currently, about 10% of the adult population are vegetarian, or consume only fish and poultry products (DEFRA, 2007).

The latent period, or interval between ‘exposure’ to meat and the increased risk of colorectal cancer, is not known. In the cohort studies included in the meta-analyses by WCRF (2007), the mean duration of follow-up was 8.9 years. In studies contributing to the meta-analysis by Larsson and Wolk (2006), the mean duration of follow-up (when this was given) was 8.7 years. We chose to assume a mean latency of 10 years, and estimate the effects on cancers occurring in 2010 from meat consumption in 2000.

Information on consumption of meat in the UK is available for 2000–2001 from the National Diet and Nutrition Survey (Food Standards Agency, 2002) as mean consumption, in grams of different types of meat per week, by age group and sex. The relevant data are shown in Table 1.

The population distribution of protein consumption, in grams per day, by age group and sex, is available from the National Diet and Nutrition Survey (Volume 2, Table 3.1; Food Standards Agency, 2003). This was converted to grams of meat per day, based on the average intake of meat (Table 1) and protein (NDNS Volume 2, Table 3.4) in each age–sex group.

The estimate for 2000 is shown in Table 2 (as the percentage of the population in different age–sex groups consuming specified amounts of red and processed meat), and in Figure 1 as the cumulative frequency (percentage) of the population in each age–sex group at different consumption levels.

The relative risk of meat consumption for each of the x consumption categories shown in Table 2 was calculated according to the following formula:

$$RR_x = \exp(R_g \times G_x)$$

where $R_g$ is the increase in risk of colon cancer per gram of meat (0.0025) and $G_x$ is the consumption of meat in gram per day in category x.

Population-attributable fractions (PAFs) were calculated for each sex–age group according to the following formula:

$$PAF = \frac{\sum(p_i \times ERR_i)}{1 + \sum(p_i \times ERR_i)}$$

where $p_i$ is the proportion of population in consumption category $x$ and ERR$_x$, the excess relative risk ($RR_x - 1$) in consumption category $x$. 

**METHODS**

The relative risk of meat consumption for colorectal cancer is taken from the WCRF report (2007), and is based on the effect of red meat in a meta-analysis of three prospective studies (1.29 per 100 g red meat per day). Under the assumption that the increase in risk is a logarithmic function of intake of meat, the risk is increased by 0.0025 for each gram of meat consumed. The effect of processed meat, based on five studies, was 1.21 per 50 g per day (the excess risk corresponds to 0.0038 per gram).
RESULTS

Table 3 shows PAFs of colorectal cancer resulting from meat consumption in 2000–2001, and the estimated number of cases 'caused' in 2010. The final three columns show the excess numbers of cases of colorectal cancer caused by meat consumption expressed as a fraction of the total burden of (incident) cancer. The estimate is 3.5% cancers in men and 1.9% in women, or 2.7% of cancers overall.

DISCUSSION

The association between consumption of red and processed meat and the risk of cancer of the colon and rectum is now well established. Although the risk for processed meat products (such as ham, bacon, sausages, pate and tinned meat) is greater than that for fresh meat, in this analysis we have considered both together, partly because separate estimates of intake (by age group and sex) would be difficult, and partly because it would not affect the overall estimate, which is concerned with the proportion of colorectal cancer related to any meat consumption (i.e., over and above a diet including poultry and fish, as sources of animal protein).

The estimation of attributable fraction is against a baseline of a diet that would contain no red meat, and is based on the relative risks of consumption of red meat, according to the review by WCRF (2007). The values for red meat consumption (1.29 per 100 g per day) are rather higher than those in the more recent meta-analysis of Larsson and Wolk (1.29 per 120 g per day, when adjusted for BMI, physical activity, smoking, energy intake and so on). These values would have given a total of 18% of colon cancers due to consumption of red meat (rather than 21.1%, as in Table 3).

Norat et al (2002) estimated the proportion of colorectal cancer risk attributable to current (1995) red meat consumption in North and Central Europe as 7.8% in men and 5.8% in women, much lower than the estimated percentages in the UK, but estimated per caput red meat consumption of this population (47.3 g per day in men and 35 g per day in women) was around one-half of that in the UK in 2000 (Table 1). WCRF (2009), based on the relative risks from the EPIC study (Norat et al, 2005; 1.49 per 100 g red meat, 1.70 per 100 g processed meat), estimated that 15% of colorectal cancer in the UK in 2002 was due to consumption in excess of 10 g per day of red meat and 10 g per day of processed meat.

Several other cancers have been linked to consumption of red or processed meat. However, at the time of the review by WCRF

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Table 1

|            | Men | Women |
|------------|-----|-------|
| Meat       | 19–24 | 25–34 | 35–49 | 50–64 | All men | 19–24 | 25–34 | 35–49 | 50–64 | All women |
| Red meata (including liver) | 63 | 72 | 74 | 77 | 73 | 45 | 37 | 50 | 52 | 47 |
| Processed meatb | 63 | 50 | 43 | 35 | 45 | 32 | 24 | 21 | 19 | 23 |
| Red (including processed) | 125 | 122 | 118 | 111 | 118 | 77 | 62 | 71 | 71 | 69 |
| All meat productsa | 144 | 142 | 137 | 133 | 138 | 86 | 70 | 81 | 80 | 78 |

*aExcludes poultry. bBacon, ham, sausages, burgers, kebabs.

Table 2

| Consumption of red and processed meat | 19–24 | 25–34 | 35–49 | 50–64 | All ages |
|-------------------------------------|-------|-------|-------|-------|----------|
| Consumption category | grams per day % | grams per day % | grams per day % | grams per day % | grams per day % |
| Men | | | | | |
| 1 | 0 | 6 | 0 | 0 | 0 | 2 | 0 | 3 | 0 | 2 |
| 2 | 79 | 6 | 66 | 2 | 64 | 4 | 62 | 3 | 66 | 4 |
| 3 | 88 | 0 | 74 | 3 | 71 | 1 | 68 | 1 | 73 | 1 |
| 4 | 93 | 11 | 81 | 14 | 79 | 6 | 76 | 7 | 81 | 9 |
| 5 | 111 | 22 | 95 | 14 | 91 | 9 | 88 | 14 | 94 | 14 |
| 6 | 127 | 19 | 101 | 16 | 105 | 19 | 100 | 19 | 107 | 18 |
| 7 | 143 | 19 | 112 | 21 | 118 | 23 | 113 | 13 | 120 | 19 |
| 8 | 161 | 19 | 133 | 13 | 131 | 14 | 125 | 16 | 134 | 13 |
| 9 | 177 | 17 | 149 | 9 | 144 | 8 | 138 | 8 | 147 | 9 |
| 10 | 193 | 1 | 162 | 3 | 157 | 6 | 151 | 10 | 161 | 5 |
| 11 | 217 | 0 | 182 | 1 | 176 | 4 | 169 | 6 | 181 | 6 |
| Mean gram per day | 125 | 122 | 118 | 111 | 118 |

Women

| Consumption of red and processed meat | 19–24 | 25–34 | 35–49 | 50–64 | All ages |
|-------------------------------------|-------|-------|-------|-------|----------|
| Consumption category | grams per day % | grams per day % | grams per day % | grams per day % | grams per day % |
| 1 | 0 | 7 | 0 | 0 | 0 | 4 | 0 | 2 | 0 | 4 |
| 2 | 52 | 9 | 42 | 13 | 44 | 6 | 42 | 6 | 44 | 9 |
| 3 | 59 | 4 | 48 | 1 | 50 | 2 | 49 | 1 | 50 | 1 |
| 4 | 66 | 17 | 54 | 22 | 56 | 15 | 54 | 11 | 55 | 16 |
| 5 | 77 | 28 | 63 | 26 | 65 | 21 | 63 | 25 | 65 | 24 |
| 6 | 90 | 19 | 74 | 17 | 76 | 26 | 74 | 25 | 76 | 23 |
| 7 | 103 | 9 | 84 | 9 | 87 | 16 | 84 | 16 | 87 | 13 |
| 8 | 116 | 6 | 95 | 6 | 98 | 6 | 95 | 10 | 98 | 7 |
| 9 | 129 | 1 | 105 | 1 | 109 | 3 | 106 | 4 | 109 | 2 |
| 10 | 148 | 0 | 121 | 1 | 125 | 1 | 121 | 0 | 125 | 1 |
| Mean gram per day | 77 | 62 | 71 | 71 | 69 |

Figure 1

Estimated consumption of red and processed meat, by age group and sex, expressed as grams per day.
(2007), the evidence with respect to cancers of the oesophagus, lung, pancreas, endometrium, stomach and prostate was considered to be ‘limited’. Only the associations between consumption of red and processed meat with an increased risk of colorectal cancer were considered to be ‘convincing’.

| Table 3 | Colorectal cancer diagnosed in 2010, attributable to meat consumption in 2000–2001 |
|---------|----------------------------------------------------------------------------------|
| Age (years) | Colon–rectum | All cancers* |
| At exposure | At outcome | PAF | Observed cases | Excess attributable cases | PAF (%) | Observed cases | Excess attributable cases | PAF (%) |
| **Men** | | | | | | | | |
| 19–24 | 29–34 | 0.27 | 92 | 24.8 | 26.9 | 1333 | 24.8 | 1.9 |
| 25–34 | 35–44 | 0.26 | 397 | 102.5 | 25.8 | 4124 | 102.5 | 2.5 |
| 35–49 | 45–59 | 0.26 | 2921 | 756.7 | 25.9 | 22388 | 756.7 | 3.4 |
| 50–64 | ≥ 60 | 0.25 | 18643 | 4611.3 | 24.7 | 128192 | 4611.3 | 3.6 |
| All ages | | 0.22 | 12127 | 5495.3 | 24.8 | 158667 | 5495.3 | 3.5 |
| **Women** | | | | | | | | |
| 19–24 | 29–34 | 0.17 | 97 | 16.9 | 17.5 | 2248 | 16.9 | 0.8 |
| 25–34 | 35–44 | 0.14 | 402 | 57.0 | 14.2 | 8619 | 57.0 | 0.7 |
| 35–49 | 45–59 | 0.16 | 2292 | 376.0 | 16.4 | 31631 | 376.0 | 1.2 |
| 50–64 | ≥ 60 | 0.17 | 14926 | 2465.6 | 16.5 | 110403 | 2465.6 | 2.2 |
| All ages | | 0.17 | 17787 | 2915.5 | 16.4 | 155584 | 2915.5 | 1.9 |

| Persons | | | | | | | | |
| 19–24 | 29–34 | 0.17 | 189 | 42 | 22.1 | 3582 | 42 | 1.2 |
| 25–34 | 35–44 | 0.14 | 799 | 160 | 20.0 | 12743 | 160 | 1.3 |
| 35–49 | 45–59 | 0.16 | 5213 | 1133 | 21.7 | 54019 | 1133 | 2.1 |
| 50–64 | ≥ 60 | 0.17 | 33569 | 7077 | 21.1 | 238595 | 7077 | 3.0 |
| All ages | | 0.17 | 39914 | 8411 | 21.1 | 314251 | 8411 | 2.7 |

Abbreviations: PAF = population-attributable fraction. *Excluding non-melanoma skin cancer.

See acknowledgements on page Si.

Conflict of interest

The author declares no conflict of interest.

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