In 2002, the International Agency for Research on Cancer Handbook on Weight Control and Physical Activity concluded that overweight and obesity are related to cancers of the colon, endometrium, kidney and oesophagus (adenocarcinomas), as well as postmenopausal breast cancer. Since that report, continuing epidemiological investigation has suggested that other cancers are related to obesity and overweight. In addition to those listed above, the report by the World Cancer Research Fund (WCRF) Panel on Food, Nutrition, Physical Activity, and the Prevention of Cancer (WCRF, 2007) considered that there was convincing evidence for an association with cancers of the pancreas and rectum (as well as colon), and a probable association with cancers of the gall bladder. The fraction of these cancers occurring in 2010 attributable to overweight and obesity in the UK population is estimated in this section.

METHODS

The estimates of risk associated with overweight (BMI 25 < 30 kg m$^{-2}$) and obesity (BMI 30 + kg m$^{-2}$), relative to a BMI ≤ 25 kg m$^{-2}$, for the seven cancers, are shown in Table 1. The estimates of relative risk for an increase of 5 kg m$^{-2}$ from the meta-analyses by WCRF (2007) have been used for the category ‘overweight’. Assuming a constant rate of increase in risk with BMI, the square of this value was taken for the category ‘obese’. For postmenopausal breast cancer, WCRF reported that the increase in risk was 8% per BMI increase of 5 kg m$^{-2}$ for cohort studies (17 considered) and 13% per BMI increase of 5 kg m$^{-2}$ for case–control studies (48 considered). The estimates from the meta-analyses of Bergstrom et al (2001) and Renhan et al (2008) were almost identical (12% per BMI increase of 5 kg m$^{-2}$), and thus this value has been selected.

The latent period, or interval between ‘exposure’ to overweight/obesity and the appropriate increase in risk of these cancers, is not known. Renhan et al (2008) calculated the geometric mean duration of follow-up in the cohort studies available for a meta-analysis of relative risks due to overweight and obesity. The periods ranged from 8.4 years (for breast cancer) to 12.7 years (for gall bladder cancer). We therefore chose to assume that the latency between ‘exposure’ and outcome would be, on average, 10 years, and thus examine the effects on cancers occurring in 2010 from suboptimal levels of body mass in 2000. The proportion of adults in the age group of 19–64 who were overweight or obese in Great Britain in 2000–2001 is available from the National Diet and Nutrition Survey (FSA, 2004; Table 4.1). For older adults (aged ≥ 65), we used the values for 2000 from the Health Survey for England (Health and Social Care Information Centre, 2010). The results are shown in Table 2.
## Table 3  Cancer cases diagnosed in 2010 attributable to overweight and obesity in 2000

| Age (years) | Proportion overweight or obese in 2000 | Oesophagus (adenocarcinoma) | Gallbladder | Pancreas | Colon-rectum | Breast | Corpus uteri | Kidney |
|-------------|----------------------------------------|-----------------------------|-------------|----------|--------------|--------|-------------|--------|
|             | At exposure +10 years                   | At outcome                  | Overweight  | Obese    |
| **Men**     |                                        |                             | PAF         | Obs.     | PAF          | Obs.   | PAF         | Obs.   | PAF          | Obs.   |
| 19 – 24     | 0.25                                   | 0.18                        | 0.28        | 4        | 0.13         | 0.00   | 0.08        | 9      | 0.07         | 0.13   |
| 25 – 34     | 0.42                                   | 0.18                        | 0.33        | 27       | 0.16         | 0.2    | 0.10        | 67     | 0.68         | 0.11   |
| 35 – 44     | 0.45                                   | 0.25                        | 0.37        | 358      | 0.19         | 0.24   | 0.12        | 587    | 0.71         | 0.13   |
| 45 – 59     | 0.45                                   | 0.25                        | 0.37        | 358      | 0.19         | 0.24   | 0.12        | 587    | 0.71         | 0.13   |
| 50 – 64     | 0.46                                   | 0.32                        | 0.41        | 1405     | 0.21         | 0.83   | 0.14        | 1771   | 2.46         | 0.15   |
| 65 – 74     | 0.50                                   | 0.24                        | 0.38        | 963      | 0.19         | 0.59   | 0.13        | 1188   | 1.49         | 0.13   |
| ≥ 75        | 0.52                                   | 0.17                        | 0.34        | 371      | 0.17         | 0.22   | 0.11        | 460    | 0.56         | 0.12   |
| **Total (%)** | —                                    | —                           | 573.1       | 1358.1   | 191.0        | 37.5   | 4084.0      | 523.1  | 22.1         | 127.7 |

| **Women**   |                                        |                             | PAF         | Obs.     | PAF          | Obs.   | PAF         | Obs.   | PAF          | Obs.   |
| 19 – 24     | 0.25                                   | 0.14                        | 0.25        | 1        | 0.11         | 0.1    | 0.07        | 11     | 0.8          | 0.08   |
| 25 – 34     | 0.28                                   | 0.16                        | 0.27        | 4        | 0.12         | 1.0    | 0.08        | 53     | 4.2          | 0.09   |
| 35 – 44     | 0.31                                   | 0.23                        | 0.33        | 50       | 0.16         | 0.73   | 0.10        | 437    | 4.41         | 0.11   |
| 45 – 59     | 0.41                                   | 0.22                        | 0.35        | 267      | 0.17         | 0.198  | 0.11        | 1320   | 16.69        | 0.12   |
| 50 – 64     | 0.41                                   | 0.22                        | 0.35        | 267      | 0.17         | 0.198  | 0.11        | 1320   | 16.69        | 0.12   |
| 65 – 74     | 0.41                                   | 0.30                        | 0.39        | 320      | 0.20         | 1.43   | 0.13        | 1574   | 17.74        | 0.14   |
| ≥ 75        | 0.41                                   | 0.30                        | 0.39        | 320      | 0.20         | 1.43   | 0.13        | 1574   | 17.74        | 0.14   |
| **Total (%)** | —                                    | —                           | 5219.0      | 1853.2   | 315.3        | 11.2   | 4280.0      | 493.6  | 17.87        | 2162.4 |

| **Persons** |                                        |                             | PAF         | Obs.     | PAF          | Obs.   | PAF         | Obs.   | PAF          | Obs.   |
| 19 – 24     | —                                      | —                           | 0           | 1.2      | 0.1          | 0.1    | 20          | 1.5    | 269          | 2.18   |
| 25 – 34     | —                                      | —                           | 31          | 10.0     | 9.1          | 1.2    | 120         | 11.0   | 799          | 7.73   |
| 35 – 44     | —                                      | —                           | 408         | 150.4    | 97.1         | 16.1   | 1024        | 115.3  | 5213         | 62.57  |
| 45 – 59     | —                                      | —                           | 1672        | 672.4    | 281          | 51.6   | 3291        | 411.5  | 15597        | 2048.1 |
| 50 – 64     | —                                      | —                           | 1283        | 714.4    | 202          | 40.0   | 2562        | 126.6  | 12301        | 166.49 |
| 65 – 74     | —                                      | —                           | 591         | 305.1    | 108          | 19.0   | 1344        | 150.8  | 5671         | 444.10 |
| ≥ 75        | —                                      | —                           | 8532        | 1853.2   | 700          | 128    | 8364        | 1107.2 | 39914        | 5172.0 |
| **Total (%)** | —                                    | —                           | 8532.0      | 1853.2   | 700.0        | 128.0  | 8364.0      | 1107.2 | 39914.0      | 5172.0 |

Abbreviations: Obs = observed cases; PAF = population-attributable fraction. *Observed cases are for adenocarcinoma only. **Total observed cases (and percentages) are for all oesophageal cancers, and so are greater than the sum of observed cases.
The number of oesophageal cancers diagnosed in 2010 was partitioned by histological subtype, according to the age- and sex-specific distribution observed in the UK Cancer registries reporting to Cancer Incidence in Five Continents, Volume VIII (Parkin et al, 2002). These age-specific proportions were scaled to correspond to the crude proportions observed in the UK registries in 2000–2002 (Curado et al, 2007), when adenocarcinomas comprised 69.9% of oesophageal cancers in men and 39.9% in women.

The population-attributable fraction (PAF) was calculated for each sex–age group, corresponding to the level of overweight/obesity 10 years previously, according to the usual formula:

$$ PAF = \frac{p_1 \times ERR_1 + p_2 \times ERR_2}{1 + (p_1 \times ERR_1 + p_2 \times ERR_2)} $$

where $p_1$ is the proportion of population overweight, $p_2$ the proportion of population obese, $ERR_1$ the excess relative risk (RR−1) for overweight and $ERR_2$ the excess relative risk (RR−1) for obesity.

RESULTS

Table 3 shows the calculation of attributable fractions, and corresponding numbers of attributable cases, by age group and sex, for seven cancer types accepted to be causally related to excess body weight, assuming a 10-year latency between the presence of excess body mass and cancer risk. Table 4 summarises these results. An estimated 17,294 excess in cancer cases occurring in 2010 were due to overweight and obesity (5.5% of all cancers). The sites contributing most to this excess are large bowel (5172) and breast (4194).

DISCUSSION

The list of cancers that have been selected as being related to excess body mass (overweight and obesity) is a conservative one. It corresponds to those in the consensus statements of IARC (2002) and WCRF (2007). Needless to say, other studies have identified a larger number of other cancers to be associated with excess body mass. In the recent meta-analysis of prospective studies (cohort studies and clinical trials) by Renehan et al (2008), there was a positive (statistically significant) association between BMI and cancer of the thyroid, leukaemia, malignant melanoma (men only), non-Hodgkin lymphoma and multiple myeloma. Others have reported significant associations with cancers of the prostate (Bergstrom et al, 2001), ovary (Reeves et al, 2007; Schouten et al, 2008; Lahmann et al, 2010) and brain (Benson et al, 2008), as well as cancers of the liver (Larsson and Wolk, 2007) and gastric cardia (Calle and Kaaks, 2004).

In common with most reviews, we have chosen to ignore possible differences in risk between men and women, although for some cancers – especially colorectal cancers – a greater effect in men than in women is found in some studies (Calle and Kaaks, 2004; Renehan et al, 2008) but not others (Bergstrom et al, 2001).

The 10-year ‘latency’ used to define the relevant time period at which to measure population prevalence of overweight and obesity is somewhat arbitrary. It was based on the average period of follow-up in the large cohort studies from which the estimates of relative risk are derived (as reported by Renehan et al, 2008).

Several previous estimates of the fraction of cancer in the UK attributable to overweight and obesity have been published. Bergstrom et al (2001) considered a similar range of cancers to those in this paper, but included cancers of the prostate as related to BMI, and excluded oesophageal adenocarcinomas; based on relative risks from their own meta-analyses, they estimated that 2.7% of cancers diagnosed in men and 4.9% in women in the UK in 1995 were related to overweight/obesity during 1983–6. Renehan et al (2010) include a much wider range of cancers, as noted earlier, based on their meta-analysis of 2008 (Renehan et al, 2008); their estimate of attributable fraction (for 2002, based on overweight/obesity (single category) in 1992 (from WHO)) was 4.01% in women and 3.42% in men. Reeves et al (2007) used the results of the Million Women Study to estimate that 5% of cancers in postmenopausal women in 2004 were related to overweight and obesity (based on prevalence in England in the same year), and including nine cancers observed to have a significant trend of increasing risk with increasing BMI (including leukaemia, ovary, multiple myeloma and non-Hodgkin lymphoma, but excluding colorectal cancers). The estimate of the proportion of cancers related to ‘body fatness’ in the UK in 2002 by WCRF/AICR (2009) is given only for the seven sites analysed in this paper: 18% of the five cancers in men and 16% of the seven in women. This would be equivalent to an overall AF (for all cancers) of 4.2% in men and 8.7% in women. There are several reasons for this larger estimate. WCRF selected ‘representative’ studies from which to take the relative risks – almost all are in excess of the pooled values from their own meta-analyses. Exposure prevalence was taken from data for the same year as outcome (2002); exposure prevalence would have been lower if prevalence at an earlier period had been used, given the continuously rising trend of overweight and obesity in recent years. Finally, the baseline category (not overweight or obese) was not always ≤25 kg m$^{-2}$, but for some cancers (breast and pancreas) it was ≤23 kg m$^{-2}$.

See acknowledgements on page Si.

Conflict of interest

The authors declare no conflict of interest.

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| Cancer       | Male   | Female | Persons |
|--------------|--------|--------|---------|
| Oesophagus   | 1538 (26.9) | 315 (11.2) | 1853 (21.7) |
| Gallbladder  | 381 (9.7)   | 91 (17.8)  | 128 (18.3)  |
| Pancreas     | 523 (12.8)  | 494 (11.5) | 1017 (12.2) |
| Colorectum   | 3009 (13.6) | 2162 (12.2) | 5172 (13.0) |
| Breast       | —       | 4194 (8.7) | 4194 (8.7)  |
| Endometrium  | 2759 (33.7) | 749 (22.2) | 2171 (24.0) |
| All cancers  | 6530 (4.1)  | 10764 (6.9) | 17294 (5.5) |

Table 4 Numbers and proportion of cases occurring at selected sites attributable to overweight and obesity (UK 2010)

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