In 1988, the International Agency for Research on Cancer (IARC) Monograph on the carcinogenic risk to humans of alcohol drinking concluded that the occurrence of malignant tumours of the oral cavity, pharynx, larynx, oesophagus and liver was causally related to the consumption of alcoholic beverages. In an updated review (Baan et al, 2007; Secretan et al, 2009), they noted the consistent finding of an increased risk of breast cancer with increasing alcohol intake, and that an association between alcohol consumption and colorectal cancer had been reported by more than 50 prospective and case–control studies, with no difference in the risk for colon and rectal cancers (Baan et al, 2007). The World Cancer Research Fund report (WCRF, 2007) considered that the evidence for an association of alcohol intake with these sites was convincing and, for liver cancer, probable.

### METHODS

#### Quantitative risk of alcohol

Table 1 shows the increase in risk associated with consumption of 1 g per day of alcohol. The estimates in these studies had been adjusted for major confounders, notably smoking.

With respect to breast cancer, the estimate was derived from a meta-analysis of 53 studies, conducted by the Collaborative Group on Hormonal Factors in Breast Cancer (Hamajima et al, 2002), which found that the risk was increased by 7.1% for every 10 g of daily alcohol intake. The values observed in subsequent studies are not substantially different. A pooled analysis of six cohort studies with data on alcohol and dietary factors found that the risk of breast cancer increased monotonically with increasing intake of alcohol; the multivariate relative risk (RR) for a 10-g per day intake was 1.09 (95% CI = 1.01–1.13; Smith-Warner et al, 1998). The EPIC study (Tjønneland et al, 2007) found that the risk was 1.03 (95% CI = 1.01–1.05) per 10 g per day recent alcohol intake, whereas in the Million Women Study the increase in risk associated with 10 g per day intake was 12% (Allen et al, 2009).

With respect to cancers of the colorectum, a pooled analysis of eight cohort studies reported a borderline statistically significant 16% risk increase for people drinking 30–45 g per day of alcohol and a significant 41% risk increase for people drinking ≥45 g per day (Cho et al, 2004). A more recent meta-analysis of cohort studies found a 15% increase in the risk of colon or rectal cancer for an increase of 100 g alcohol intake per week (Moskal et al, 2007), with no difference between men and women. In the EPIC study (Ferrari et al, 2007), the effect was a bit weaker, with alcohol intake at study baseline increasing colorectal cancer risk by 9% per 15 g per day, a risk greater for rectal cancer than for cancer of the distal colon, which in turn was greater than the risk for cancer of the proximal colon. In the WCRF (2007) report, a meta-analysis of eight studies of colon cancer yielded a combined RR of 1.09 (1.03–1.14) per 10 g intake per day, and a meta-analysis of nine studies of rectal cancer yielded an RR of 1.06 (1.01–1.12) per 10 g intake per day.

The means in the meta-analyses of Cho et al (2004), Moskal et al (2007), the EPIC study (Ferrari et al, 2007) and WCRF (2007) are 0.75% per gram alcohol per day for colon cancer and 0.85% per gram per day for rectal cancer. As these estimates are similar, the global figure of 0.8% per gram (increase of 0.008 per gram per day) was used for colorectal cancer as a whole (Table 1).

For the remaining cancers, the meta-analysis of Corrao et al (2004) was used to estimate the RR. They present RRs associated with a mean intake of 0, 25, 50 and 100 g of alcohol per day. The RR per gram of alcohol intake was estimated by assuming a log–linear relationship between exposure and risk, so that:

\[
\text{Relative risk} (x) = \exp(\log(\text{risk per unit}) \times \text{exposure level (x)})
\]

where \(x\) is the exposure level (in grams per day).

#### Prevalence of exposure to alcohol

The latent period or interval between ‘exposure’ to alcohol and the appropriate increase in risk of these cancers is not known. We chose to assume that this would be, on average, 10 years, and thus examine the effects on cancers occurring in 2010 from non-optimal levels of alcohol consumption in the year 2000.

There are two main ways of measuring the amount of alcohol consumed: asking people how much alcohol they drink or counting how much alcohol is sold. As the estimates of the effect of past alcohol drinking on cancer risk are based on epidemiological studies in which alcohol intake is estimated from questionnaire data, it is most appropriate to base the exposure prevalence on data from a similar source.

We have used data from the National Diet and Nutrition Survey, a survey of the diet and nutrition of a representative sample of adults in the age group of 19–64 years living in private households in Great Britain, carried out between July 2000 and June 2001.

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For the age group 465 years, we used data on the proportion of non-drinkers, and average alcohol consumption from the General Household Survey (for England) (Goddard, 2006). From these tables, an estimate was prepared of the proportions of individuals (by age group and sex) consuming different quantities of alcohol in terms of grams per day, assuming that 1 unit of alcoholic beverages contains 8 g of pure alcohol (Table 2).

The same data are shown in Figure 1, as the cumulative percentages of men and women of different ages with different levels of alcohol intake in 2000, as grams per day of alcohol.

### Estimation of population attributable fractions (PAFs)

For the six cancer types, PAFs were calculated for each sex–age group according to the usual formula:

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

where $p_x$ is the proportion of the population in consumption level $x$ ($x = 1–12$) and $\text{ERR}_x$ the excess relative risk (RR$_x$–1) in consumption level $x$ ($x = 1–12$).

The ERR of alcohol consumption for each level $x$ of alcohol consumption given in Table 2 was calculated as follows:

$$\text{ERR}_x = \exp(R_g \times G_x) - 1$$

### Results

Table 3 shows for each sex and age group the numbers of cases of the six alcohol-related cancers in the UK in 2010, the PAFs due to alcohol consumption 10 years earlier (2000–2001) and the corresponding number of excess cases (calculated as (observed / PAF)).

Because of the high risk of upper aero-digestive tract cancer associated with alcohol drinking, cancers of the mouth and pharynx, as well as larynx, had the highest percentages of alcohol-attributable cases (30.4% of cancers of the oral cavity and pharynx, 24.6% of laryngeal cancers). Although the fractions of colorectal (11.6%) and breast (6.4%) cancers were much lower, the actual numbers of alcohol-attributable cases were much greater – together, they account for about 7700 alcohol-attributable cases in 2010 (or 62% of all alcohol-related cancers).

Table 4 sums the excess numbers of cases at the six sites, caused by alcohol consumption, and expresses these numbers as a fraction of the total burden of (incident) cancer. The estimates are 4.6%
Table 3  Cancer cases diagnosed in 2010 attributable to alcohol consumption in 2000–2001

| Age (years) | Oral cavity and pharynx | Oesophagus | Colon–rectum | Liver | Larynx | Breast |
|------------|-------------------------|------------|--------------|-------|--------|--------|
| At exposure | At outcome (+10 years) | PAF Obs. | Excess attrib. cases | PAF Obs. | Excess attrib. cases | PAF Obs. | Excess attrib. cases | PAF Obs. | Excess attrib. cases | PAF Obs. | Excess attrib. cases |
| Men        | 15–24 25–34             | 0.36       | 55            | 19.6   | 0.25   | 11            | 2.8    | 0.16               | 133      | 20.8               | 0.12   | 19               | 2.1    | 0.26               | 2          | 0.5                |
|            | 25–34 35–44             | 0.39       | 244           | 96.1   | 0.28   | 86            | 24.0   | 0.17               | 397      | 69.2               | 0.13   | 43               | 5.5    | 0.29               | 35          | 10.3               |
|            | 35–49 45–59             | 0.40       | 1591          | 63.1   | 0.28   | 970           | 274.9  | 0.18               | 2921     | 521.1              | 0.12   | 101              | 12.1   | 0.28               | 914         | 25.9               |
|            | 50–64 60–74             | 0.38       | 1888          | 70.1   | 0.26   | 2535          | 668.2  | 0.16               | 9481     | 1540.8             | 0.10   | 828              | 83.7   | 0.24               | 444         | 105.3              |
| >65        |                       | 0.32       | 768           | 24.9   | 0.22   | 2106          | 473.7  | 0.14               | 9162     | 1262.7             | 0.10   | 828              | 83.7   | 0.24               | 444         | 105.3              |
| Total      |                       |            | 4571          | 1705.9 | 5713    | 1443.5        | 2212   | 3421.8             | 2270     | 2259.1             | 1803   | 491.3             |        |                   |
| %          |                       | 373        | 25.3          |        | 6.9     |                | 15.5   | 11.4               | 27.3     |                   |        |                   |

Women: 15–24 25–34 0.23 50 11.4 0.16 4 0.6 0.10 136 13.0 0.07 12.11 0.9 0.17 2 0.3 0.08 715.1 60.7
Men: 35–49 45–59 0.18 131 23.2 0.12 27 3.3 0.07 402 29.9 0.05 29.48 1.6 0.13 12 1.5 0.07 3857 254.0
Women: 50–64 60–74 0.17 855 146.3 0.12 303 37.9 0.08 2292 174.8 0.06 142.8 8.0 0.13 168 13.1 0.07 14628 987.4

Table 4  Estimated total numbers of cancers in the UK in 2010, PAFs due to alcohol consumption 10 years earlier (2000–2001), and the corresponding number and percentage of excess cases, by age group and sex

| Age (years) | Outcome (+10 years) | Observed cases | Excess attributable cases | PAF (%) |
|------------|---------------------|----------------|--------------------------|---------|
| Men        | 15–24 25–34         | 2109           | 46                       | 2.2     |
|            | 25–34 35–44         | 2412           | 205                      | 5.0     |
|            | 35–49 45–59         | 22388          | 1596                     | 7.1     |
|            | 50–64 60–74         | 68043          | 3301                     | 4.9     |
|            | >65 75+             | 60149          | 2175                     | 3.6     |
| Total      |                     | 158667         | 7322                     | 4.6     |

Women: 15–24 25–34 35–44 45–59 50–64 60–74 >65 75+ 22841 87 313 1353 8361 1335 9696 1837 55437 1564 5136 3.3

Persons: 15–24 25–34 35–44 45–59 50–64 60–74 >65 75+ 3539 133 519 2303 5138 12309 3738 115586 12458 4.0

DISCUSSION

The estimates of the RR of alcohol consumption for various cancers are an ‘average’ taken from widely cited meta-analyses; more extreme values can be found in specific studies.

Table 5 compares the excess RRs of 1 g of alcohol consumption per day as used in this study with those from the Million Women Study (Allen et al, 2009) and the EPIC study (Ferrari et al, 2007; Tjonneland et al, 2007), as well as with those derived from various meta-analyses by WCRF (2007). The values for cohort studies are shown for cancers of the breast, colon, rectum and liver. For upper aero-digestive and oesophageal cancers, meta-analyses were based on case–control studies only.

For the most part, the risks associated with consumption of alcohol used in the present study are similar to those in the three comparative studies listed in Table 5. The ERRs reported in the Million Women Study (Allen et al, 2009) are rather higher than those in Table 1 for cancers of the oesophagus, liver and larynx, although the values used in the current analysis (Table 1) lie within the relevant 95% confidence intervals; for colon cancer, however, the value is considerably lower.

With respect to cancer of the oesophagus, some of the differences may relate to the differing proportions of squamous cell and adenocarcinomas in the series of cancers in various studies. Although squamous cell carcinomas are clearly related to alcohol exposure, the risk of adenocarcinoma is much lower, or nil (Lagergren et al, 2000; Wu et al, 2001; Lindblad et al, 2005; Pandey et al, 2009). Currently, adenocarcinomas comprise cancers in men and 3.3% in women due to alcohol consumption, or 4.0% cancers overall.
approximately 70% of oesophageal cancers in men in the UK, and 40% in women (see section 8, in Cancers attributable to overweight and obesity). However, the studies currently used to estimate the RR of oesophageal cancer in relation to alcohol do not distinguish between the histological subtypes, and no correction to the estimate for the UK has been made on this basis.

We chose to use the estimates of alcohol consumption in the UK based on population survey data (the National Diet and Nutrition Survey). However, it is well known that surveys produce figures far lower than would be expected from alcohol sales. Alcohol sales are estimated based on clearance data produced by HM Revenue and Customs (HMRC, 2008). The large difference between the two sets of data is unlikely to be due to large amounts of purchased alcohol not being consumed. Both the General Household Survey and the Government's alcohol strategy (HMRC, 2007) believe that many people underestimate the amount of alcohol they drink. However, as estimates of risk are generally based on responses to questionnaires, they are likely to overestimate the risk in relation to actual alcohol consumption. It is more appropriate, therefore, to use estimates of alcohol intake from (self-reported) survey data than the more accurate clearance data.

The current estimate (3.6% of new cancers in 2010 related to alcohol) is similar to the figure published by Doll and Peto (2003) – that around 6% of UK cancer deaths could be avoided if people did not drink. The estimation is based on the attribution to alcohol of 2/3 deaths from alcohol-related cancers (mouth, pharynx, larynx, oesophagus) in men and 1/3 in women, plus ‘a small proportion’ of liver cancer deaths. A recent publication, based on the risks of alcohol consumption observed in the EPIC study, estimates a rather higher fraction of cancers attributable to alcohol in the UK – especially in men: 8% of cancer in men and 3% in women (Schultze et al., 2011). The difference appears to be mainly because of the rather higher level and prevalence of alcohol consumption that were used to estimate attributable fractions (an average intake of 35.2 g per day in men and 17.6 g per day in women, cf. Table 2). These were calculated from data available on the World Health Organisation website, which appear to be derived from clearance data, with levels of consumption equivalent to those in Table 6 (on average, annually 13.4l of alcohol per capita in 2003–5). As noted above, it would seem more appropriate to use self-reported consumption, even though this is an underestimate of the true situation, as the RR appropriate, therefore, to use estimates of alcohol intake from (self-reported) survey data than the more accurate clearance data.

**Conflict of interest**

The author declares no conflict of interest.

### Table 5

| Cancer                 | Excess relative risk (ERR) | This study | MWS 2009* | WCRF/AICR 2007* | EPICc |
|------------------------|----------------------------|------------|-----------|-----------------|-------|
| Breast                 |                            |            | 0.0071    | 0.0114          |       |
| Colon                  |                            | 0.0081     | 0.0010    | 0.0086          |       |
| Rectum                 |                            | 0.0081     | 0.0096    | 0.0058          | 0.0070|
| Liver                  |                            | 0.0059     | 0.0217    | 0.0095          |       |
| Oesophagus             |                            | 0.0129     | 0.0201    | 0.0183          |       |
| Oral cavity and pharynx|                            | 0.0185     | 0.0258    | 0.0183          |       |
| Larynx                 |                            | 0.0136     | 0.0371    | 0.0138          |       |

*Million Women Study, Allen et al (2009). **WCRF (2007). †European Prospective Investigation into Cancer and Nutrition, Ferrari et al (2007). ††Tjønneland et al (2007).

*Based on meta-analysis of case-control studies only.

### Table 6

| Year | General Household Survey* | HM Revenue and Customsb |
|------|---------------------------|-------------------------|
|      | Units per week | Litres of pure alcohol per year | Units per week | Litres of pure alcohol per year |
| 1990 | 10.8          | 5.3                      | 19.2          | 10                       |
| 2000 | 12.0          | 6.2                      | 20.2          | 10.5                     |
| 2005 | 10.8          | 5.6                      | 21.9          | 11.4                     |

*General Household Survey (Goddard, 2006). †HM Revenue and Customs (HMRC, 2008).

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