

**'Optimal' levels of alcohol consumption  
for men and women at different ages,  
and the all-cause mortality attributable to drinking**

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# 1. Summary

## Background

Alcohol consumption increases the risk of a variety of diseases, but moderate consumption decreases the risk of ischaemic heart disease. The relationship between all-cause mortality and alcohol consumption is therefore U-shaped at older ages. We aimed to identify the level of alcohol consumption at which risk is least and the level of alcohol consumption at which risk becomes large. We also quantified the deaths and years of life lost that were attributable to alcohol consumption in England and Wales in 1997.

## Methods

Reviews of the international literature provided models relating the risk of 15 causes of death to alcohol consumption. Using data from England and Wales on drinking habits and on causes of death, we estimated the total risk of death for any level of alcohol consumption for men and women of different ages.

From our models we estimated the nadir, the level of alcohol consumption at which mortality is least. We also estimated the number of deaths and person-years of life lost attributable to or prevented by any drinking, drinking more than recommended limits, drinking more than the nadir, and drinking less than the nadir.

## Risk curves

The nadir was below 1 unit/week at ages 16-34 in men and at ages 16-54 in women. It increased with age, rising to 3 units/week in women aged over 65 and 8 units/week in men aged over 65.

The level at which the mortality risk was increased by 5% above the nadir increased from 8 units/week in women aged 16-24 to 20 units/week in women aged over 85, and from 5 units/week in men aged 16-24 to 34 units/week in men aged over 85.

## Attributable deaths

If ischaemic heart disease is ignored, 4216 deaths in women and 9246 deaths in men were attributable to drinking. Including the protective effect on ischaemic heart disease gave a balance of 166 deaths or 0.1% of all deaths in women attributed to alcohol consumption, and 2030 deaths or 0.8% of all deaths in men prevented. The ischaemic heart disease deaths tended to occur at older ages, so when we considered years of life lost to age 65, 5.6% of all years lost in women and 10.3% of all years lost in men were attributed to alcohol consumption.

The Royal Colleges recommend limits of 21 units/week in men and 14 units/week in women<sup>1</sup>, and we calculated the total impact of drinking above these limits. In women, 2346 deaths (0.8% of all deaths) and 4.0% of all years of life lost were attributable to drinking above these limits. In men the figures were 5491 deaths (2.1% of all deaths) and 8.5% of all years of life lost.

## Conclusions

Although the overall mortality risks and benefits of alcohol consumption appear roughly equal, there is a large loss of life due to drinking above recommended limits.

We interpret the nadir as an 'optimal' level of alcohol consumption: it is substantially lower than the recommended limits, especially in younger people. These findings should be combined with research on morbidity, disability and social consequences of alcohol consumption to inform public health policy.

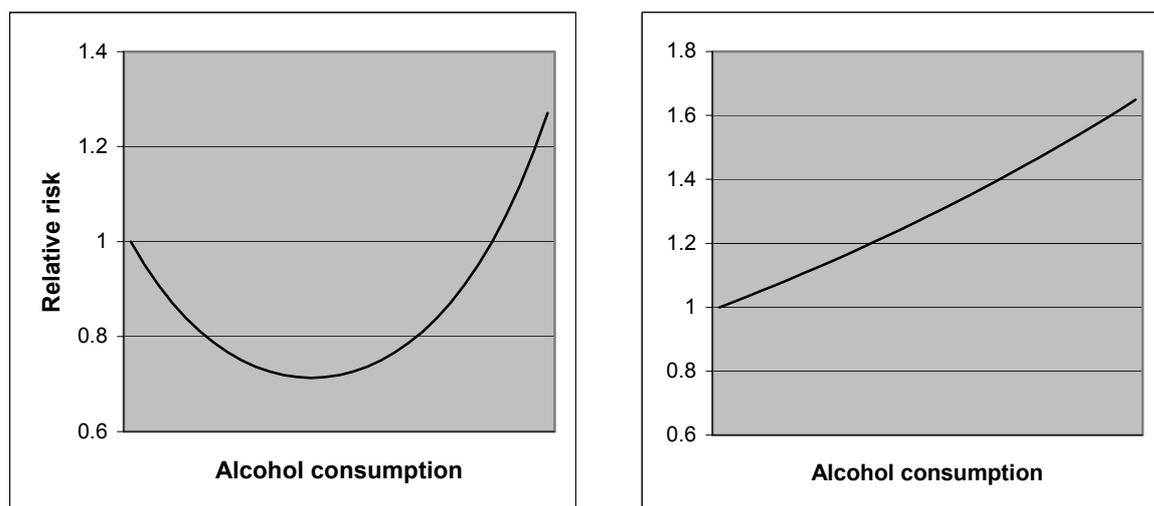
## 2. Introduction

Alcohol consumption is believed to have mixed effects on health:

- Risk of various cancers, hypertension, liver disease, and accidents and violence all increase with increasing alcohol consumption
- Risk of ischaemic heart disease is lower in moderate drinkers than non-drinkers

In people with substantial risk of dying from ischaemic heart disease (compared with these other causes), overall mortality is therefore lower among moderate drinkers than among non-drinkers – the so-called “U-shaped curve” (Figure 1, left). However, drinking patterns and disease incidence rates vary with age and sex. In young people, ischaemic heart disease is rare while accidents and violence are relatively common, so the left arm of the U may disappear altogether (Figure 1, right).

**Figure 1: examples of alcohol-mortality curves**



We estimated the average shape of the U-shaped curve for men and women of different ages.

### 3. Methods

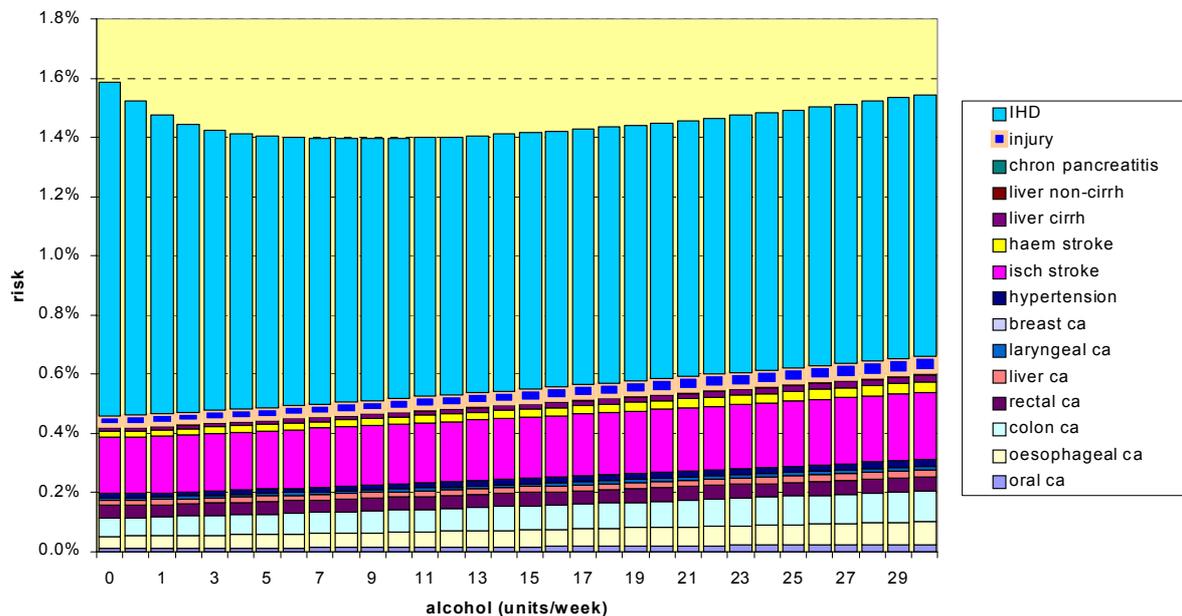
We worked out the overall risk of death by combining the risks of 15 causes of death that are associated with alcohol consumption. To do this we used three sources of data:

- **Relative risk functions.** An Italian group recently reviewed the international epidemiological literature and published relative risk functions<sup>2,3</sup>. These describe the risk of each cause of death as a function of alcohol consumption compared with non-drinkers. In most cases they were taken to be the same for men and women and for all ages. We adapted these relative risk functions to England and Wales.
- **Alcohol consumption by age and sex** was derived from the 1996/7 General Household Survey, in which participants reported number of units of alcohol consumed per week. We take 1 unit of alcohol to be 9 grams of alcohol, roughly half a pint of beer, a small glass of wine or a tot of spirits.
- **Deaths by age and sex** for the 15 causes of death were taken from the Office for National Statistics report for 1997.

We converted the relative risks to absolute risks and hence we worked out the overall risk of death.

For example, for men aged 65-74, the overall risk of death as a function of alcohol consumption was built up as shown in Figure 2. Each bar shows the absolute yearly risk of death divided into the 15 alcohol-related causes; for clarity, other causes of death are excluded from this figure. Apart from ischaemic heart disease, all the bars increase in size as alcohol consumption increases. The main risks, and the main contributors to the extra risk in heavier consumers, are ischaemic stroke and cancer of the colon and oesophagus. However the decreasing size of the ischaemic heart disease bar at lower levels of alcohol consumption gives an overall U-shaped curve.

**Figure 2: risk of death from alcohol-related causes for men aged 65-74.**



The overall alcohol-risk relationship enabled us to identify:

- The nadir – the level of alcohol consumption at which mortality is least.
- The number of deaths attributable to drinking.
- The number of deaths attributable to drinking more than recommended limits.
- Corresponding numbers of person-years of life lost.

Deaths attributable to drinking were calculated by comparing actual numbers of deaths with those predicted by applying the risk of non-drinkers to all drinkers. Deaths attributable to drinking more than recommended limits were calculated by similarly applying the risk of those drinking at the limit to all those drinking above this level. Some other causes of death which are directly attributable to alcohol consumption – for example, “Non-dependent abuse of alcohol” – were included in both these calculations.

All calculations apply to England and Wales in 1997.

## 4. Alcohol-mortality curves

Figure 3 shows the risk of death from all causes for women of different ages, relative to non-drinkers of the same age. Relative risks at all alcohol levels decline with age, and the positive relationship seen up to age 35-44 becomes increasingly U-shaped from age 55-64.

**Figure 3: Risk of death from all causes relative to non-drinkers – women**

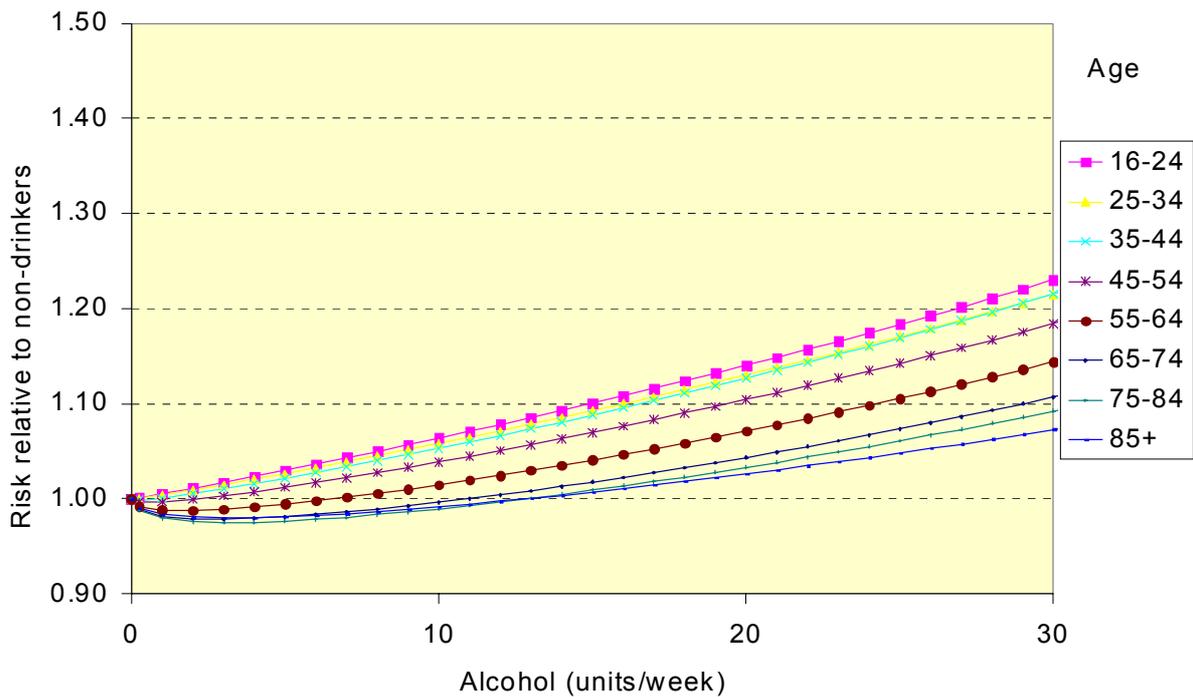
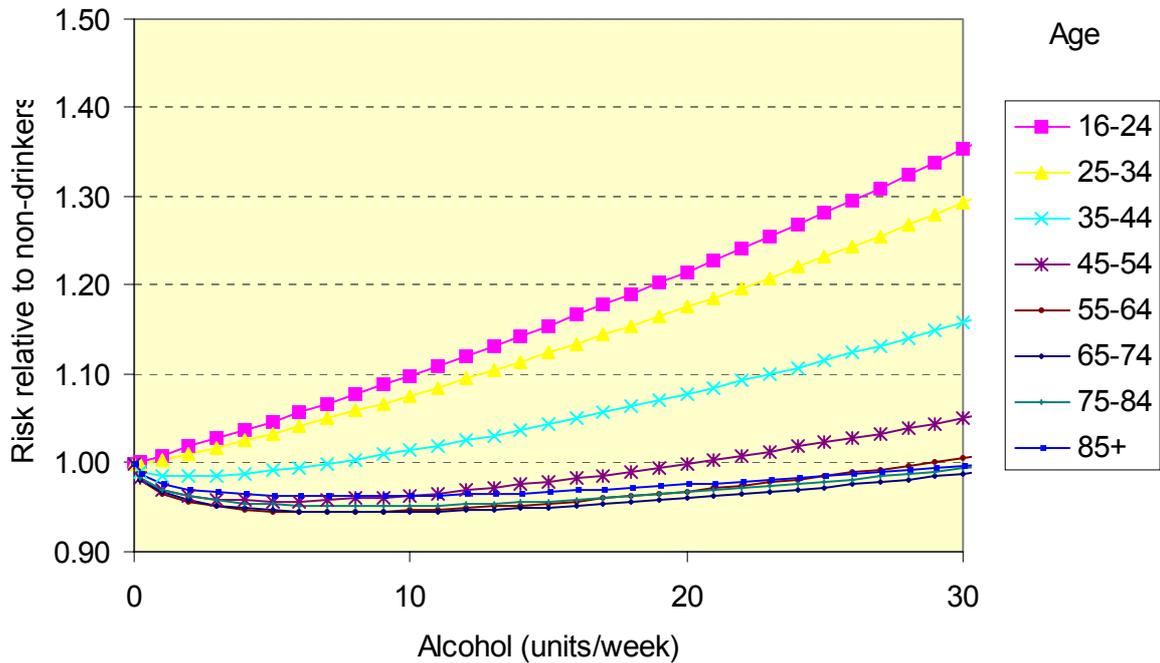


Figure 4 shows the corresponding results for men. For men at young ages, the curve is steeper than for women, but the U-shape appears at age 35-44, and the mortality reduction in the lightest drinkers is larger and is sustained up to higher levels of consumption than for women.

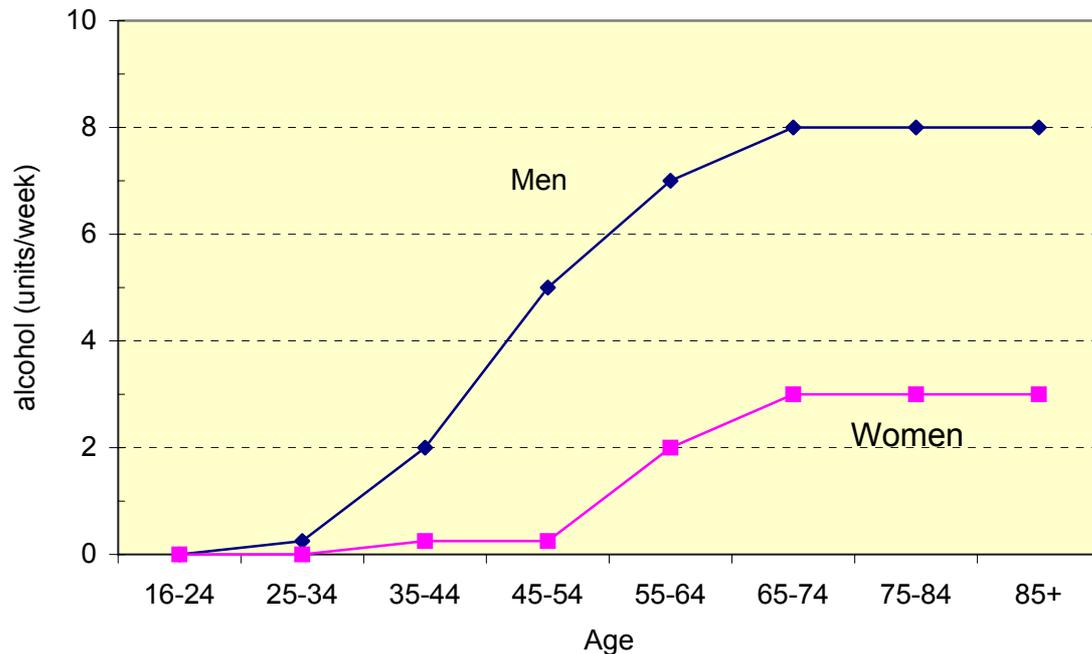
**Figure 4: Risk of death from all causes relative to non-drinkers – men**



### Estimated nadirs

The nadir for men and women of a given age is the level of alcohol consumption at which mortality is least: this can be derived directly from Figure 3 and Figure 4. The nadir rises from 0 units/week at ages 16-34 to around 8 units/week in men and around 3 units/week in women at ages over 65 (Figure 5).

**Figure 5: The nadir – the level of alcohol consumption at which risk is least**



The following points must be noted:

- Alcohol consumption is typically under-reported, so the nadirs are levels of *reported* alcohol consumption at which risk is least.
- The alcohol-risk curves are averages, and are likely to be different for certain individuals – for example, for those with a history of alcohol abuse.

Our results for the nadir are quite robust both in terms of sensitivity to major modelling assumptions and in terms of uncertainty about the relative risks. The main potential sources of error are

- We assume that the pattern of drinking in England and Wales is typical of the countries in which relative risks were estimated. If instead the pattern of drinking in and confers greater susceptibility to disease then the estimated nadirs are too high. Other work has suggested that nadirs in the UK may be higher than in the USA<sup>4</sup>, so our estimated nadirs may be too low.
- The way in which the risk function for ischaemic heart disease declines in very light drinkers is unknown. Using an alternative risk function with a steeper decline suggested a slightly lower nadir.
- It is unclear whether the risk function for ischaemic stroke increases or decreases at light to moderate levels of alcohol consumption<sup>5</sup>. We assumed it increases, but an alternative assumption of no increase yielded a slightly higher nadir at older ages.

The importance of the nadir is that it may be possible for individuals to decrease their mortality risk by moving their level of alcohol consumption towards the nadir. This assumes that the effects of alcohol consumption act over relatively short periods (no more than 5-10 years). If instead alcohol consumption in middle age affects

ischaemic heart disease risk in old age then the optimum level of consumption would be higher in middle age than we have estimated and lower in old age than we have estimated. On the other hand, if alcohol consumption in middle age affects cancer risk in later life, then the reverse is true.

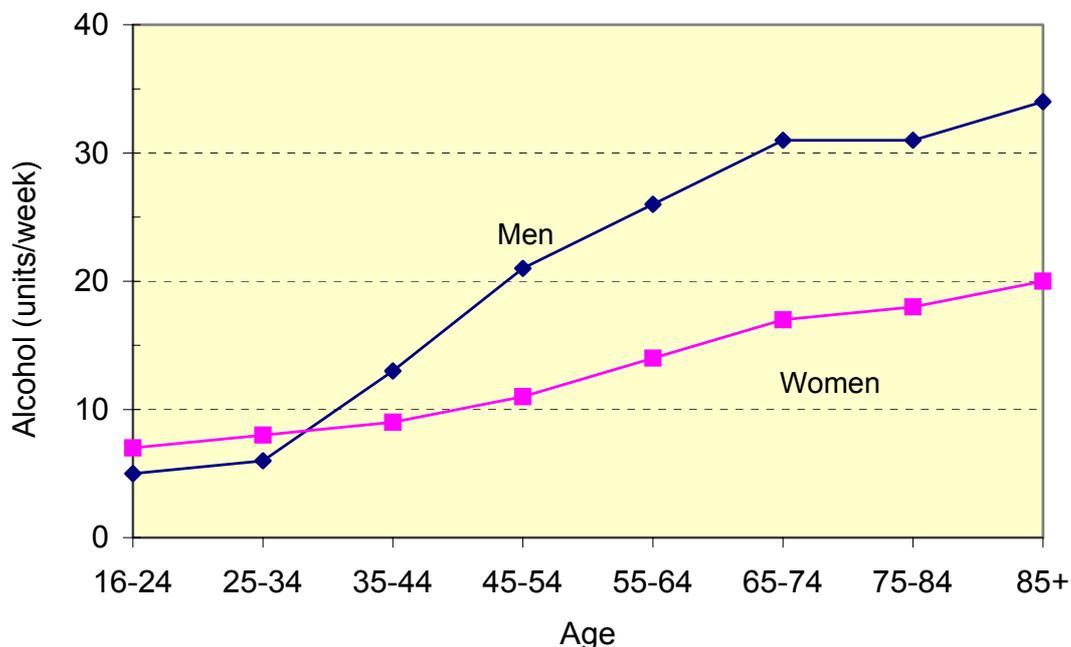
When the nadir is above zero, there is also the potential for avoiding deaths if people drinking below the nadir increased their drinking to the nadir. In this scenario ischaemic heart disease deaths would decrease substantially and deaths from other causes would increase slightly. However, many people drinking below the nadir have personal, religious or other health-related reasons for doing so.

### 5% bounds

We investigated the levels of alcohol consumption at which risk is 5% more than risk at the nadir. This may correspond to an acceptable increase in risk for an individual, although a 5% increase in risk for everyone in England and Wales would imply 27000 extra deaths each year.

Figure 6 shows these 5% bounds. For women the 5% bound is 8 units/week at ages 16-24 and increases to around 20 units/week at ages over 85. For men the 5% bound is only 5 units/week at ages 16-24 (reflecting the steeper slope of the risk curve in young men than in young women) and increases to 30-35 units/week at ages over 65.

**Figure 6: The level of alcohol consumption at which risk is increased by 5% over the nadir.**

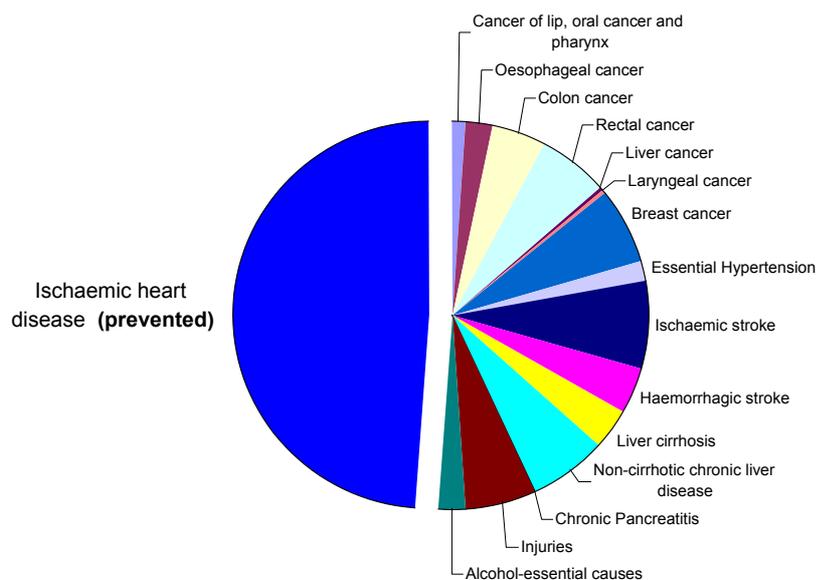


## 5. Deaths attributable to alcohol consumption

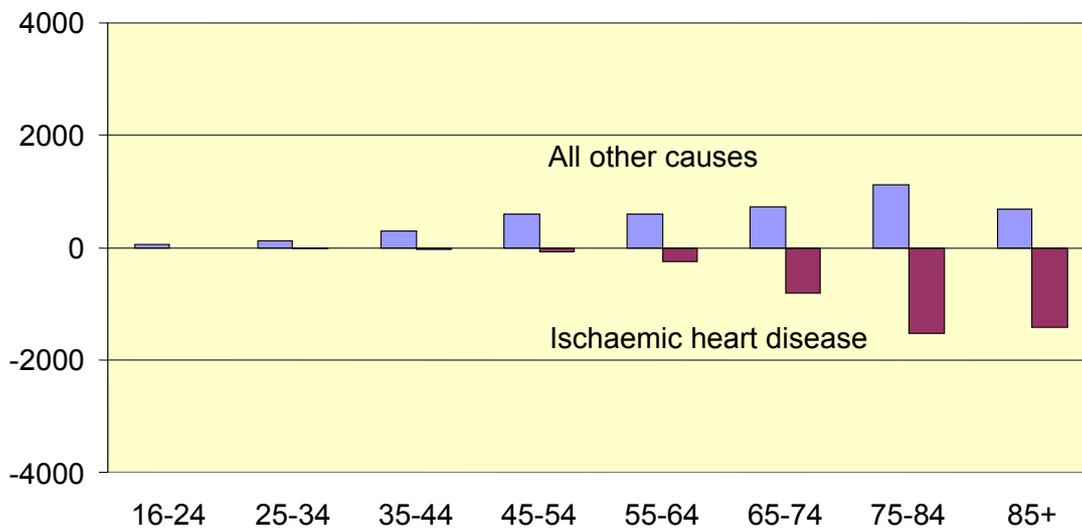
We estimated the number of deaths that would be avoided if all drinkers became non-drinkers – or more precisely, if their risk became equal to the risk of non-drinkers.

Figure 7 shows the causes of death for the 4216 deaths in women attributed to drinking and 4050 ischaemic heart disease deaths prevented by drinking. All ages are combined and there is a rough balance between deaths attributed and prevented. However this conceals large differences by age (Figure 8). At younger ages, deaths attributable to causes other than ischaemic heart disease far exceed ischaemic heart disease deaths prevented. The prevented deaths do not outnumber the attributed deaths until age 65-74.

**Figure 7: Deaths attributable to alcohol consumption for women, by cause.**

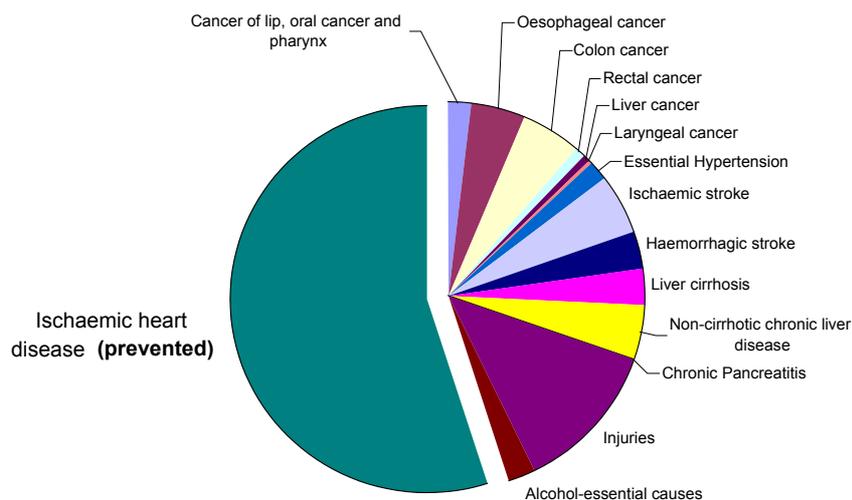


**Figure 8: Deaths attributable to alcohol consumption for women, by age.**

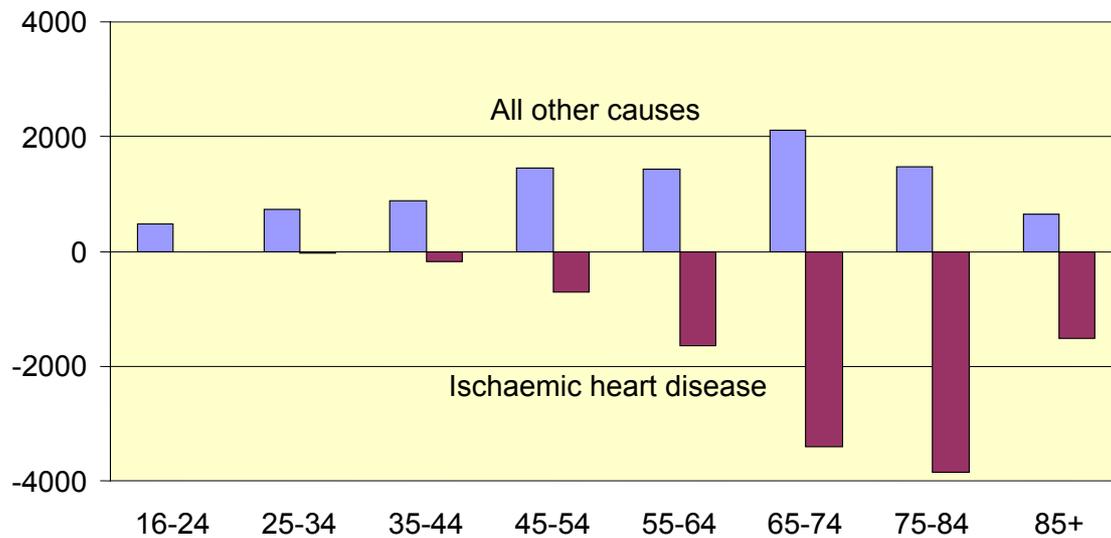


For men the pattern is similar, but ischaemic heart disease is a commoner cause of death and the 9246 deaths attributed to drinking are outweighed by the 11276 ischaemic heart disease deaths prevented (Figure 9). As for women, the balance is unfavourable at younger ages but it becomes favourable at age 55-64 (Figure 10).

**Figure 9: Deaths attributable to alcohol consumption for men, by cause.**



**Figure 10: Deaths attributable to alcohol consumption for men, by age.**

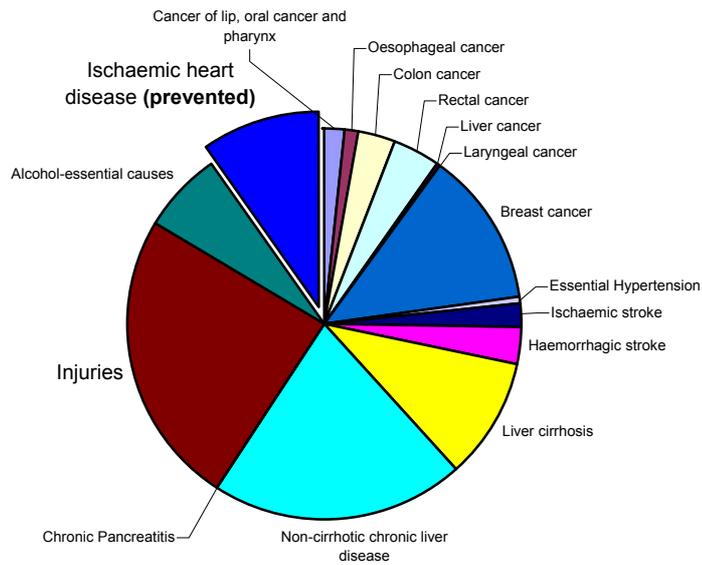


The contribution of injuries is very large at younger ages, especially for men, reaching 97% of all alcohol-attributable deaths in men aged 16-24.

### **Years of life lost attributable to alcohol consumption**

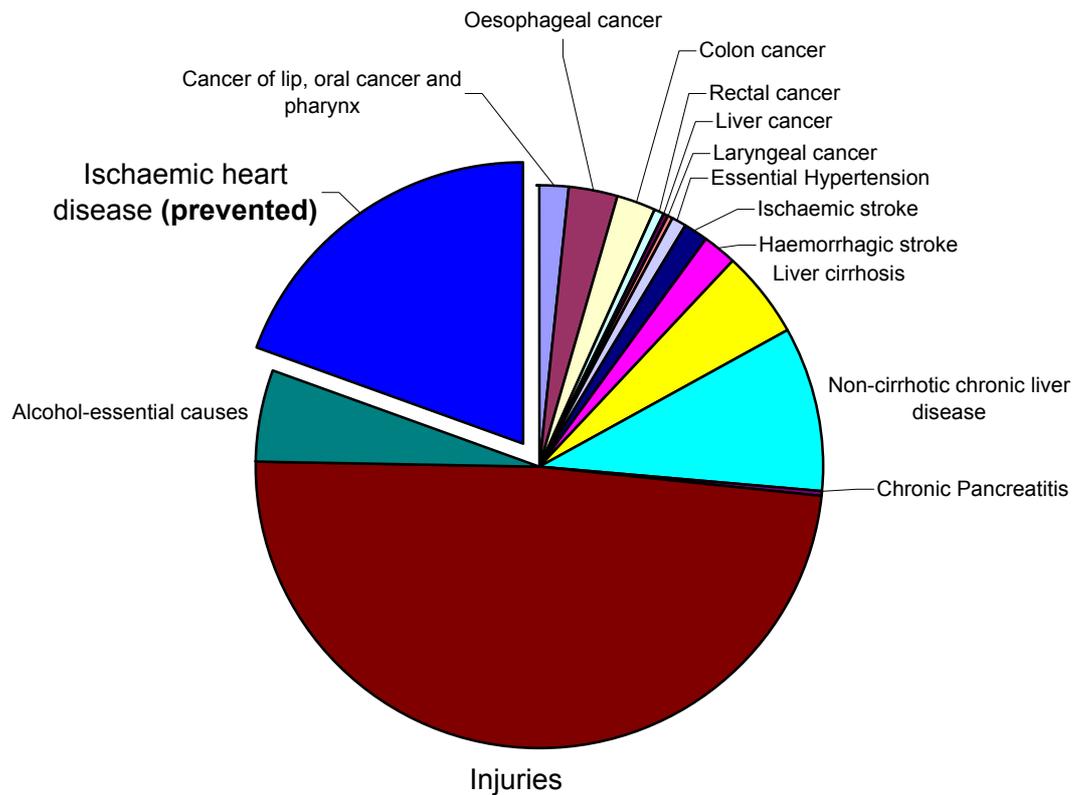
To allow for the greater impact of deaths at younger ages, we calculated the total years of life lost to age 65 that are attributable to alcohol consumption. As Figure 11 shows, ischaemic heart disease has much less impact in this analysis, while injuries and liver disease have much greater impact. Overall, we estimate that 5.6% of all years of life lost in women are attributable to alcohol consumption.

**Figure 11: Person-years of life lost to age 65 attributable to alcohol consumption for women, by cause.**



Injuries in men are even more important (Figure 12), because they occur predominantly at younger ages. Overall, 10.3% of all years of life lost in men are attributable to alcohol consumption.

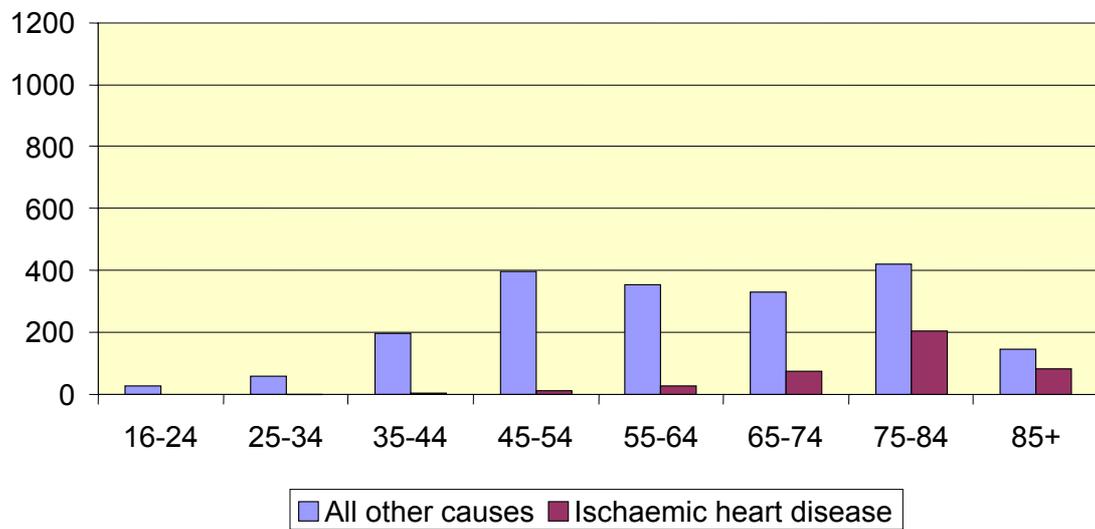
**Figure 12: Person-years of life lost to age 65 attributable to alcohol consumption for men, by cause.**



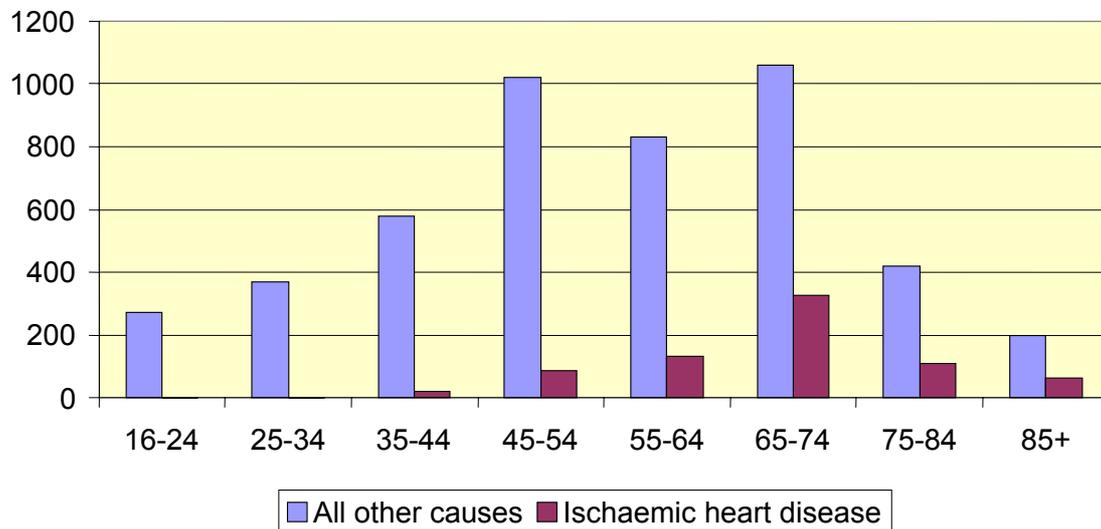
### Deaths attributable to drinking above recommended levels

The Royal Colleges recommend that women drink no more than 14 units/week and men drink no more than 21 units/week. We estimated the number of deaths that would be avoided if everyone drinking above these limits reduced their drinking to these limits. Figure 13 and Figure 14 show that a few ischaemic heart disease deaths are now *attributed* to alcohol, reflecting the increase in ischaemic heart disease risk at heavier levels of drinking. In total, 2346 deaths in women (0.8% of all deaths in women) and 5491 deaths in men (2.1% of all deaths in men) are attributed to drinking above these levels. Corresponding results for years of life lost are 4.0% of all years of life lost in women and 8.5% of all years of life lost in men.

**Figure 13: Deaths attributable to women drinking more than 14 units/week**



**Figure 14: Deaths attributable to men drinking more than 21 units/week**



## Summary

Table 1 summarises these results and expresses them as a percentage of all deaths. The table gives corresponding results for the Government guidelines for sensible drinking, 3 units/day for women and 4 units/day for men (which we took as 21 and 28 units/week)<sup>6</sup>. It also presents the results if sensible drinking is defined as drinking at the nadir for each age-sex group.

Deaths attributable to exceeding the Government's guidelines are slightly lower than for exceeding the Royal Colleges' guidelines, while the total deaths attributable to drinking more than the nadir are higher.

For the older age groups with a U-shaped curve, it may be possible to avoid deaths if people drinking below the nadir increased their drinking to the nadir. These "deaths attributable to drinking below the nadir" should be regarded as upper limits on the potential health benefits. They are nevertheless markedly fewer than those attributable to drinking more than the nadir.

**Table 1: Annual deaths attributable to drinking**

	All causes except ischaemic heart disease		Ischaemic heart disease		Balance	
	Number	% of all female deaths	Number	% of all female deaths	Number	% of all female deaths
<b>Women</b>						
Drinking any alcohol	4216	1.5%	-4050	-1.4%	166	0.1%
Drinking > 14 units/week	1938	0.7%	408	0.1%	2346	0.8%
Drinking > 21 units/week	1651	0.6%	314	0.1%	1965	0.7%
Drinking more than nadir	3460	1.2%	137	0.0%	3597	1.2%
Drinking less than nadir	-1165	-0.4%	3673	1.3%	2508	0.9%
<b>Men</b>						
	Number	% of all male deaths	Number	% of all male deaths	Number	% of all male deaths
Drinking any alcohol	9246	3.5%	-11276	-4.3%	-2030	-0.8%
Drinking > 14 units/week	4752	1.8%	739	0.3%	5491	2.1%
Drinking > 21 units/week	4017	1.5%	620	0.2%	4637	1.8%
Drinking more than nadir	7397	2.8%	-19	0.0%	7378	2.8%
Drinking less than nadir	-1448	-0.6%	4787	1.8%	3339	1.3%

## 6. Public health implications

Our estimates of the nadir and the 5% bounds have implications for formulating sensible drinking messages.

'Optimal' drinking can bring a reduction in overall mortality of up to 6% relative to not drinking (in men aged 55-74). On the other hand, drinking at the Royal Colleges' recommended limit can carry a large increase in risk in younger people. At age 16-24, women have a 9% increase in risk and men have a 23% increase; at the Government's recommended limit these figures become 15% and 32%. Thus

- the sensible drinking message of the Royal Colleges allows some fairly substantial increases in risk;
- increases in risk are larger with the Government's sensible drinking message;
- these increases in risk are especially large at younger ages in both men and women.

An evidence-based definition of sensible drinking could be drinking behaviour that is associated with a mortality risk within 5% of the minimum risk for women or men of a particular age. This view agrees closely with current sensible drinking messages for older adults but not for younger adults. In this view, public health policy should aim to encourage

- women to drink no more than 1 unit/day up to age 44, no more than 2 units/day up to age 74, and no more than 3 units/day over age 75.
- men to drink no more than 1 unit/day up to age 34, no more than 2 units/day up to age 44, no more than 3 units/day up to age 54, no more than 4 units/day up to age 84, and no more than 5 units/day over age 85.

The benefits of having different advice for younger people must of course be balanced against the disadvantages of increased complexity of the message. The current increase in heavy drinking among younger women may well justify a specific message aimed at younger women.

Non-drinking men aged 55-84 also have risk slightly more than 5% above the minimum risk. We do not advocate encouraging these men to drink as this could encourage heavier drinking, which carries a much greater overall public health burden.

However, some caveats apply to these results. First, they should not be taken to apply to everyone: some individuals may have different alcohol-risk curves. Secondly, public health must take account of morbidity as well as mortality, even though the former is harder to measure. Rehm has observed that "alcohol world-wide accounted for ... 1.5% of all deaths, 2.1% of all life-years lost, and 6% of all years lost to disability" so that a greater focus on disability is required.<sup>7</sup>

## 7. References

- <sup>1</sup> Royal Colleges of Physicians, Psychiatrists and General Practitioners. Alcohol and the heart in perspective: sensible limits reaffirmed. London: Royal Colleges (1995).
- <sup>2</sup> Corrao, G., Bagnardi, V., Zambon, A. and Arico, S. Exploring the dose-response relationship between alcohol consumption and the risk of several alcohol-related conditions: a meta-analysis. *Addiction* 1999;94:1551-1573.
- <sup>3</sup> Corrao, G., Rubbiata, L., Bagnardi, V., Zambon, A. and Poikolainen, K. Alcohol and coronary heart disease: a meta-analysis. *Addiction* 2000;95:1505-1523.
- <sup>4</sup> White IR. The level of alcohol consumption at which all-cause mortality is least. *Journal of Clinical Epidemiology* 1999;52:967-975.
- <sup>5</sup> Grobbee, DE, Rimm EB, Keil U, Renaud S. Alcohol and the cardiovascular system. Health issues related to alcohol consumption, ed. MacDonald I, pp. 126-179. Oxford: Blackwell Science, second edition (1999).
- <sup>6</sup> Inter-Departmental Working Group. Sensible Drinking. London: Department of Health (1995).
- <sup>7</sup> Rehm J. Alcohol consumption and mortality. What do we know and where should we go? *Addiction* 2000;95:989-995.