Different measures of alcohol consumption and risk of coronary heart disease and all-cause mortality: 11-year follow-up of the Whitehall II Cohort Study

Annie Britton & Michael Marmot

Department of Epidemiology and Public Health, University College London, UK

Correspondence to:
Annie Britton
International Centre for Health and Society
Department of Epidemiology and Public Health
University College London
1–19 Torrington Place
London WC1E 6BT
UK
Tel: +44 20 7679 5626
Fax: +44 20 7813 0242
E-mail: a.britton@public-health.ucl.ac.uk

Submitted 29 January 2003;
initial review completed 19 May 2003;
final version accepted 23 June 2003

ABSTRACT

Aims To investigate the relationship between three measures of alcohol consumption obtained simultaneously in a large cohort and the validated risk of coronary heart disease and all-cause mortality during follow-up.

Design Prospective cohort study with median follow-up of 11 years.

Setting The Whitehall II Cohort Study: London-based civil service.

Participants A total of 10 308 (33% female) civil servants aged 35–55 years at baseline (1985–88).

Measurements Self-reported volume of alcohol consumed during past week, frequency of drinking over past year, usual amount consumed per drinking session.

Main outcome measures Coronary heart disease and all-cause mortality until 1999.

Findings A *U*-shaped relationship was found between volume of alcohol consumed per week and outcome. Compared to those who drank moderately (10–80 g alcohol per week), non-drinkers and those drinking more than 248 g per week had approximately a twofold increased risk of mortality. The optimal frequency of drinking was between once or twice a week and daily, after adjustment for average volume consumed per week. Those drinking twice a day or more had an increased risk of mortality (male hazard ratio 2.44 95% CI 1.31–4.52) compared to those drinking once or twice a week. Drinking only once a month or only on special occasions had a 50% increased risk of mortality. The usual amount consumed per drinking session was not indicative of increased health risk in this cohort.

Conclusions Epidemiological studies should collect information on frequency of drinking in addition to average volume consumed in order to inform sensible drinking advice.

KEYWORDS Alcohol, drinking patterns, coronary heart disease, mortality, prospective cohort study.

INTRODUCTION

The relationship between volume of alcohol consumed and risk of coronary heart disease (CHD) has been reported extensively and summarized in several statistical meta-analyses (English *et al.* 1995; Corrao *et al.* 2000). There is a general consensus that light-to-moderate drinkers have a lower risk of heart disease than both abstainers and heavier drinkers, after adjustment for other established risk factors. The risk reduction may be as much as 25% when consuming an average of 20–30 g per day compared to non-drinkers (Corrao *et al.* 2000), although the optimal level is likely to vary by individuals and across populations (White 1999; Britton & McPherson 2001; White *et al.* 2002).

The apparent cardio-protective effect of moderate drinking is consistently shown in epidemiological studies and supported by plausible biological mechanisms (Marmot 2001). However, it is becoming increasingly clear that the frequency of drinking in addition to the average volume consumed is particularly important, not only for all-cause mortality (Rehm *et al.* 2001; Mukamal *et al.* 2003), but also for coronary heart disease. Epidemiological studies that measure frequency of drinking and subsequent cardiovascular events are rare, but those that do have revealed that drinking in 'binges' may *increase* the risk of heart disease, particularly sudden cardiac death (Britton & McKee 2000; Murray *et al.* 2002). This is supported by physiological evidence which suggests that possible mechanisms include adverse changes in low-density lipoproteins, increased risk of thrombosis, histological changes to the myocardium and a reduction in the threshold for ventricular fibrillation (McKee & Britton 1998).

In this paper we explore three different alcohol assessments asked simultaneously of a healthy working population in a self-completion questionnaire: volume consumed in the past week, frequency of drinking over the past year and usual amount consumed per drinking session. The measures were taken at baseline in a longitudinal cohort study of office-based civil servants, followed from 1985 to 1999. The health outcomes considered were fatal and non-fatal coronary heart disease and all-cause mortality. Sequential adjustments were made in the analyses for conventional risk factors measured at baseline and the possible confounding effects of social class (Knupfer 1989; Marmot 1997).

METHODS

The Whitehall II study was established in 1985 as a longitudinal study to examine the socio-economic gradient in health and disease among 10 308 civil servants (6895 men and 3413 women). Full details of the cohort and its follow-up have been published elsewhere (Marmot *et al.* 1991). All civil servants aged 35–55 years in 20 London-based departments were invited to participate by letter. In total, 73% of those invited agreed to take part in phase 1. Baseline examination (phase 1) took place during 1985–88, and involved a clinical examination and a self-administered questionnaire containing sections on demographic characteristics, health and life-style factors. Participants were approached again in 1989–90 (phase 2: postal questionnaire, $n = 8133$), in 1991–93 (phase 3: postal questionnaire and screening examination, $n = 8637$), in 1995–96 (phase 4: postal questionnaire, $n = 8629$) and 1997–99 (phase 5: postal questionnaire and screening examination, $n = 7830$). The length of follow-up was a median of 11.2 years (range 9.1–13.8 years). University College London ethics committee approved the study.

Alcohol consumption

At baseline subjects were asked to report the frequency of their drinking over the last 12 months by circling one of six specified options (twice a day or more/almost daily/once or twice a week/once or twice a month/special occasions only/none). Participants were then asked to report the number of drinks they had consumed in the last 7 days. This was divided into 'measures' of spirits, 'glasses' of wine and 'pints' of beer and then converted to units per week, where a unit is 8 g of alcohol. Finally they were asked about their usual consumption of beer or spirits/wine in one drinking session.

Baseline risk factors

Participants completed a baseline questionnaire detailing job title, behavioural factors and general health questions. Based on salary and work role, the civil service defines a hierarchy of employment grades which we analysed in three levels: unified grades 1–7 (high), executive officers (medium) and clerical and support staff (low), as described previously (Marmot *et al.* 2001). Participants were asked to report whether they currently smoked (cigarettes, hand-rolled tobacco or cigars), the number smoked per day or when they gave up. The 30-item standard General Health Questionnaire (GHQ) was used (Goldberg 1972). At the baseline physical examination, blood pressure was measured twice in the sitting position after 5 minutes rest with the Hawksley random-zero sphygmomanometer. Body mass index (BMI) was calculated as weight/height^2. Total cholesterol was also measured.

Coronary heart disease and mortality

A total of 10 300 (99.9%) participants were flagged at the National Health Service Central Registry, who notified us of the date and cause of death up to the end of 1999. Participants were defined as having a coronary death if the underlying cause had an ICD-9 code 410–414 (World Health Organization 1977). Potential non-fatal myocardial infarction (MI) and angina events were ascertained by questionnaire items on: chest pain (the World Health Organization Rose questionnaire; Rose *et al.* 1982), recall of a doctor's diagnosis, investigation (exercise electrocardiography, stress imaging or angiography) and treatment (nitrates or revascularisation). Details of physician diagnoses were sought from clinical records to validate the events. Clinical records were also

sought where the Civil Service gave a reason of sickness absence as angina or MI or when the spell of absence exceeded 21 days in duration. Twelve-lead resting electrocardiograms were performed at study phases 1 (1985–8), 3 (1991–3) and 5 (1997–99) and classified according to the Minnesota code. Classification of MI and angina was carried out independently by two trained coders, with adjudication by a third in the (rare) event of disagreement.

Statistical analysis

Analyses were carried out separately for men and women in recognition of a likely effect modification by gender (Gill 1997; Graham *et al.* 1998). Cox proportional hazards regression analyses on time to first event were performed and confidence limits were set at the 95% level.

RESULTS

Three per cent of men and 6% of women reported that they had not consumed alcohol in the last year (Table 1). This proportion was higher among low employment-grade workers (8.3% and 9.5% low grade men and women, respectively). The most common consumption level reported by men was an average of between 1 and 10 units (8–80 g alcohol) in the last week (46%) while most women consumed 1–6 (8–48 g) per week (42%). More women in high-grade jobs (13.4%) reported consumption of 21 + units per week (168 + grams) compared to women in low-grade jobs (1.9%). The most common response to the drinking frequency question was 'once or twice per week', except high-grade women who were most likely to report daily consumption. Low-grade workers were more likely than high-grade workers to report a usual consumption of more than five drinks in one drinking session, but the most common response was one or two drinks across all grades.

Units consumed in the past 7 days

There was a *U*-shaped relationship between volume of alcohol consumed at baseline and mortality during follow-up (Table 2). Those who did not drink alcohol or who consumed more than 31 units per week had approximately a twofold risk compared to those who drank 1–10 units per week (hazard ratio for non-drinking men and men consuming 31 + units 2.24 95% CI 1.32–3.81 and 1.73 95% CI 1.14–2.63, respectively). Similar findings were found among women, although they did not reach statistical significance. Adjustment for conventional risk factors slightly attenuated the findings. Excluding those participants with baseline coronary heart disease did not alter these results (data not shown).

Non-drinkers had an 80% increased risk of coronary heart disease compared to those drinking light amounts. Women drinking more than 20 units per week also had an increased risk of CHD (hazard ratio 1.57 95% CI 1.01–2.45), whereas men drinking more than 30 units per week were not at increased CHD risk (hazard ratio 0.94 95% 0.72–1.23).

Frequency of consumption

The optimal drinking frequency was once or twice a week up to almost daily (Table 3). Compared to consumption of alcohol once or twice per week, those consuming less frequently were at higher risk of mortality and CHD, even after adjustment for conventional risk factors and total volume consumed per week. Drinking twice a day was associated with a more than twofold increased risk of mortality or CHD (male mortality hazard ratio 2.44 95% CI 1.31–4.52). Some of the findings for women are based on small numbers of events and did not reach statistical significance.

Usual amount consumed per session

There was a suggestion that drinking more than five glasses of wine/spirits or five pints of beer in a usual drinking session increased the risk of mortality and coronary heart disease, but the relationships were not consistent and did not reach statistical significance (Table 4).

Similar findings were found in all the analyses if they were restricted to fatal/non-fatal myocardial infarction rather than all CHD (data not shown).

Summary

The volume consumed over 7 days and the frequency of drinking over the past year, reported at baseline, had a *U*-shaped relationship with mortality. The optimal number of units consumed per week was between 1 and 10 (8–80 g alcohol) and the optimal frequency of drinking was once or twice per week or daily. The third measure in this study, the usual amount consumed per drinking session, was not indicative of increased health risk.

DISCUSSION

Most epidemiological studies of alcohol consumption and mortality discuss average amounts consumed per unit of time and have repeatedly shown a *U*-shaped curve. The data from the Whitehall II cohort study are compatible with these findings. However, it is becoming increasingly

Table 1 Volume of alcohol consumed in past week, frequency of drinking in past year, usual amount per drinking occasion measured at baseline by employment grade (column percentage).

	Employment grade			
	High	*Medium*	*Low*	*Total*
Volume per week				
Men	*n* = 2625	*n* = 3578	*n* = 637	*n* = 6840
Never drink	1.9	3.3	8.3	3.2
None in past week	5.7	10.9	20.9	9.8
1–10 units	46.9	45.3	42.1	45.6
11–20 units	15.2	11.7	7.1	12.6
21–30 units	20.8	18.6	13.0	18.9
31 + units	9.4	10.3	8.6	9.8
Women	*n* = 380	*n* = 1323	*n* = 1671	*n* = 3374
Never drink	2.1	3.7	9.5	6.4
None in past week	6.8	17.8	30.2	22.7
1–6 units	31.6	44.1	43.3	42.3
7–10 units	20.3	14.0	9.6	12.5
11–20 units	25.8	14.7	5.5	11.4
21 + units	13.4	5.7	1.9	4.7
Frequency in past year				
Men	*n* = 2638	*n* = 3602	*n* = 635	*n* = 6875
Never	1.9	3.2	8.3	3.2
Special occasions only	4.4	9.4	23.1	8.8
Once or twice a month	9.1	13.6	11.7	11.7
Once or twice a week	42.9	43.2	37.0	42.5
Almost daily	36.5	26.5	17.2	29.5
Twice a day or more	5.2	4.0	2.7	4.3
Women	*n* = 380	*n* = 1332	*n* = 1691	*n* = 3403
Never	2.1	3.7	9.5	6.4
Special occasions only	6.1	18.2	35.8	25.6
Once or twice a month	7.4	14.8	14.8	14.0
Once or twice a week	34.7	38.0	31.3	34.3
Almost daily	44.5	23.6	8.1	18.2
Twice a day or more	5.3	1.7	0.6	1.6
Usual amount per occasion				
Men	*n* = 2635	*n* = 3571	*n* = 625	*n* = 6831
Beer 1–2 pints	73.2	63.8	55.7	66.7
3–4 pints	10.2	20.2	21.9	16.5
5 or more	0.3	1.8	4.5	1.5
Do not drink beer	16.1	14.2	17.9	15.3
Spirits/wine 1–2 units	53.9	50.0	45.4	51.1
3–4 units	38.4	36.7	25.9	36.4
5 or more units	4.3	5.2	6.2	4.9
Don't drink spirits/wine	3.4	8.1	22.4	7.6
Women	*n* = 378	*n* = 1315	*n* = 1617	*n* = 3310
Beer 1–2 pints	38.1	27.7	17.4	23.9
3–4 pints	1.1	0.7	1.1	0.9
5 or more	0.3	0.0	0.1	0.1
Don't drink beer	60.6	71.6	81.4	75.1
Spirits/wine 1–2 units	60.6	62.2	48.5	55.3
3–4 units	33.6	29.8	30.3	30.4
5 or more units	1.6	2.7	6.1	4.3
Do not drink spirits/wine	4.2	5.2	15.2	10.0

Totals are different due to missing responses. 1 unit = 8 g alcohol; 1 pint = 16 g alcohol.

Table 2 Volume of alcohol consumption and risk of all-cause mortality and CHD (hazard ratios and 95% confidence intervals).

No. of events mortality/CHD	*All-cause mortality age-adjusted*	*All-cause mortality fully adjusted**	*CHD age-adjusted*	*CHD fully adjusted**
Men				
Never drink (16/43)	2.24 (1.32–3.81)	2.09 (1.22–3.59)	1.84 (1.34–2.52)	1.82 (1.32–2.52)
None in past week (35/77)	1.78 (1.20–2.62)	1.48 (0.98–2.23)	1.12 (0.87–1.43)	1.01 (0.78–1.32)
1–10 units (94/338)	1	1	1	1
11–20 units (24/94)	0.99 (0.63–1.55)	0.86 (0.53–1.40)	1.04 (0.82–1.30)	0.99 (0.78–1.25)
21–30 units (42/148)	1.20 (0.84–1.73)	1.08 (0.74–1.58)	1.13 (0.93–1.37)	0.99 (0.81–1.21)
31 + (29/75)	1.73 (1.14–2.63)	1.40 (0.90–2.18)	1.16 (0.91–1.49)	0.94 (0.72–1.23)
Women				
Never drink (9/43)	1.42 (0.69–2.91)	1.17 (0.52–2.63)	1.77 (1.27–2.48)	1.77 (1.23–2.50)
None in past week (34/104)	1.43 (0.91–2.25)	1.28 (0.80–2.03)	1.14 (0.90–1.46)	1.06 (0.82–1.37)
1–6 units (42/173)	1	1	1	1
7–10 units (11/52)	0.96 (0.49–1.86)	0.88 (0.44–1.77)	1.07 (0.78–1.46)	1.14 (0.83–1.57)
11–20 units (11/38)	1.07 (0.55–2.07)	1.01 (0.51–2.00)	0.86 (0.60–1.22)	0.96 (0.67–1.38)
21 + units (4/24)	1.08 (0.36–2.84)	0.90 (0.32–2.58)	1.47 (0.96–2.26)	1.57 (1.01–2.45)

1 unit = 8 g alcohol. *Age, smoking (no/ex/light/moderate/heavy), employment grade (high/medium/low), blood cholesterol, blood pressure, body mass index, general health questionnaire score.

Table 3 Frequency of alcohol consumption and risk of all-cause mortality and coronary heart disease (hazard ratios and 95% confidence intervals).

	Age-adjusted	*Fully adjusted**	*Fully adjusted + adjusted for units consumed in last week*
All-cause mortality			
Men (no. of events)			
Never drink (16)	2.26 (1.32–3.87)	2.20 (1.27–3.82)	2.22 (1.27–3.89)
Special occasions (33)	1.80 (1.20–2.70)	1.43 (0.92–2.24)	1.44 (0.92–2.27)
1–2 times/month (37)	1.57 (1.06–2.31)	1.48 (0.99–2.24)	1.46 (0.96–2.22)
1–2 times/week (82)	1	1	1
Almost daily (52)	0.92 (0.65–1.30)	0.93 (0.65–1.32)	0.91 (0.62–1.34)
Twice a day or more (22)	2.83 (1.77–4.54)	2.49 (1.52–4.07)	2.44 (1.31–4.52)
Women (no. of events)			
Never drink (9)	1.82 (0.85–3.88)	1.51 (0.65–3.53)	1.40 (0.59–3.35)
Special occasions (40)	1.89 (1.15–3.10)	1.72 (1.04–2.86)	1.62 (0.95–2.78)
1–2 times/month (14)	1.31 (0.68–2.51)	1.26 (0.66–2.42)	1.28 (0.66–2.49)
1–2 times/week (26)	1	1	1
Almost daily (18)	1.39 (0.76–2.54)	1.39 (0.75–2.60)	1.70 (0.86–3.36)
Twice a day or more (5)	4.50 (1.73–11.72)	4.77 (1.79–12.72)	7.01 (2.29–21.45)
CHD			
Men (no. of events)			
Never drink (43)	1.21 (0.94–1.55)	1.82 (1.32–2.53)	1.77 (1.27–2.47)
Special occasions (76)	1.08 (0.86–1.37)	1.05 (0.80–1.37)	1.02 (0.78–1.34)
1–2 times/month (93)	1.03 (0.87–1.23)	1.03 (0.81–1.31)	1.00 (0.78–1.23)
1–2 times/week (306)	1	1	1
Almost daily (219)	1.03 (0.87–1.23)	0.94 (0.78–1.12)	0.97 (0.80–1.12)
Twice a day or more (41)	1.39 (1.00–1.92)	1.10 (0.78–1.54)	1.23 (0.83–1.83)
Women (no. of events)			
Never drink (43)	1.80 (1.28–2.53)	1.82 (1.26–2.57)	1.98 (1.37–2.85)
Special occasions (127)	1.26 (0.99–1.60)	1.15 (0.89–1.49)	1.25 (0.95–1.63)
1–2 times/month (61)	1.10 (0.81–1.48)	1.01 (0.78–1.44)	1.15 (0.84–1.57)
1–2 times/week (137)	1	1	1
Almost daily (59)	0.84 (0.62–1.13)	0.84 (0.61–1.16)	0.72 (0.50–1.02)
Twice a day or more (7)	1.18 (0.55–2.51)	1.29 (0.60–2.77)	0.81 (0.33–2.01)

*Age, smoking (no/ex/light/moderate/heavy), employment grade (high/medium/low), blood cholesterol, blood pressure, body mass index, general health questionnaire score.

Table 4 Usual amount consumed in one session and risk of CHD and death (hazard ratios and 95% confidence intervals).

Usual amount consumed (no. of events mortality/CHD)	*All-cause mortality age-adjusted*	*All-cause mortality fully adjusted**	*CHD age-adjusted*	*CHD fully adjusted*
Men				
Spirits/wine				
1–2 units (126/378)	1	1	1	1
3–4 units (72/288)	0.94 (0.70–1.26)	0.90 (0.66–1.23)	1.17 (1.00–1.36)	1.16 (0.99–1.37)
5 + units (14/41)	1.29 (0.74–2.24)	0.91 (0.49–1.67)	1.23 (0.89–1.70)	1.04 (0.73–1.48)
Beer				
1–2 pints (139/504)	1	1	1	1
3–4 pints (45/124)	1.76 (1.25–2.47)	1.22 (0.82–1.81)	1.19 (0.98–1.46)	0.98 (0.77–1.23)
5 + pints (2/12)	1.03 (0.26–4.18)	0.67 (0.16–2.86)	1.42 (0.80–2.54)	0.76 (0.39–1.51)
Women				
Spirits/wine				
1–2 units (66/211)	1	1	1	1
3–4 units (26/122)	0.75 (0.48–1.18)	0.72 (0.44–1.16)	1.03 (0.82–1.28)	0.99 (0.78–1.26)
5 + units (6/18)	1.37 (0.59–3.17)	0.97 (0.39–2.39)	1.17 (0.72–1.90)	0.99 (0.58–1.68)
Beer				
1–2 pints (20/82)	1	1	1	1
3–4 pints (2/7)	2.43 (0.57–10.39)	1.90 (0.44–8.27)	2.20 (1.02–4.76)	1.86 (0.78–4.21)
5 + pints –	–	–	–	–

*Age, smoking (no/ex/light/moderate/heavy), employment grade, blood cholesterol, blood pressure, body mass index, general health questionnaire score and total volume consumed per week. 1 unit = 8 g alcohol; 1 pint = 16 g alcohol.

clear that the frequency of drinking may be an important indicator of chronic health consequences. In addition to average volume consumed, we therefore compared the use of two other alcohol measures, frequency of drinking per year and usual amount per session. After adjustment for volume consumed, we found frequency of consumption was associated with ill health. The third measure, usual amount consumed per drinking session, was not predictive of increased risk, but this may have been due to low numbers of our participants drinking large quantities in one session. In other populations this may prove to be useful; for example, Murray *et al.* (2002) found that consumption of eight or more drinks in one session was associated with increased cardiovascular consequences in a Canadian-based population study (aged 18–64 years). In Finland, drinking six or more bottles of beer in one session was associated with a more than twofold risk of cardiovascular mortality compared to drinking less than three beers in one session, adjusted for total volume (Kauhanen *et al.* 1997a).

Data from the Whitehall II study are an important contribution to the debate on alcohol consumption and CHD. This is a large prospective cohort, with more than 10 years' follow-up, and rigorous attempts were made to minimize loss to follow-up. This paper suggests that it may be advantageous to obtain additional information on drinking habits over and above asking average volume consumed per unit of time. We do not suggest, however, that the measures used in the Whitehall II study are the definitive questions to ask. In particular, the measures of frequency and amount refer to different periods (last year and last week, respectively) and this complicates the interpretation.

There are clear advantages of using a simple, self-completion instrument to measure alcohol intake in a large cohort study. These advantages include a reduction in participant burden and facilitation of comparison with other epidemiological study findings. Studies have shown self-reports to be generally reliable in terms of test–retest stability (Giovannucci *et al.* 1991). However, more research into the validity of self-reported consumption is needed, given that comparisons of volumes derived from surveys with volumes derived from sales data show that the latter are consistently higher (Pernanen 1974). Rehm (1998) compared studies on assessment instruments and reported that the more specific the questions about alcohol consumption asked, the higher the volume reported. Beverage-specific questions yielded higher volumes than questions asking only for total alcohol consumption.

While there is a desire for standardization in alcohol measurement within and across studies to facilitate comparisons of research results, there is also recognition that a single instrument may not be able to measure all extremes of consumption behaviour (Dawson 1998). For example, depending on the population of interest, it may be appropriate to use a measure of inebriation as an indicator of alcohol abuse. Kauhanen *et al.* (1997b) studied the relation between frequent hangovers and cardiovascular mortality in a sample of middle-aged Finnish men.

Among the heaviest quartile of drinkers (average weekly alcohol use 248 g), having frequent hangovers (at least monthly) was associated with a 2.36 (95% CI 1.02–5.48) risk of cardiovascular death, adjusting for age and total alcohol intake.

A more fundamental problem of using such simple instruments in follow-up studies is that alcohol consumption may change over time. Exposure in epidemiological studies is measured typically among participants at baseline and health outcomes are tracked during the follow-up period. It is assumed typically that the initial consumption level reported at baseline is an accurate measure of exposure throughout the study period (which may be several decades). Studies that have attempted to analyse changes in consumption over time with respect to health consequences include Lazarus *et al.* (1991), Shaper & Wannamethee (1998) and Kujala *et al.* 2002. More advanced statistical techniques are needed to analyse multiple repeated measures in order to disentangle the health consequences of changes in drinking practices over the life course.

ACKNOWLEDGEMENTS

The Whitehall II study has been supported by grants from the Medical Research Council, British Heart Foundation, Health and Safety Executive, Department of Health, National Heart Lung and Blood Institute (HL36310), US, NIH: National Institute on Aging (AG13196), US NIH, Agency for Health Care Policy Research (HS06516) and the John D. and Catherine T. MacArthur Foundation Research Networks on Successful Midlife Development and Socioeconomic Status and Health. Michael Marmot is supported by an MRC Research Professorship. We thank all participating civil service departments and their welfare, personnel and establishment officers, the Occupational Health and Safety Agency, the Council of Civil Service Unions, all participating civil servants in the Whitehall II study and all members of the Whitehall II study team.

REFERENCES

Britton, A. & McKee, M. (2000) The relationship between alcohol and cardiovascular disease in Eastern Europe: explaining the paradox. *Journal of Epidemiology and Community Health*, **54**, 328–332.

Britton, A. & McPherson, K. (2001) Mortality in England and Wales attributable to current alcohol consumption. *Journal of Epidemiology and Community Health*, **55**, 383–388.

Corrao, G., Rubbiati, L., Bagnardi, V., Zambon, A. & Poikolainen, K. (2000) Alcohol and coronary heart disease: a meta-analysis. *Addiction*, **95**, 1505–1523.

Dawson, D. (1998) Measuring alcohol consumption: limitations and prospects for improvement. *Addiction*, **93**, 965–968.

English, D. R., Holman, C. D. J., Milne, E., Winter, M. G., Hulse, G. K., Codde, J. P., Bower, C. I., Corti, B., de Klerk, N., Knuiman, M. W., Kurinczuk, J. J., Lewin, G. F. & Ryan, G. A. (1995) *The Quantification of Drug Caused Morbidity and Mortality in Australia 1995*. Canberra: Commonwealth Department of Human Services and Health.

Gill, J. (1997) Women, alcohol and the menstrual cycle. *Alcohol and Alcoholism*, **32**, 435–441.

Giovannucci, E., Colditz, G., Stampfer, M. J., Rimm, E. B., Litin, L., Sampson, L. & Willet, W. C. (1991) The assessment of alcohol consumption by a simple self-administered questionnaire. *American Journal of Epidemiology*, **133**, 810–817.

Goldberg, D. P. (1972) *The Detection of Psychiatric Illness by Questionnaire*. Maudesley Monograph no. 21. London: Oxford University Press.

Graham, K., Wilsnack, R., Dawson, D. & Volgeltanz, N. (1998) Should alcohol consumption measures be adjusted for gender differences? *Addition*, **93**, 1137–1147.

Kauhanen, J., Kaplan, G. A., Goldberg, D. E. & Salonen, J. T. (1997a) Beer binging and mortality: results from the Kuopio ischaemic heart disease risk factor study, a prospective population based study. *British Medical Journal*, **315**, 846–851.

Kauhanen, J., Kaplan, G. A., Goldberg, D. D., Cohen, R. D., Lakka, T. A. & Salonen, J. T. (1997b) Frequent hangovers and cardiovascular mortality in middle-aged men. *Epidemiology*, **8**, 310–314.

Knupfer, G. (1989) The prevalence in various social groups of eight different drinking patterns, from abstaining to frequent drunkenness: analysis of 10 US surveys combined. *British Journal of Addiction*, **84**, 1305–1318.

Kujala, U. M., Kaprio, J. & Koskenvuo, M. (2002) Modifiable risk factors as predictors of all-cause mortality: the roles of genetics and childhood environment. *American Journal of Epidemiology*, **156**, 985–993.

Lazarus, N. B., Kaplan, G. A., Cohen, R. D. & Diing-Jen, L. (1991) Change in alcohol consumption and risk of death from all causes and from ischaemic heart disease. *British Medical Journal*, **303**, 553–556.

Marmot, M. (1997) Inequality, deprivation and alcohol use. *Addiction*, **92**, S13–S20.

Marmot, M. G. (2001) Alcohol and coronary heart disease. *International Journal of Epidemiology*, **30**, 724–729.

Marmot, M., Shipley, M., Brunner, E. & Hemingway, H. (2001) Relative contribution of early life and adult socioeconomic factors to adult morbidity in the Whitehall II study. *Journal of Epidemiology and Community Health*, **55**, 301–307.

Marmot, M. G., Smith, G. D., Stansfeld, S., Patel, C., North, F., Head, J., White, I., Brunner, E. & Feeney, A. (1991) Health inequalities among British civil servants: the Whitehall II study. *Lancet*, **337**, 1387–1393.

McKee, M. & Britton, A. (1998) The positive relationship between alcohol and heart disease in eastern Europe: potential physiological mechanisms. *Journal of the Royal Society of Medicine*, **91**, 402–407.

Mukamal, K. J., Conigrave, K. M., Mittleman, M. A., Camargo, C. A., Stampfer, M. J., Willet, W. C. & Rimm, E. B. (2003) Roles of drinking pattern and type of alcohol consumed in coronary heart disease in men. *New England Journal of Medicine*, **348**, 109–118.

Murray, R. P., Connett, J. E., Tyas, S. L., Bond, R., Ekuma, O., Silversides, C. K. & Barnes, G. E. (2002) Alcohol volume, drinking pattern, and cardiovascular disease morbidity and

mortality: is there a U-shaped function? *American Journal of Epidemiology*, **155**, 242–248.

Pernanen, K. (1974) Validity of survey data on alcohol use. In: Gibbins, R. G., Israel, Y., Kalant, H., Popham, R. E., Schmidt, W. & Smart, R. G., eds. *Research Advances in Alcohol and Drug Problems*, pp. 355–374. New York: Wiley.

Rehm, J. (1998) Measuring quantity, frequency, and volume of drinking. *Alcoholism: Clinical and Experimental Research*, **22**, 4S–14S.

Rehm, J., Greenfield, T. K. & Rogers, J. D. (2001) Average volume of alcohol consumed, patterns of drinking, and all-cause mortality: results from the US National Alcohol Survey. *American Journal of Epidemiology*, **153**, 64–71.

Rose, G. A., Blackburn, H., Gillum, R. F. & Prineas, R. J. (1982) *Cardiovascular Survey Methods*, 2nd edn. Geneva: World Health Organization.

Shaper, A. G. & Wannamethee, S. G. (1998) The J-shaped curve and changes in drinking habit. In: Chadwick, D. J. & Goode, J. A., eds. *Alcohol and Cardiovascular Disease*, pp. 173–188. Novartis Foundation Symposium no. 216. Chichester, UK: John Wiley & Sons.

White, I. R. (1999) The level of alcohol consumption at which all-cause mortality is least. *Journal of Clinical Epidemiology*, **52**, 967–975.

White, I. R., Altmann, D. R. & Nanchahal, K. (2002) Alcohol consumption and mortality: modelling risks for men and women at different ages. *British Medical Journal*, **325**, 191–197.

World Health Organization (1977) *International Classification of Diseases—9th Revision.* Geneva: World Health Organization.