Alcohol Volume, Drinking Pattern, and Cardiovascular Disease Morbidity and Mortality: Is There a U-shaped Function?

Robert P. Murray, John E. Connett, Suzanne L. Tyas, Ruth Bond, Okechukwu Ekuma, Candice K. Silversides, and Gordon E. Barnes

The health effects of a binge pattern of alcohol consumption have not been widely investigated. The objective of this study was to evaluate the cardiovascular consequences of binge drinking (consumption of eight or more drinks at one sitting) and usual (nonbinge) drinking in a longitudinal, population-based study. Data obtained from 1,154 men and women aged 18–64 years interviewed in Winnipeg, Manitoba, Canada, in 1990 and 1991 were linked to health care utilization and mortality records. Using an 8-year follow-up period, the authors performed separate Cox proportional hazards regression analyses for men and women on time to first event for physician visits, hospitalizations, and deaths due to coronary heart disease, hypertension, and other cardiovascular disease. Binge drinking increased the risk of coronary heart disease in both men (hazard ratio (HR) = 2.26, 95% confidence interval (CI): 1.22, 4.20) and women (HR = 1.10, 95% CI: 1.02, 1.18). It increased the risk of hypertension in men (HR = 1.57, 95% CI: 1.04, 2.35) but not in women. Binge drinking had no effect on the risk of other cardiovascular disease. In contrast, usual drinking had significant cardioprotective effects in both men and women. Thus, the harmful effects of binge drinking on cardiovascular disease morbidity and mortality can be disaggregated from the protective effects of usual drinking at various levels of consumption. *Am J Epidemiol* 2002;155:242–8.

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Abbreviations: HR, hazard ratio; ICD-9-CM, International Classification of Diseases, Ninth Revision, Clinical Modification.

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There has recently been an increasing interest in patterns of drinking and their health consequences (6, 13, 14). The health effects of a binge pattern of drinking have not been widely investigated using population-based studies, largely because questions on drinking pattern are not yet commonly included in epidemiologic surveys (15). Suggestive evidence comes from studies that examine the high end of the range of responses to questions on quantity and frequency (16–18), from international comparisons of drinking and its health consequences between countries where binge drinking is common and countries where it is not (19), and from studies that use self-reported illness burden as an outcome measure (20, 21). A recent study linked volume and pattern of drinking to mortality outcomes but failed to show the effects of pattern across all levels of volume (22).

The present study linked health care utilization data to data on alcohol consumption in Manitoba, Canada. Manitoba is a jurisdiction where the cost of all medical and hospital care, with minor exceptions, is covered by a government health care plan (23). Anonymized administrative data are contained in the Population Health Research Data Repository. The repository was developed by the Manitoba Centre for Health Policy and Evaluation, a research organization that routinely receives, extracts, and analyzes such data through an arrangement with the provincial government (24, 25).

The primary objective of this study was to assess the protective cardiovascular effects of increasing volumes of usual drinking by gender and to separate these from the deleterious effects of binge drinking. Data on alcohol consumption were obtained from the Winnipeg Health and Drinking Survey, a study of a community sample of adults drawn from Winnipeg, Manitoba, and followed for 8 years. An unusual aspect of these data is that they include information from a specific question about binge drinking—the frequency of consumption of eight or more drinks per occasion.

MATERIALS AND METHODS

The Manitoba Health Services Commission (now Manitoba Health) initially provided the study sample. The sample specification was for a random selection of equal numbers of men and women in equal-sized age groups of 18–34, 35–49, and 50–64 years. This sample design was originally specified for a study of the relation between drinking and personality across the adult life span. No screening was done for preexisting health conditions, including cardiovascular disease. The total sampling frame was provided in 1989 and consisted of 4,000 names and addresses. In-home interviews were conducted in 1990 and 1991 with a random subsample, such that 1,257 completed interviews were approximately equally distributed among the six age/gender cells. Of this original sample, the present analysis included data for 1,154 persons who completed the baseline interview and later consented to all-cause surveillance (eight had incomplete interviews and 95 withheld consent). The response rate, defined as the percentage of completed interviews compared with the number of persons who were located and eligible, was 64.3 percent. Sampling and survey procedures have been described in detail elsewhere (26, 27). The protocol was approved by ethics review boards at the University of Manitoba and Manitoba Health.

Measures

Volume of drinking was assessed by asking each respondent about the number of occasions in the past 12 months on which he or she had usually consumed drinks containing alcohol and how many drinks were usually consumed on those occasions. Both of these questions were asked separately for wine, beer, and liquor. For example, the questions for beer were “How often do you usually have beer?” and “Now, think of all the times you have had beer recently. When you drink beer, how many glasses do you usually have?”. The responses were converted to average grams of ethanol per day by multiplying frequency and quantity together and by assuming that a 12-ounce (355-ml) can or bottle of beer contained 13.2 g of ethanol, that a standard drink of liquor contained 15.1 g of ethanol, and that a 4-ounce (118-ml) glass of wine contained 10.8 g of ethanol (28). With these conversion values, a standard drink is considered to contain approximately 13 g of ethanol. Volume of drinking is referred to as “usual drinking” in this paper, since that is how the questions were phrased, and to distinguish it from binge drinking.

The frequency distribution of drinking (in grams of ethanol) from 0.65 g and up was divided into tertiles which were calculated separately for men and women. Among men, these corresponded to 0.65–5.77 g of ethanol per day for the lowest tertile and rose to 5.78–18.1 g and >18.1 g for the two higher tertiles. Among women, the tertiles for average volume of ethanol consumed daily were 0.65–2.92 g, 2.93–9.15 g, and >9.15 g.

Binge drinking was measured by asking the respondent, with regard to wine, beer, and liquor, how often he or she had consumed eight or more drinks at one sitting in the past 12 months. Responses were summed together for reports of wine, beer, and liquor and were expressed as the number of times per month that a respondent reported consuming eight or more drinks at one sitting. In the proportional hazards models described below, indicator variables for both usual drinking and binge drinking were included. The continuous covariate (frequency of binge drinking per month) accounted for more variance in the women’s models, whereas a dichotomous version (any occurrence of binge drinking) accounted for more variance among men.

Physician visits and hospital stays with diagnoses of coronary heart disease, hypertension, and other cardiovascular disease within the 8-year period following the first interview were identified using International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) codes (coronary heart disease: codes 410–414; hypertension: codes 401–405; other cardiovascular disease: codes 390–398 and 415–459). Cause-of-death data (ICD-9-CM diagnoses) over the 8-year follow-up period were extracted from vital statistics files for each of the three categories of diseases. We used the “most responsible diagnosis,” coded to five digits, from the hospital discharge abstract data. Only one diagnosis, coded to three digits, was available from the
physician claims data. Although the motivation of physicians to provide coded claims is high because payment for services is dependent on submission of claims, Manitoba hospital claims data tend to be of higher quality than physician claims data (29).

Statistical methods

Cox proportional hazards regression methods were used to assess time-to-event data in models stratified by gender, with no weighting for age (30). Time to event was defined as the number of days from the individual’s wave 1 interview to the first reporting of the index diagnosis. The proportional hazards assumption was tested by examining the interaction of an alcohol covariate with log(time) in the model and by the examination of weighted Schoenfeld residuals (31, 32). Examination of residuals in the men’s coronary heart disease model identified two binge outliers; removal of the outliers did not lead to any different inferences. For the women’s cardiovascular disease model, one binge outlier was removed.

RESULTS

The study participants were approximately equally divided between men and women (table 1). Former drinkers were older and less well educated than drinkers in most other categories. Never drinkers and occasional drinkers were more likely to be married and much less likely to be smokers than the overall sample. Heavy drinkers and binge drinkers were less likely to be married and more likely to be smokers than the overall sample. Binge drinkers were also likely to be young. On average, men consumed more than twice the volume of alcohol as women, and binge drinking was reported more frequently by men than by women.

Tables 2 and 3 show hazard ratios for coronary heart disease according to binge drinking and three levels of volume of drinking (current abstainers and occasional drinkers (<0.05 drinks, or <0.65 g per day) were used as the comparison group) in men and women, respectively. Former drinkers were excluded from these analyses because of the presumed presence of “sick quitters” (persons who stopped drinking due to illness) among them (33). Among men, the consumption of more than 18.1 g of ethanol per day was significantly protective against coronary heart disease (hazard ratio (HR) = 0.30). Lower levels of usual consumption were not significantly associated with coronary heart disease, although the results were suggestive of a protective effect. Any report of binge drinking was associated with a greater than twofold increase in the risk of coronary heart disease (HR = 2.26). Among women, in whom coronary heart disease events were less than half as frequent, none of the levels of usual drinking were associated with a significant risk of coronary heart disease. However, the frequency of binge drinking per month was associated with a significantly higher risk of coronary heart disease (HR =

<table>
<thead>
<tr>
<th>TABLE 1. Selected baseline characteristics of a community sample of adults, by alcohol consumption, Winnipeg, Manitoba, Canada, 1990–1991</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Former drinkers</strong></td>
</tr>
<tr>
<td></td>
</tr>
<tr>
<td><strong>Men (n = 580)</strong></td>
</tr>
<tr>
<td>% of total</td>
</tr>
<tr>
<td>No. of subjects</td>
</tr>
<tr>
<td>Mean age (years)</td>
</tr>
<tr>
<td>Educational level¶</td>
</tr>
<tr>
<td>Married (%)</td>
</tr>
<tr>
<td>Cigarette smoker (%)</td>
</tr>
<tr>
<td><strong>Women (n = 574)</strong></td>
</tr>
<tr>
<td>% of total</td>
</tr>
<tr>
<td>No. of subjects</td>
</tr>
<tr>
<td>Mean age (years)</td>
</tr>
<tr>
<td>Educational level¶</td>
</tr>
<tr>
<td>Married (%)</td>
</tr>
<tr>
<td>Cigarette smoker (%)</td>
</tr>
</tbody>
</table>

* Previously consumed alcohol but not during the past year.
† Tertiles of usual volume of alcohol consumed for men were 0.65–5.77, 5.78–18.1, and ≥18.2 g of ethanol per day. Tertiles for women were 0.65–2.92, 2.93–9.15, and ≥9.16 g/day.
‡ Binge drinking was defined as consumption of eight or more drinks at one sitting, once or more in the past 12 months. Binge drinking was treated as independent of usual drinking in these analyses.
§ Numbers in parentheses, standard deviation.
¶ Education was coded in eight categories. Category 4 was completion of high school. Category 5 was completion of some college or receipt of a technical diploma.

Among women (table 3), both the upper and lower tertiles of usual alcohol consumption were significantly protective against hypertension (HR = 0.60 and HR = 0.59, respectively); binge drinking had no effect.

In men, all levels of usual drinking above the reference category significantly reduced the risk of other cardiovascular disease (table 2). The middle tertile of alcohol consumption was significantly protective (HR = 0.48) against other cardiovascular disease in women (table 3). Binge drinking was not a significant predictor of other cardiovascular disease in men or women.

All models were adjusted for age, educational level, marital status, and cigarette smoking status. Age was a significant covariate in all models, and no other covariates were significant in any model. All models were also tested with inclusion of the interactions between levels of usual drinking and binge drinking. Results were not significant in any model.

### TABLE 2. Adjusted relative hazards for cardiovascular disease morbidity and mortality according to alcohol drinking pattern in a community sample of adult men ($n = 525$), Winnipeg, Manitoba, Canada, 1990–1991 to 1998–1999*

<table>
<thead>
<tr>
<th>Disease</th>
<th>No. of events</th>
<th>Mean ethanol intake (g) per day</th>
<th>Baseline pattern (any report of ≥8 drinks at one occasion)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0–0.64†</td>
<td>0.65–5.77</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>59</td>
<td>1.00</td>
<td>0.90</td>
</tr>
<tr>
<td>$p$ value</td>
<td></td>
<td></td>
<td>0.81</td>
</tr>
<tr>
<td>Hypertension</td>
<td>132</td>
<td>1.00</td>
<td>0.69</td>
</tr>
<tr>
<td>$p$ value</td>
<td></td>
<td></td>
<td>0.25</td>
</tr>
<tr>
<td>Other cardiovascular disease</td>
<td>125</td>
<td>1.00</td>
<td>0.53</td>
</tr>
<tr>
<td>$p$ value</td>
<td></td>
<td></td>
<td>0.03</td>
</tr>
</tbody>
</table>

* Proportional hazards models adjusted for baseline age, educational level, married status, and cigarette smoking status. The reference category for volume of drinking included never drinkers and occasional drinkers. Former drinkers were excluded from the analyses. The reference category for binge drinking was no report of binge drinking.
† Reference category.
‡ Numbers in parentheses, 95% confidence interval.

### TABLE 3. Adjusted relative hazards for cardiovascular disease morbidity and mortality according to alcohol drinking pattern in a community sample of adult women ($n = 535$), Winnipeg, Manitoba, Canada, 1990–1991 to 1998–1999*

<table>
<thead>
<tr>
<th>Disease</th>
<th>No. of events</th>
<th>Mean ethanol intake (g) per day</th>
<th>Baseline pattern (frequency of ≥8 drinks at one occasion)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>0–0.64†</td>
<td>0.65–2.92</td>
</tr>
<tr>
<td>Coronary heart disease</td>
<td>28</td>
<td>1.00</td>
<td>1.17</td>
</tr>
<tr>
<td>$p$ value</td>
<td></td>
<td></td>
<td>0.75</td>
</tr>
<tr>
<td>Hypertension</td>
<td>116</td>
<td>1.00</td>
<td>0.59</td>
</tr>
<tr>
<td>$p$ value</td>
<td></td>
<td></td>
<td>0.04</td>
</tr>
<tr>
<td>Other cardiovascular disease</td>
<td>119</td>
<td>1.00</td>
<td>0.71</td>
</tr>
<tr>
<td>$p$ value</td>
<td></td>
<td></td>
<td>0.16</td>
</tr>
</tbody>
</table>

* Proportional hazards models adjusted for baseline age, educational level, married status, and cigarette smoking status. The reference category for volume of drinking included never drinkers and occasional drinkers. Former drinkers were excluded from the analyses. The reference category for binge drinking was no report of binge drinking.
† Reference category.
‡ Numbers in parentheses, 95% confidence interval.
**DISCUSSION**

Is there a U-shaped curve describing the relation between consumption of alcohol and risk of heart disease? We argue that this question may oversimplify the relation. Almost all previous studies used measures derived from self-reported quantity and frequency of alcohol consumption. Many subjects with very high daily quantities of alcohol intake would likely have also been binge drinkers, with amounts of alcohol consumed during binge drinking simply being counted as part of their total alcohol consumption. In the absence of explicit binge-pattern data, a U- or J-shaped hazard curve has been reported, but not consistently (for example, see Hammar et al. (16) vs. Kauhanen et al. (17)).

In our study, questioning people separately about usual drinking and binge-pattern drinking appears to have disaggregated the protective and hazardous effects of alcohol relatively well. The effects of usual drinking among both men and women, when statistically significant, were uniformly protective. The effects of binge-pattern drinking, when statistically significant, were uniformly hazardous. The drinking pattern questions that have worked well historically to identify social harms appear also to work well when applied to illness and mortality outcomes.

Usual drinking appeared to be protective at all levels in our data. This finding, however, must be interpreted with some explicit cautions. Our inclusion of morbidity as an outcome provided significant results in multivariate analyses, but we cannot assume that a study which is predominantly a study of morbidity is equivalent to a study of mortality. Because we divided the distribution of drinking into tertiles, our heavier level of alcohol consumption (>18.1 g for men) included a quantity of alcohol that is close to the optimum protective level in studies of coronary heart disease (20–25 g) (34). Did the “heavy among the heavier” drinkers in this study exhibit harm from alcohol? There is no indication of it, but a larger study is needed to address this question directly.

The use of hypertension as an outcome in this study was chosen after we reviewed initial analyses divided between coronary heart disease and cardiovascular disease. We found that hypertension was the largest single category of cardiovascular disease events reported in physician offices. We then decided to examine hypertension as a surrogate for more advanced cardiovascular disease and found that it too was suggestively linked to pattern of alcohol use.

In looking for a relation between drinking patterns and health, we linked documented episodes of medical care over an 8-year period to baseline drinking estimates derived from questions on usual drinking and binge drinking. We found significant results for coronary heart disease, hypertension, and other cardiovascular disease. Among men, we found a protective effect for coronary heart disease beginning at about 1.5 drinks per day and a detrimental effect with any report of eight or more drinks per occasion. Among women, we found only a risk linked to the frequency of reported binge drinking. Among binge-drinking men, there was evidence of a risk for hypertension. There was a similar number of hypertension events (that is, diagnoses) among women and evidence of a protective effect of usual drinking, but no evidence of an increased risk with binge drinking. Among men, there was a uniformly protective effect for other cardiovascular disease across the drinking range, but no effect for binge drinking. Among women, there was a protective effect against other cardiovascular disease at levels of approximately half a drink per day.

These effects were found primarily with regard to cardiovascular disease morbidity, not cardiovascular disease mortality, which is the usual outcome in these types of studies. The focus on morbidity provided a much greater number of events for a given sample size and thus greater statistical power than would have been achieved in a study of mortality alone. It also provided a different mix of endpoints for different diagnoses. In addition, by examining physician visits and hospital admissions, we were able to obtain unique information regarding endpoints. For example, acute myocardial infarction may be associated with a hospital admission and several physician visits. The management of hypertension, on the other hand, is associated with many physician office visits and infrequent hospitalization. When looking in the aggregate at the first occurrence of events, this difference is represented by more observations of hypertensive events than of coronary heart disease events. One consequence of this difference is the apparently greater power of the hypertension and other cardiovascular disease analyses compared with the coronary heart disease analysis. In our results, the protective effect of usual alcohol use against coronary heart disease was seen only among men, and only with the use of more than 18.1 g of alcohol per day. The protective effect for cardiovascular disease other than coronary heart disease and hypertension was observed for men at all levels of usual alcohol consumption. Thus, in men, the protective effect occurred at all levels of usual alcohol use for other cardiovascular disease and at the high end only for coronary heart disease. These different results may in fact represent different protective mechanisms in the two clusters of diseases. However, they have not been seen in studies of mortality, and it is possible that here they resulted from differences in the power of the models. It has been suggested that a particularly hazardous pattern of drinking is heavy episodic drinking among individuals who have modest levels of usual drinking (35), but this was not supported by our data.

Puddey et al. (8) reviewed mechanisms that plausibly underlie drinking-pattern effects such as those demonstrated here. They reported on several studies in which usual drinking at binge levels was identified and found an associated increased risk of major coronary heart disease events. Our binge drinking questions were based on a different approach to measurement but delivered comparable results. Puddey et al. cited several studies supporting the relation between heavy episodic drinking and hypertension, although this finding was not universal. This lends at least some support to our finding of an increased risk of hypertension among binge-drinking men.

This study had some clear limitations. Because the sample was relatively small, tertiles of alcohol consumption within gender were used in place of finer categorizations.
that could distinguish more extreme levels of alcohol use. Among men, baseline pattern of binge drinking was categorized as a dichotomous variable rather than at the several levels of frequency that were available. On the other hand, we had approximately equal samples of women and men, which allowed for separate and corresponding models for each gender. We defined binge drinking as consuming eight or more drinks at one sitting; a lower number of drinks, perhaps five, may have been more appropriate for women.

Other limitations were related to the available variables. The baseline survey did not include measures of diet, blood lipid levels, body mass index, or exercise—all factors that have been found to be important in predicting coronary heart disease, hypertension, and other cardiovascular disease.

These results, if replicated, have implications for the manner in which the effects of alcohol consumption are communicated to the public. They suggest that usual alcohol consumption at almost any level may be cardioprotective. This protective effect begins at quite low levels, as is commonly known. The higher levels are also cardioprotective but introduce known risks for other diseases such as cancer and liver disease. Most important in these results is the evidence that binge drinking, possibly even at relatively infrequent intervals, presents a significant risk for coronary heart disease and hypertension.

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REFERENCES