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Per capita alcohol consumption and IHD mortality in a panel of US states from 1950 to 2002

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Abstract

Aims—To estimate the overall impact of alcohol on IHD mortality in the United States using aggregate-level models and to consider beverage-specific effects that may better represent changes in drinking patterns over time that are related to both harmful and protective impacts of alcohol consumption on IHD.

Design—Several model specifications are estimated, including state-specific ARIMA models and generalized least squares (GLS) panel models on first-differenced data.

Setting—US states from 1950 to 2002.

Participants—US general population.

Measurements—Per capita alcohol sales and cigarette sales, age-standardized IHD and cirrhosis mortality rates.

Findings—IHD mortality rates were significantly positively related to apparent consumption of total alcohol, with an overall increase in IHD of about 1% per liter of ethanol. Beverage-specific models found that spirits consumption was significantly positively related to IHD mortality overall, for both genders and in three regions defined by drinking culture (or “wetness”), while beer was found to have a significant protective relationship overall and in the wet region. Results for wine also suggest a protective relationship, but only marginally significant effects were found. Cirrhosis mortality rates were consistently positively related to IHD mortality. Combined results from state-specific ARIMA models including both cigarette sales and cirrhosis rates were generally consistent with the GLS results.

Conclusions—Population-level models confirm individual-level findings of both harmful and protective relationships between alcohol use patterns and IHD mortality. However, an overall harmful impact of per capita alcohol consumption on IHD mortality was found for the US.

Keywords

time-series; per capita alcohol; ischemic heart disease

INTRODUCTION

The relationship between alcohol consumption and ischemic heart disease (IHD) mortality at the population level is complicated by a number of factors, some similar to and some different from those complicating analyses at the individual level. While recent individual-level studies continue to find protective effects from low to moderate alcohol intake and

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harmful effects from higher alcohol intake (1), it has become increasingly clear that consumption pattern is more important than overall volume (2), with regular and somewhat frequent low to moderate alcohol use being associated with protection, while heavy drinking occasions are associated with harm (3). However, these studies have not fully addressed key methodological issues, including the “sick quitter” effect (4,5), control for the many health, social and behavioral risk factors correlated with alcohol use patterns (6,7) and potential misclassification of drinkers and non-drinkers from a lifetime perspective (7).

The interpretation of aggregate relationships, on the other hand, is complicated by the variable and shifting variety of drinking patterns in the underlying population, as well as possible confounding by potentially correlated risk factor trends, such as those for tobacco use, diet, obesity and stress. However, aggregate-level analyses avoid the main problems in individual-level studies, particularly the “sick quitter” effect, misclassification of drinkers, and the clustering of risk factors within individuals. As such, models of population-level alcohol use and IHD mortality can inform the literature through confirmation of individual-level findings and, most importantly, through the direct estimation of overall effects on the population given the possibility of both harmful and protective effects on individuals (8). Although studies based on surveys can be extrapolated to estimate potential harmful and protective effects on the population when associations with specific drinking patterns can be identified (9), this is a major difficulty given the limited assessment of alcohol pattern in most prospective studies (10). Further, surveys are known to underestimate alcohol consumption and may fail to include many of the heaviest drinkers (11), making estimates based on individual-level data likely to overestimate protective effects and underestimate harmful effects of alcohol consumption. Aggregate-level analyses offer a more direct method for estimating the overall impact of alcohol use on IHD mortality, as both per capita apparent consumption and mortality statistics are much closer to having complete population coverage than survey-based estimates.

Previous studies utilizing autoregressive integrated moving average (ARIMA) models using data from the US and other countries have found harmful (12,13), protective (14) and, in a multi-country European analysis, generally insignificant (15) effects. An innovative multi-level approach to modeling IHD mortality in a panel of countries was able to reconcile these different results to some extent by including a measure of the countries’ drinking pattern. Harmful relationships between alcohol consumption and IHD mortality were found in the countries with the most harmful drinking patterns, protective relationships were seen in countries with the least harmful patterns, and no effect was found in countries with intermediate patterns, including the US (16). Our previous analysis of trends for the US as a whole was consistent this finding of no effect from total alcohol, but extended the analyses to include beverage-type specific consumption and also utilized cirrhosis mortality rates as an indicator of chronic heavy drinking. These multivariate analyses appear to have enabled the protective effects and harmful effects to be disentangled to some extent, with significant harmful effects associated with both spirits consumption and cirrhosis rates, and significant protective effects associated with beer consumption. Spirits consumption has been previously associated with cirrhosis mortality trends (17) and with pre-WWII birth cohorts in the US (18), who are heavily represented in mortality over the 1950-2002 period, while beer consumption has been associated with drinkers in the baby-boom cohorts (18) and with the expansion of the drinking population into the 1970s (8).

The current study uses data on total and beverage-specific per capita apparent alcohol consumption, as well as per capita cigarette use and cirrhosis mortality rates, in a panel of 48 US states (or state groups) over the 1950 to 2002 period to evaluate relationships between these and IHD mortality rates. Panel models utilizing multiple time-series offer a methodologically stronger evaluation of relationships (19) than single time-series or cross-

sections. The use of beverage-specific series, previously identified as potentially associated with different drinking patterns, allows the separation of harmful and protective effects. We also utilize series for each state and panel models of state subgroups based on recent drinking patterns to assess differences in relationships between relatively dry states and relatively wet states, where dry states are defined by higher proportions of abstainers, relatively low population proportions of heavy occasion drinkers (although these may have high proportion of heavy occasions among drinkers) and lower per capita consumption, and wet states are defined by high proportions of drinkers and heavy occasion drinkers and high per capita consumption (20). Given individual-level findings suggesting increased IHD risk among abstainers and heavy drinkers, it is hypothesized that states with higher proportions of either or both of these groups, particularly the dry states, would show more harmful associations between alcohol use and IHD mortality. It is important to note that these “wetness” definitions differ from those used earlier in the US (21,22), which were based primarily on abstention and attitudes, and from the definition used in Europe and globally (23), where wet patterns imply both high proportions of frequent moderate drinkers and low proportions of infrequent heavy occasion drinkers.

METHODS

Data

Yearly IHD and cirrhosis mortality rates were taken from the Vital Statistics of the United States (24,25) from 1950 to 1967 and from the National Center for Health Statistics Compressed Mortality File series (26-28) for the years 1968 to 2002. The rates were age-standardized to the 2000 US population using the number of deaths in each specific age group along with population estimates for that group. State- and age-specific population estimates came from the same sources as the mortality data from 1968 to 2002. The 1968 population estimates were used with data from the 1950 and 1960 US Decennial Census to calculate population estimates for all remaining years, with interpolations assuming a constant rate of increase (or decrease) between data points.

Mortality due to IHD was defined based on several revisions of the International Classification of Diseases (ICD) using code 420 for ICD-6 and ICD-7, codes 410 to 414 for ICD-8 and ICD-9, and codes I20 to I25 for ICD-10. Mortality due to cirrhosis was defined using code 581 for ICD-6 and ICD-7, code 571 for ICD-8 and ICD-9, and codes K70, K73 and K74 for ICD-10. Natural logs of age-standardized IHD mortality rates were used in all models. Data for per capita apparent consumption of ethanol (in liters) from beer, wine, spirits and combined for total alcohol are derived from volume sales by beverage type and utilize state- and year-specific estimates of mean alcohol content as described in detail with sources in Kerr *et al.* (29). Data on state cigarette sales in packs per year came from the Tobacco Institute (30) for 1955-1969 and from Orzechowski and Walker (31) for 1970-2002 and were converted to a per capita 15+ basis using the same population data used for the alcohol data.

Because of substantial cross-border alcohol purchases between New Hampshire and Massachusetts and between the District of Columbia and Maryland and Virginia, two multi-state groups were created and population-averaged variables were utilized for each. Four states (Alaska, Hawaii, Mississippi and Oklahoma) were missing data for mortality or alcohol consumption in the 1950s and early 1960s due to a late date of statehood or being completely dry, resulting in a shorter series for each of those states. Cigarette sales data were not widely available until 1955; thus the panel models including this variable use a shorter series than the unadjusted models. Both the ARIMA and panel models used a 0.7 geometric distributed lag truncated after 5 years for the alcohol and cigarette variables, because previous consumption is theoretically relevant to IHD risk and because the lag relationship

fit the data better than current year data only, in contrast to findings for the US as a whole where current values were used (8). Several years of data are lost in the creation of distributed lags, thus models using the cigarette series start in 1960 rather than in 1955. Data on cigarette sales also is missing in earlier years for four states (noted in Tables 1 and 2), resulting in shorter series for those states.

Analysis

The ARIMA modeling technique developed by Box and Jenkins (32) was used to evaluate relationships between IHD mortality and per capita alcohol consumption measures in each state. The first difference of mortality rate and consumption series was utilized to remove unit roots, present in each of the series. Models were fit in EViews version 5 (33), regressing the logged age-standardized IHD mortality rates first on total alcohol consumption volume and then on beer, wine and spirits consumption volumes, with both models controlling for cigarette sales and cirrhosis mortality. Indicator variables for ICD changes in 1968, 1979 and 1999 were included in all models based on their significance in the analyses for the US as a whole (8). Autoregressive (AR) and moving average (MA) error terms were included as indicated by inspection of model errors and residual tests. In most cases no error terms were needed, and MA terms were only needed for the beverage-specific models in two states. The results of the ARIMA models for the 48 states and state groups were combined using the meta command in STATA (34), utilizing either random or fixed effects estimates, depending on the significance of heterogeneity tests. In these, the coefficients are weighted by the inverse of their standard errors. ARIMA results were combined for the full sample and for groups of states based on classification as wet (19 states), moderate (18 states) or dry (11 states) drinking cultures as detailed in Kerr (20), which is noted in Tables 1 and 2 and listed in the footnote to Table 4.

Panel models including all 48 states or state groups were estimated using generalized least squares (GLS). GLS is a generalized method specifying the variance-covariance matrix of the error structure, allowing the modeling of differences in variances across panels (heteroscedasticity) as well as panel-specific, first-order AR error terms. Panel models were fit using STATA version 10 (34). The panel models also utilized a first-differenced series, a conservative approach to address state-specific time trends. As with the ARIMA models, the panel models regressed IHD mortality on total alcohol consumption volume and then on beer, wine and spirits consumption volumes, with and without adjustment for cigarette sales and cirrhosis mortality. Each model was estimated for the total population and for men and women separately. Additional models were estimated within the wet, moderate and dry state groups. All panel models controlled for the years corresponding to an ICD version change. Exploratory analyses confirmed that the presented panel variance specification produced findings similar to those from GLS models using a correlated panel data structure in a smaller, fully-balanced dataset containing 39 states from 1960-2002. Presented results were also generally consistent with those from models utilizing variable levels (not differenced) and controlling for state fixed effects and quadratic time trends. However, in these models the effect of wine was consistently protective and significant (data not shown).

RESULTS

The results from the multivariate ARIMA models for each state are presented in Table 1, including coefficients representing the proportional effect on mortality rates from liters of total alcohol as well as for cigarette sales in packs per year and cirrhosis mortality rates, an alternative indicator of chronic heavy drinking. States are divided into three groups based on a wetness measure based on the prevalence of drinking, heavy episodic drinking and per capita consumption in 2006 (20), but presumably having some validity over the earlier period covered here. Alcohol coefficients in all models represent the percentage increase in

IHD mortality rates from a one liter increase in per capita ethanol intake, with negative associations indicating protective effects and positive associations indicating harmful effects of alcohol. The state-specific results for total alcohol vary, with many positive and negative coefficients and a positive, but small and non-significant overall combined coefficient. No significant results are found by wetness group. The coefficients for cigarettes are mostly positive, with some significant effects resulting in an overall significant harmful effect. Results for cirrhosis mortality rates also suggest harmful effects of chronic heavy drinking; the combined coefficient is positive and significant overall and for the moderate wetness group, with marginally significant results in the other groups. Results for ARIMA models using beverage-specific alcohol series, also controlling for cigarette sales and cirrhosis rates (coefficients not shown), are presented in Table 2. Coefficients for beer and wine are mostly negative, suggesting protective effects, while those for spirits are mostly positive (suggesting harmful effects). Combined results find significant protective effects related to beer consumption with a negative coefficient indicating that IHD rates declined 3.7% for each marginal one liter of ethanol increase in beer intake. A similar, but non-significant, effect size is found for wine. For spirits, a significant harmful effect is found, indicating an increase of 4.5% in IHD rates for each additional liter of spirits intake. Results by wetness group find that the wet region has the only significant protective effect of beer consumption on IHD mortality, with a 6.3% per liter estimated effect, while significant harmful effects for spirits are found in both the moderate and wet regions, with an estimated effect size of about 5.8% per liter in each.

The results from the GLS panel models are summarized in Tables 3 and 4. Each table presents the results for six models, allowing inspection of results for models including only the alcohol variables, with control for cigarette sales, and finally with control for cigarettes and including cirrhosis mortality rates as an alternative measure of chronic heavy drinking. Table 3 presents the results of models for the whole population and for men and women separately, while Table 4 presents the results for models by wetness region. These results show an overall significant and harmful effect for alcohol sales, which is reduced, but remains significant, when cigarettes are controlled, indicating that a one liter increase in alcohol intake results in a 1% increase in IHD mortality. A stronger effect of 2% per liter is found for men's IHD mortality, while no significant effect is found for women. Regional results in Table 4 indicate a significant effect of 2.7% per liter in the dry region but very small and non-significant effects in the moderate and wet regions. Beverage-specific models, shown in Table 3, find an overall harmful and significant effect from spirits and a significant protective effect from beer and wine. After controlling for cigarettes, the wine effect becomes only marginally significant. The harmful effect of spirits remains significant for both men and women, with about double the effect size for men at 7% per liter of ethanol in the model including wine, beer and cigarettes. The protective effects of beer and wine are no longer significant for women when cigarettes are controlled, but are marginally significant for men. Regional models in Table 4 show that while the harmful effect of spirits is significant in all regions with similar effect sizes of about 5% per liter of ethanol, the protective effect related to per capita alcohol intake from beer is only significant in the wet region after controlling for cigarette sales.

DISCUSSION

Our analyses showed significant relationships between population measures of alcohol intake and IHD mortality for the US utilizing state-level data. These population-level models confirm individual-level findings of both harmful and protective effects of alcohol use on IHD mortality (2,3). Overall, the effect of apparent consumption of total alcohol is found to increase IHD rates by 1% per liter of ethanol. This harmful impact is found to primarily impact men, for whom a significant effect of 2% per liter was found, while no effect was

seen for women after controlling for cigarette sales, however, cirrhosis mortality rates were significantly harmfully related to IHD for women. Protective effects at the aggregate-level are associated most clearly with the apparent consumption of beer, and these effects appear to be stronger and more common in the wet region. Evidence is also found suggesting a protective effect of apparent consumption of wine, with marginally significant effects overall, for men and in the moderate wetness region. Harmful effects are most consistently associated with the apparent consumption of spirits and appear to occur in all regions, and for both men and women. This suggests that while heavy drinking is common throughout the US and has been mainly associated with spirits, the frequent low to moderate intake patterns expected to be associated with protective effects are more common among beer drinkers in the wet region and perhaps among wine drinkers in all regions. In this way, the wet region of the US, primarily comprising New England and the North Central states, shows some similarity with the wet countries of Southern Europe (35). However, these states also have the highest proportions of heavy occasion drinkers (20) and the overall effect of alcohol consumption on IHD mortality was found to be close to zero and not significant, indicating that protective drinking patterns are balanced by harmful ones in the populations of these states. This is not the case in the dry region, primarily in the Southern US states, where protective drinking patterns appear to be less common such that an overall significant harmful effect on IHD mortality of 2.7% per liter of ethanol is found. Results for the moderate states are in between these, with a non-significant overall harmful effect that was close to the 1% per liter found for all states together. The cirrhosis mortality rate, used as a proxy for chronic heavy drinking, was consistently positively related to IHD mortality with significant effects in most models. Inclusion of this variable tended to reduce the estimated effects size for total alcohol and for spirits, however, these remained significant in most cases.

This study builds on our previous time-series analysis of data for the US as a whole over the same time period (8), which showed a significant protective effect of total alcohol consumption and, in beverage-specific models, a significant protective effect of beer consumption using ARIMA models controlling for cigarette sales and cirrhosis mortality rate. In the current analyses, which used a larger dataset consisting of time-series data from 48 state series, findings from ARIMA models for the total sample showed a *harmful* but not statistically significant overall effect of alcohol on IHD mortality when controlling for cigarette sales and cirrhosis mortality, which varies from our previous results. However, we also noted a significant protective effect of beer in the current beverage-specific ARIMA models, as well as significant harmful effects of cigarettes and chronic heavy drinking (indicated by cirrhosis mortality), which is consistent with the prior study. The current study differs from the earlier one in two important respects: (1) variation in rates across 48 state-specific series (rather than only one national series) allowed better testing of model specifications and more detailed estimates, including state panel analyses separated for men and women and by geographic region, which revealed notable differences in estimated relationships with IHD mortality for both overall and beverage-specific alcohol consumption; and (2) a distributed lag specification for the alcohol variables was utilized and found to fit the data better than the contemporaneous measure used in the previous study. These improvements suggest more reliable estimates than could be achieved with a single series; thus, we believe that the new results present important findings extending those provided by our previous analysis.

There are a number of potential limitations regarding the data, modeling choices and interpretation of results that should be considered when evaluating this study. Mortality rates are based on underlying cause determination and random misattribution and systematic errors are possible. Alcohol consumption data may also be biased by un-recorded consumption, particularly in the 1950s and 60s and in certain states, and by cross-border

purchases and tourism, although the clearest cases of this have been grouped with adjacent states to address this issue. Although the use of first differenced data and control for serial correlation can to some extent control for trends in unmeasured confounders, there is still a risk of bias from trends in alternative IHD risk factors such as diet, body mass index, exercise, stress, depression and others, which may also be related to alcohol consumption patterns, including abstinence. While the long measurement period is an advantage for model estimation and enables the more conservative specifications employed, there also is the likelihood of structural change in the underlying drinking patterns and drinker characteristics that generate overall alcohol sales. Such changes could result in variance in the relationships estimated over the time period within the sample and could mean that they no longer apply to current or future populations. Similarly, the wetness regions utilized in our analyses are based on recent data and may not reflect changes over the period of study. However, the utility of these groups for identifying differential relationships with alcohol measures suggests a degree of stability and serves to validate the grouping. Caution also is suggested in the interpretation of beverage-specific findings, as these could be related to associations with drinking patterns or birth cohort preferences and such associations will likely differ across countries and over time.

Despite these caveats, we believe that the presented results are consistent with the substantial literature on alcohol's relationships with IHD mortality and add important information, which should be explored further in future studies at both the aggregate and individual levels. In particular, beverage-specific measures should be employed in individual-level studies and in aggregate-level analyses for other countries to elucidate the drinking patterns associated with IHD mortality and whether such findings extend to other cultures and policy situations. Further utilization of regional wetness groupings in both individual and aggregate analyses is also needed to understand the underlying differences between these groups and to catalog outcomes with differential effects. Perhaps most importantly, these findings suggest that harmful drinking patterns are common in the US and that their effects on IHD balance or exceed those of protective drinking patterns in all regions. Therefore, effective policies for reducing alcohol consumption in general (36) would also be expected to reduce IHD mortality. In addition to these, efforts to shift drinkers from frequent or infrequent heavy occasion patterns to more regular light to moderate occasion patterns, or to abstinence, are needed. These could include brief interventions for those identified as having harmful patterns (37), potentially incorporating social norms (38). Policies explicitly targeting heavy drinkers such as minimum prices (39) and earlier closing times (40) for both on- and off-premise outlets may also result in lower consumption levels over time. Policies favoring beer and wine are not necessarily suggested as all alcoholic beverages are known to be harmful when high quantities per occasion are consumed and alcohol has been found to cause a number of serious acute and chronic health conditions including accidents and injuries, cancers, liver disease and suicide (41).

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REFERENCES

1. Mukamal KJ, Chen CM, Rao SR, Breslow RA. Alcohol consumption and cardiovascular mortality among U.S. adults, 1987 to 2002. *Journal of the American College of Cardiology*. 2010; 55:1328–1335. [PubMed: 20338493]
2. Breslow RA, Graubard BI. Prospective study of alcohol consumption in the United States: quantity, frequency, and cause-specific mortality. *Alcoholism: Clinical and Experimental Research*. 2008; 32:1–9.

3. Roerecke M, Rehm J. Irregular heavy drinking occasions and risk of ischemic heart disease: a systematic review and meta-analysis. *American Journal of Epidemiology*. 2010; 171:633–644. [PubMed: 20142394]
4. Shaper AG, Wannamethee G, Walker M. Alcohol and mortality in British men: explaining the U-shaped curve. *Lancet*. 1988; 2:1267–1273. [PubMed: 2904004]
5. Rehm J, Irving H, Ye Y, et al. Are lifetime abstainers the best control group in alcohol epidemiology? On the stability and validity of reported lifetime abstention. *American Journal of Epidemiology*. 2008; 168:866–871. [PubMed: 18701442]
6. Naimi TS, Brown DW, Brewer RD, et al. Cardiovascular risk factors and confounders among nondrinking and moderate-drinking U.S. adults. *American Journal of Preventive Medicine*. 2005; 28:369–373. [PubMed: 15831343]
7. Kerr WC, Ye Y. Relationship of life-course drinking patterns to diabetes, heart problems, and hypertension among those 40 and older in the U.S. National Alcohol Survey. *Journal of Studies on Alcohol and Drugs*. 2010; 71:515–525. [PubMed: 20553659]
8. Kerr WC, Ye Y. Population-Level Relationships Between Alcohol Consumption Measures And Ischaemic Heart Disease Mortality In U.S. Time-Series. *Alcoholism: Clinical And Experimental Research*. 2007; 31:1913–1919.
9. Rehm J, Greenfield TK, Rogers JD. Average volume of alcohol consumption, patterns of drinking and all-cause mortality. Results from the U.S. National Alcohol Survey. *American Journal of Epidemiology*. 2001; 153:64–71. [PubMed: 11159148]
10. Fillmore KM, Kerr WC, Stockwell T, Chikritzhs T, Bostrom A. Moderate alcohol use and reduced mortality risk: systematic error in prospective studies. *Addiction Research and Theory*. 2006; 14:101–132.
11. Greenfield TK, Kerr WC. Alcohol measurement methodology in epidemiology: recent advances and opportunities. *Addiction*. 2008; 103:1082–1099. [PubMed: 18422826]
12. Ramstedt M. Is alcohol good or bad for Canadian hearts? A time-series analysis of the link between alcohol consumption and IHD mortality. *Drug and Alcohol Review*. 2006; 25:315–320. [PubMed: 16854656]
13. Ramstedt M. Fluctuations in Male ischaemic heart disease mortality in Russia 1959-1998: assessing the importance of alcohol. *Drug and Alcohol Review*. 2009; 28:390–395. [PubMed: 19594793]
14. Skog O-J. Methodological problems in the analysis of temporal covariation between alcohol consumption and ischemic heart disease. *British Journal of Addiction*. 1983; 78:157–172. [PubMed: 6575805]
15. Hemström ö. Per capita alcohol consumption and ischaemic heart disease mortality. *Addiction*. 2001; 96:s93–s112. [PubMed: 11228081]
16. Gmel G, Rehm J, Frick U. Trinkmuster, Pro-Kopf-Konsum von Alkohol und koronare Mortalität. *Sucht*. 2003; 49:95–104.
17. Kerr WC, Fillmore KM, Marvy P. Beverage-specific alcohol consumption and cirrhosis mortality in a group of English-speaking beer-drinking countries. *Addiction*. 2000; 95:339–346. [PubMed: 10795350]
18. Kerr WC, Greenfield TK, Bond J, Ye Y, Rehm J. Age, period and cohort influences on beer, wine and spirits consumption trends in the US National Surveys. *Addiction*. 2004; 99:1111–1120. [PubMed: 15317631]
19. Baltagi BH, Griffin JM. A dynamic demand model for liquor: the case for pooling. *Review of Economics and Statistics*. 1995; 308:545–554.
20. Kerr WC. Categorizing US state drinking practices and consumption trends. *International Journal of Environmental Research and Public Health*. 2010; 7:269–283. [PubMed: 20195444]
21. Room, R. Region and urbanization as factors in drinking practices and problems. In: Kissin, B.; Begleiter, H., editors. *The Pathogenesis of Alcoholism: Psychosocial factors*. Plenum Press; New York: 1983. p. 555-604.
22. Hilton ME. Regional diversity in United States drinking practices. *British Journal of Addiction*. 1988; 83:519–532. [PubMed: 3382810]

23. Rehm J, Gmel G, Room R, Frick U. Average volume of alcohol consumption, drinking patterns and related burden of mortality in young people in established market economies of Europe. *European Addiction Research*. 2001; 7:148–151. [PubMed: 11509845]
24. National Office of Vital Statistics. *Vital Statistics of the United States, 1950–1958*. U.S. Public Health Service; Washington, DC: 1954–1960.
25. National Center for Health Statistics. *Vital Statistics of the United States, 1959–1967*. U.S. Public Health Service; Washington, DC: 1961–1969.
26. National Center for Health Statistics. *Compressed Mortality File 1968–1988*. National Center for Health Statistics; Hyattsville, MD: 2000.
27. National Center for Health Statistics. *Compressed Mortality File 1989–1998*. National Center for Health Statistics; Hyattsville, MD: 2003.
28. National Center for Health Statistics. *Compressed Mortality File 1999–2002*. National Center for Health Statistics; Hyattsville, MD: 2004.
29. Kerr WC, Greenfield TK, Tujague J. Estimates of the mean alcohol concentration of the spirits, wine, and beer sold in the U.S. and per capita consumption: 1950– 2002. *Alcoholism: Clinical and Experimental Research*. 2006; 30:1583–1591.
30. The Tobacco Institute. *The Tax Burden on Tobacco: Historical compilation, 1993*. The Tobacco Institute; Washington, DC: 1994.
31. Orzechowski and Walker. *The Tax Burden on Tobacco: Historical compilation, 2007*. Orzechowski and Walker; Arlington, VA: 2008 [04/15/10]. [http://www.nocigtax.com/upload/file/1/Tax_Burden_2007_vol._42.pdf]
32. Box, GEP.; Jenkins, GM. *Time Series Analysis. Forecasting and control*. Holden Day; London, UK: 1976.
33. EViews. *EViews 5 User's Guide*. Quantitative Micro Software; Irvine, CA: 2004.
34. STATA CORP. *Stata Statistical Software: Release 10.0*. Stata Corporation; College Station, TX: 2007.
35. Skog O-J. The wetness of drinking cultures: a key variable in epidemiology of alcoholic liver cirrhosis. *Acta Medica Scandinavica*. 1985; 703:157–184. [PubMed: 3867240]
36. Babor, TF.; Caetano, R.; Casswell, S., et al. *Alcohol: No Ordinary Commodity. Research and public policy*. Oxford University Press; New York, NY: 2003.
37. Bernstein E, Bernstein J. Effectiveness of alcohol screening and brief motivational intervention in the emergency department setting. *Annals of Emergency Medicine*. 2008; 51:751–754. [PubMed: 18436342]
38. Wild TC, Cunningham JA, Roberts AB. Controlled study of brief personalized assessment-feedback for drinkers interested in self-help. *Addiction*. 2007; 102:241–250. [PubMed: 17222278]
39. Meier PS, Purshouse R, Brennan A. Policy options for alcohol price regulation: the importance of modelling population heterogeneity. *Addiction*. 2010; 105:383–393. [PubMed: 19839965]
40. Stockwell T, Chikritzhs T. Do relaxed trading hours for bars and clubs mean more relaxed drinking? A review of international research on the impacts of changes to permitted hours of drinking. *Crime Prevention and Community Safety*. 2009; 11:153–171.
41. Rehm J, Mathers C, Popova S, et al. Global burden of disease and injury and economic cost attributable to alcohol use and alcohol-use disorders. *The Lancet*. 2009; 373:2223–2233.

Table 1

Results From Multivariate ARIMA Models^a Estimating Relationships Between Total Alcohol and IHD Mortality Rates

State	Total Alcohol B (SE)	Cigarettes B (SE)	Cirrhosis Mortality B (SE)	ARMA Terms
Alabama	-0.038 (0.041)	0.0044 (0.0030)	0.0113 (0.0048)**	none
Arkansas	-0.017 (0.051)	0.0005 (0.0026)	0.0055 (0.0038)	none
Georgia	0.026 (0.024)	0.0020 (0.0018)	0.0004 (0.0041)	none
Indiana	0.006 (0.036)	0.0028 (0.0015)*	-0.0010 (0.0045)	none
Kentucky	0.054 (0.053)	0.0003 (0.0011)	0.0002 (0.0033)	none
Mississippi	-0.006 (0.038)	0.0023 (0.0039)	0.0038 (0.0051)	none
North Carolina ^b	-0.017 (0.052)	0.0009 (0.0015)	-0.0023 (0.0049)	none
Oklahoma	0.083 (0.029)***	-0.0018 (0.0015)	0.0003 (0.0033)	none
Tennessee	0.001 (0.040)	0.0035 (0.0022)	0.0088 (0.0051)*	none
Utah	-0.017 (0.069)	0.0089 (0.0048)*	0.0006 (0.0031)	none
West Virginia	-0.001 (0.040)	0.0074 (0.0022)***	0.0027 (0.0027)	(1,0)
DRY AVERAGE	0.016 (0.012)	0.002(0.001)**c	0.002 (0.001)*	
Arizona	-0.050 (0.034)	0.0096 (0.0029)***	0.0010 (0.0035)	none
California	0.007 (0.028)	-0.0012 (0.0032)	0.0016 (0.0046)	none
Connecticut	0.027 (0.038)	0.0028 (0.0019)	-0.0049 (0.0044)	none
Delaware	0.012 (0.039)	0.0023 (0.0029)	-0.0011 (0.0023)	none
DC/MD/VA	-1.2 × 10 ⁻⁵ (0.024)	0.0009 (0.0006)	0.0069 (0.0031)**	none
Florida	-0.024 (0.022)	0.0049 (0.0020)**	0.0101 (0.0034)***	none
Hawaii ^b	-0.063 (0.034)*	0.0034 (0.0035)	-0.0150 (0.0082)*	(1,0)
Idaho	0.009 (0.052)	-0.0020 (0.0039)	0.0089 (0.0036)**	none
Louisiana	0.065 (0.054)	-0.0017 (0.0029)	-0.0064 (0.0039)	none
Nevada	0.034 (0.024)	-0.0024 (0.0031)	-0.0022 (0.0022)	(1,0)
New Jersey	0.008 (0.034)	0.0042 (0.0021)*	0.0102 (0.0036)***	none
New Mexico	0.036 (0.056)	-0.0038 (0.0068)	-0.0011 (0.0048)	none
New York	-0.014 (0.033)	0.0032 (0.0020)	0.0094 (0.0048)*	none
Oregon ^b	0.044 (0.027)	-0.0048 (0.0020)**	0.0013 (0.0050)	((1,2), 0)
Pennsylvania	-0.054 (0.029)*	0.0053 (0.0017)***	0.0157 (0.0037)***	none
South Carolina	0.043 (0.036)	-0.0014 (0.002)	0.0011 (0.0046)	none
Texas	0.012 (0.035)	-0.0004 (0.0026)	0.0151 (0.0067)**	none
Washington	0.004 (0.026)	0.0009 (0.0027)	0.0077 (0.0049)	((1,2), 0)
MODERATE AVERAGE	0.001 (0.008)	0.001 (0.001)*c	0.004 (0.002)**c	
Alaska	-0.077 (0.037)	0.0053 (0.0030)*	0.0024 (0.0033)	(1, 0)
Colorado ^b	-0.007 (0.028)	0.0011 (0.0035)	-0.0117 (0.0056)***	(1,0)
Illinois	-0.023 (0.029)	0.0066 (0.0018)***	0.0085 (0.0038)**	none

State	Total Alcohol B (SE)	Cigarettes B (SE)	Cirrhosis Mortality B (SE)	ARMA Terms
Iowa	0.002 (0.045)	0.0042 (0.0031)	-0.0002 (0.0066)	(1,0)
Kansas	-0.018 (0.052)	0.0024 (0.0029)	-0.0029 (0.0063)	none
Maine	0.020 (0.042)	0.0023 (0.0037)	0.0056 (0.0044)	none
MA/NH	0.009 (0.021)	0.0036 (0.0022)	0.0114 (0.0040)***	(1,0)
Michigan	-0.004 (0.035)	0.0031 (0.0017)*	0.0053 (0.0041)	none
Minnesota	0.037 (0.034)	0.0028 (0.0025)	-0.0041 (0.0050)	none
Missouri	-0.012 (0.039)	0.0040 (0.0024)	0.0083 (0.0056)	none
Montana	-0.013 (0.041)	0.0027 (0.0042)	0.0048 (0.0026)*	none
Nebraska	0.018 (0.041)	0.0058 (0.0034)	0.0027 (0.0040)*	none
Ohio	-0.046 (0.034)	0.0075 (0.0021)***	0.0115 (0.0046)***	none
Rhode Island	0.004 (0.039)	0.0011 (0.0025)	-0.0039 (0.0041)	(1,0)
South Dakota	0.032 (0.045)	0.0011 (0.0032)	-0.0002 (0.0021)	none
Vermont	0.013 (0.024)	0.0006 (0.0021)	0.0003 (0.0024)	none
Wisconsin	0.012 (0.026)	0.0026 (0.0034)	-0.0037 (0.0053)	none
WET AVERAGE	-0.002 (0.008)	0.004 (0.00005)***	0.002 (0.002)*^c	
OVERALL AVERAGE	0.003 (0.005)	0.002 (0.00005)***^c	0.003 (0.001)***^c	

SE, standard error.

* $P < .10$

** $P < .05$

*** $P < .01$.

^a Semi-log models using distributed lag total alcohol and adjusting for ICD changes (1968, 1979, 1999), as well as cirrhosis mortality and cigarette sales (also distributed lag). Oregon model does not adjust for ICD 1968, and models could not be fit for North Dakota or Wyoming.

^b < 35 observations included in time series.

^c Meta-analytic averages come from random effects models; all others come from fixed effects models.

Table 2

Results From Multivariate ARIMA Models^a Estimating Relationships Between Beer, Wine, Spirits, and IHD Mortality Rates

State	Beer B (SE)	Wine B (SE)	Spirits B (SE)	ARMA terms
Alabama	-0.117 (0.102)	-0.175 (0.264)	0.046 (0.087)	none
Arkansas	-0.238 (0.104)**	0.457 (0.344)	0.073 (0.110)	none
Georgia	0.004 (0.086)	-0.168 (0.212)	0.066 (0.056)	none
Indiana	-0.013 (0.102)	0.027 (0.305)	0.023 (0.091)	none
Kentucky	0.015 (0.114)	-0.364 (0.512)	0.148 (0.129)	none
Mississippi ^b	-0.096 (0.194)	0.327 (0.866)	-0.127 (0.311)	none
North Carolina ^b	0.052 (0.180)	-0.076 (0.290)	-0.080 (0.213)	none
Oklahoma ^b	0.007 (0.037)	0.180 (0.207)	-0.018 (0.048)	((1,2), 0)
Tennessee	-0.003 (0.087)	0.455 (0.469)	-0.050 (0.146)	none
Utah	-0.029 (0.139)	-0.458 (0.502)	0.174 (0.241)	none
West Virginia	0.230 (0.116) [†]	-0.653 (0.350)*	-0.064 (0.052)	(1,0)
DRY AVERAGE	-0.011 (0.026)	-0.045 (0.094)	0.007 (0.025)	
Arizona	-0.123 (0.081)	-0.062 (0.186)	0.027 (0.103)	none
California	-0.012 (0.076)	0.054 (0.087)	-0.007 (0.066)	none
Connecticut	-0.178 (0.107)	-0.031 (0.159)	0.159 (0.078)	none
Delaware	-0.020 (0.105)	-0.273 (0.184)	0.069 (0.067)**	none
DC/MD/VA	0.008 (0.062)	-0.159 (0.199)	0.031 (0.066)	none
Florida	-0.040 (0.043)	-0.054 (0.161)	0.001 (0.047)	none
Hawaii ^b	0.005 (0.053)	-0.596 (0.345)	0.039 (0.151)	(1,0)
Idaho	0.167 (0.117)	-0.139 (0.105)	-0.102 (0.165)	none
Louisiana	0.087 (0.072)	-0.099 (0.199)	0.102 (0.099)	(0,5)
Nevada	-0.021 (0.095)	-0.117 (0.105)	0.073 (0.034)**	(1,0)
New Jersey	-0.132 (0.108)	-0.106 (0.086)	0.071 (0.041)*	(1,0)
New Mexico	-0.057 (0.099)	-0.037 (0.269)	0.250 (0.119)**	(1,0)
New York	0.127 (0.102)	-0.107 (0.155)	-0.045 (0.069)	none
Oregon ^b	-0.022 (0.136)	0.210 (0.078)**	-0.089 (0.108)	((1,2), 0)
Pennsylvania	-0.089 (0.054)	-0.078 (0.215)	0.003 (0.082)	none
South Carolina	-0.242 (0.135)	0.308 (0.252)	0.116 (0.052)**	none
Texas	0.081 (0.087)	0.009 (0.139)	-0.114 (0.145)	none
Washington	-0.107 (0.052)	-0.073 (0.070)	0.145 (0.062)	(1,0)
MODERATE AVERAGE	-0.033 (0.017)*	-0.033 (0.030)*	0.057 (0.015)***	
Alaska ^b	-0.134 (0.083)	0.303 (0.169)	-0.298 (0.074)***	((1,2),0)
Colorado ^b	0.045 (0.091)	0.204 (0.221)	-0.106 (0.085)	(1,0)
Illinois	-0.132 (0.095)	-0.121 (0.176)	0.029 (0.045)	none
Iowa	-0.214 (0.132)	-0.389 (0.331)	0.330 (0.127)**	none
Kansas	-0.027 (0.099)	0.107 (0.383)	-0.028 (0.169)	none

State	Beer B (SE)	Wine B (SE)	Spirits B (SE)	ARMA terms
Maine	0.008 (0.088)	-0.117 (0.131)	0.172 (0.131)	none
MA/NH	-0.023 (0.096)	0.018 (0.132)	0.034 (0.079) *	(1,0)
Michigan	-0.295 (0.083) ***	0.043 (0.091)	0.127 (0.064) *	(1,0)
Minnesota	-0.077 (0.083)	-0.104 (0.247)	0.127 (0.058) **	none
Missouri	-0.022 (0.097)	-0.277 (0.231)	0.051 (0.080)	none
Montana	-0.060 (0.088)	0.015 (0.254)	0.033 (0.083)	none
Nebraska	-0.131 (0.132)	0.453 (0.370)	0.130 (0.105)	none
North Dakota	-0.050 (0.134)	-0.603 (0.454)	0.184 (0.114)	(1,0)
Ohio	-0.044 (0.068)	-0.088 (0.182)	-0.033 (0.075)	none
Rhode Island	-0.302 (0.204)	0.022 (0.164)	0.119 (0.101)	(1,0)
South Dakota	-0.012 (0.143)	-0.242 (0.570)	0.141 (0.129)	none
Vermont	0.046 (0.082)	-0.284 (0.143) *	0.065 (0.042)	none
Wisconsin	0.040 (0.080)	-0.082 (0.213)	0.016 (0.051)	none
Wyoming	-0.095 (0.101)	-0.779 (0.394) *	0.409 (0.154) ***	(2,1)
WET AVERAGE	-0.063 (0.022) **	-0.041 (0.042)	0.058 (0.030) **^c	
OVERALL AVERAGE	-0.037 (0.012) ***	-0.036 (0.024)	0.045 (0.014) ***^c	

SE, standard error.

* $P < .10$

** $P < .05$

*** $P < .01$.

^a Semi-log models using distributed lag for beer, wine and spirits and adjusting for ICD changes (1968, 1979, 1999), as well as cirrhosis mortality and cigarette sales (also distributed lag). Colorado, North Carolina and Oregon models do not adjust for ICD 1968.

^b < 35 observations included in time series.

^c Meta-analytic averages come from random effects models; all others come from fixed effects models.

Table 3

Effect of Alcohol Consumption on Overall and Sex-specific Ischemic Heart Disease Mortality Rates, United States, 1950-2002, From Panel Models^a Using Alcohol and Cigarettes With Distributed Lags^b

	Total Sample B (SE)	Men B (SE)	Women B (SE)
Model A:			
Total alcohol	0.022 (0.005) ***	0.034 (0.005) ***	0.020 (0.005) ***
Model B:			
Beer	-0.045 (0.011) ***	-0.042 (0.011) ***	-0.042 (0.012) ***
Wine	-0.055 (0.023) **	-0.056 (0.024) **	-0.058 (0.027) **
Spirits	0.097 (0.010) ***	0.117 (0.010) ***	0.091 (0.011) ***
Model C:			
Total alcohol	0.010 (0.005) **	0.020 (0.005) ***	0.006 (0.005)
Cigarette sales	0.002 (0.0003) ***	0.002 (0.0003) ***	0.002 (0.0003) ***
Model D:			
Total alcohol	0.008 (0.005) *	0.018 (0.005) ***	0.004 (0.005)
Cigarette sales	0.002 (0.0003) ***	0.002 (0.0003) ***	0.002 (0.0003) ***
Cirrhosis mortality	0.002 (0.001) ***	0.001 (0.0004) ***	0.002 (0.001) ***
Model E:			
Beer	-0.020 (0.010) **	-0.019 (0.011) *	-0.015 (0.012)
Wine	-0.042 (0.022) *	-0.044 (0.023) *	-0.037 (0.026)
Spirits	0.047 (0.009) ***	0.067 (0.010) ***	0.031 (0.011) ***
Cigarette sales	0.002 (0.0003) ***	0.002 (0.0003) ***	0.002 (0.0003) ***
Model F:			
Beer	-0.021 (0.010) **	-0.019 (0.011) *	-0.014 (0.012)
Wine	-0.038 (0.022) *	-0.042 (0.023) *	-0.035 (0.026)
Spirits	0.042 (0.009) ***	0.064 (0.010) ***	0.027 (0.011) **
Cigarette sales	0.002 (0.0003) ***	0.002 (0.0003) ***	0.002 (0.0003) ***
Cirrhosis mortality	0.002 (0.001) ***	0.001 (0.0004) ***	0.002 (0.001) ***

SE, standard error

* $P < .10$

** $P < .05$

*** $P < .01$.

^aSemi-logged, differenced generalized least squares (GLS) models allowing for panel heteroscedasticity and panel-specific, first-order autoregressive error structure. Models adjust for changes to ICD coding in 1958, 1968, 1979 and 1999.

^bAlcohol-only models include years 1950-2002. Models including cigarette sales span 1960-2002.

Table 4

Effect of Alcohol Consumption on Region-specific Ischemic Heart Disease Mortality Rates, United States, 1950-2002, From Panel Models^a Using Alcohol and Cigarettes With Distributed Lags^b

	Wet States ^c B (SE)	Moderate States ^d B (SE)	Dry States ^e B (SE)
Model A:			
Total alcohol	0.018 (0.007) **	0.022 (0.007) ***	0.029 (0.011) **
Model B:			
Beer	-0.065 (0.018) ***	-0.035 (0.017) **	-0.056 (0.027) **
Wine	-0.035 (0.042)	-0.056 (0.031) *	-0.162 (0.096) *
Spirits	0.103 (0.016) ***	0.091 (0.014) ***	0.125 (0.025) ***
Model C:			
Total alcohol	0.005 (0.007)	0.009 (0.007)	0.027 (0.010) ***
Cigarette sales	0.003 (0.001) ***	0.001 (0.0005) ***	0.002 (0.0005) ***
Model D:			
Total alcohol	0.003 (0.007)	0.006 (0.007)	0.025 (0.010) **
Cigarette sales	0.003 (0.001) ***	0.001 (0.0005) ***	0.002 (0.0005) ***
Cirrhosis mortality	0.001 (0.001) *	0.003 (0.001) ***	0.002 (0.001) **
Model E:			
Beer	-0.034 (0.017) **	-0.017 (0.016)	-0.009 (0.025)
Wine	-0.027 (0.038)	-0.053 (0.030) *	-0.096 (0.087)
Spirits	0.047 (0.015) ***	0.053 (0.014) ***	0.060 (0.023) **
Cigarette sales	0.003 (0.001) ***	0.001 (0.0005) ***	0.001 (0.0005) ***
Model F:			
Beer	-0.036 (0.017) **	-0.017 (0.016)	-0.010 (0.025)
Wine	-0.023 (0.038)	-0.050 (0.030) *	-0.088 (0.086)
Spirits	0.044 (0.015) ***	0.046 (0.014) ***	0.055 (0.022) **
Cigarette sales	0.003 (0.001) ***	0.001 (0.0005) ***	0.001 (0.0004) ***
Cirrhosis mortality	0.001 (0.001)	0.002 (0.001) ***	0.002 (0.001) **

SE, standard error

* $P < .10$

** $P < .05$

*** $P < .01$.

^a Semi-logged, differenced generalized least squares (GLS) models allowing for panel heteroscedasticity and panel-specific, first-order autoregressive error structure. Models adjust for changes to ICD coding in 1958, 1968, 1979 and 1999.

^b Alcohol-only models include years 1950-2002. Models including cigarette sales span 1960-2002.

^c Wet states include the North Central (AK, CO, IL, IA, KS, MI, MN, MO, MT, NE, ND, OH, SD, WI & WY) and New England (ME, MA/NH, RI & VT) regions.

^d Moderate states include the Middle Atlantic (CT, DE, DC/MD/VA, NJ, NY & PA), Pacific (CA, HI, ID, NV, OR & WA), and South Coast (AZ, FL, LA, NM, SC & TX) regions

^e Dry states include the Dry South (AL, AR, GA, IN, KY, MS, NC, OK, TN & WV) and Utah.