Beverage-Specific Associations with Drinking Driving Charges and Fatalities in Ontario

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Background
Interest in the differential effects of beer, wine and spirits has a long research history1,2. Many early studies showed that brandy given in the same doses as beer resulted in greater impairment and more aggressive responses (see Smart, 19963 for a review).

Despite the results of the early experiments referred to above, several studies have shown that beer drinkers are more likely to be involved in alcohol-related traffic accidents than are consumers of wine or spirits. For example, the Grand Rapids Study4 showed that among those involved in accidents, beer drinkers were over-represented in the higher blood alcohol groups. Perrine5 found that among drivers arrested in Vermont for drinking driving, 58% were beer drinkers, 12% were spirits drinkers and 3% wine drinkers. Also, Selzer et al.6 found that convicted drunk drivers drank more beer and less wine than drivers in general.

Several general population surveys have also shown that self-reported beer drinking and drinking driving are related, although the relationships may be complex. For example, Berger and Snortum7 interviewed 1,000 drivers in a national study in the USA. Preference for beer consumption predicted reported drinking driving violations, even when age, sex, marital status and education were controlled. The authors hypothesized a “beer culture” in which beer drinking is viewed as safe and DWI as “harmless.” Unfortunately, this study had a high refusal rate (41%). A survey study by Gruenewald et al.8 of six communities in the USA gave more complex results. These researchers found that frequent and heavy drinking as well as beer and spirits consumption predicted driving after drinking. However, factors of age, sex, education, income and place of drinking (outside the home) explained the relationships for beer. The authors concluded that “there is no direct effect of beer drinking on drinking-driving; rather, drinking-driving arises from the situational factors in which beer drinking takes place.”

Aside from the results of population surveys, there are no published studies of how consumption of different beverage types relates to drinking driving accidents or DWI charges. Somewhat contradictory predictions are elicited by the available literature. The early studies of psychomotor impairment and aggression suggest that spirits drinkers would have higher levels of impairment and hence more DWI charges and alcohol-related accidents. However, the survey studies suggest that beer drinkers, because of their more frequent drinking and driving events, should have more DWIs and alcohol-related accidents. Because of these apparent contradictions we have declined to make predictions about how trends in specific alcohol beverage consumption will be related to trends in DWIs and alcohol-related fatalities in this study. We believe that this study is the first to use time series analyses to examine these phenomena over a long period of time.
Objectives
Our study addresses the association of drinking driving fatal accidents and charges for impaired driving with beverage-specific alcohol consumption in Ontario, Canada. We examine data on beer, wine and spirits consumption as well as total alcohol consumption for the years 1963 to 1996. This is the longest period for which relationships between alcohol consumption by beverage type and drinking-related charges and fatalities have been studied using Canadian data. During that period the laws relating to drinking driving in Ontario were relatively stable except for the introduction in 1969 of the .08 law; in our analyses, we model the effects of that change.

Methodology
Rates of DWI charges and of alcohol-related fatal accidents were obtained from Ministry of Transportation reports. The total numbers of gallons of alcoholic beverages sold were obtained from 1963 to 1996 issues of "Statistics Canada - The Control and Sales of Alcoholic Beverages in Canada".

Total per capita consumption and beverage-specific consumption were expressed in absolute alcohol equivalents, which were calculated by dividing the total number of gallons sold (converted into litres by multiplying the sales gallonage by 4.546) by estimates of the alcohol content of specific beverages and then by the population aged 15 and older.

Times series analyses with auto-regressive integrated moving average (ARIMA) modeling techniques similar to those employed by other investigators were used to estimate the association of the various measures of alcohol consumption with alcohol-related driver fatalities and DWI charges for the period 1963-1996. The ARIMA technique requires stationarity and since our data showed strong time trends, the data were differenced. This means that yearly changes instead of raw data were analyzed for the models in Tables 1 and 2. Furthermore, the error-term structure, which includes other explanatory variables not considered in the model, was estimated in terms of autoregressive (AR) and moving average (MA) parameters.

The models fitted to our data were semi-logarithmic models based on the assumption that the effects of alcohol (beer, spirits or wine) interact with other factors contributing to fatal accidents and DWI charges. To interpret the results, we converted fatality and DWI coefficients from their semi-logarithmic form into attributable fractions, according to the Norström formula.

For both the alcohol-related fatal accidents and DWI charges series, we tested five models for incorporating beverage consumption into the analyses. In the first model (Model A in Tables 1 and 2) we incorporated total alcohol consumption. In Models B, C and D we incorporated beer, spirits and wine consumption respectively. Additionally, in all models in the alcohol-related fatal accidents series, rate of impaired driving charges was added as a control variable, because of its possible impact on alcohol-related accidents. Dummy variables for the year 1969 ( "0" before 1969, “1” otherwise) were included in all models to capture the effect of the lowering of BAC limits starting in 1969. Another dummy variable ("0" before 1972, “1” otherwise) was included in each series to capture the effect of the downward trend since 1972 in alcohol-related fatal accidents rates and DWI charges rates respectively. In each analysis, the model selected was one for which the Ljung-Box Q statistics and Jarque Bera test for normality of residuals were satisfactory, the noise parameters estimated for each model were below unity and a simple and reasonable structure was preserved. The Jarque Bera test for normality of residuals and Ljung-Box Q statistics are shown in both Table 1 and Table 2.
Results and Analyses
Figure 1 depicts rate of drinking driving fatalities (per 100,000 population), rate of DWI charges (shown here per 1,000 population), total per capita alcohol consumption, and the consumption of each of beer, spirits and wine in Ontario for the period, 1963 to 1996.

Table 1 shows the results of the analyses for alcohol-involved fatally injured drivers. Rates of drinking and driving fatal accidents (per 100,000 population) are associated with total alcohol consumption (per person aged 15 and over) (Model A), beer consumption (Model B) and spirits consumption (Model C). Wine consumption (Model D), though, shows no significant association with rate of fatal accidents over the period 1963-1996. Comparing these models we observe that the estimated effect parameter for beer consumption is higher than it is for spirits consumption or for total alcohol consumption. This means that a 1-litre increase in beer consumption entails a 41% increase in fatal accidents while the corresponding figures for spirits and total alcohol are, respectively, 18% and 12%. However, the standard error for the beer parameter is also relatively higher when compared with spirits and total alcohol effect parameters. The other input variable (rates of impaired driving charges) added to the models in Table 1 helped reduce unexplained variation in Models A to D. The estimated effect parameter for this variable is significant, though relatively small.
### Table 1: Comparison of models of total alcohol consumption and beverage-specific consumption predicting drinking and driving fatal accidents in Ontario, 1963-1996.

<table>
<thead>
<tr>
<th>Model</th>
<th>Total Alcohol</th>
<th>Beer</th>
<th>Spirits</th>
<th>Wine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect</td>
<td>SE</td>
<td>Effect</td>
<td>SE</td>
<td>Effect</td>
</tr>
<tr>
<td>Total Alcohol</td>
<td>0.112***</td>
<td>0.039</td>
<td>0.168**</td>
<td>0.070</td>
</tr>
<tr>
<td>Spirits</td>
<td>0.344***</td>
<td>0.10</td>
<td>0.002***</td>
<td>0.000</td>
</tr>
<tr>
<td>Beer</td>
<td>0.344***</td>
<td>0.10</td>
<td>0.002***</td>
<td>0.000</td>
</tr>
<tr>
<td>Dummy 69</td>
<td>-0.235***</td>
<td>0.085</td>
<td>-0.223**</td>
<td>0.089</td>
</tr>
<tr>
<td>Dummy 72</td>
<td>-0.358***</td>
<td>0.126</td>
<td>-0.51***</td>
<td>0.117</td>
</tr>
</tbody>
</table>

**Noise Parameters:**
- MA(1) 0.42*** 0.113
- MA(2) 0.77*** 0.120
- MA(3) -0.676*** 0.150 -0.88*** 0.06 -0.65*** 0.142
- MA(4) -0.21 0.148

**Tests:**
- Adjusted R-Squared 0.40 0.37 0.39 0.39
- Box-Ljung Q (lag 7) 5.115, p>0.529 4.76, p>0.574 4.02, p>0.547 1.56, p>0.91
- Jarque-Bera Normality 1.001, p>0.606 0.335, p>0.846 1.13, p>0.570 0.06, p>0.97

*a* Impdriv = Rate of driving while impaired charges.

*** p<0.01, ** p<0.05, * p<0.10

Table 2 shows the results of the analyses for rates of DWI charges. Rates of DWI charges (per 100,000 population) are associated with total alcohol consumption (per person aged 15 and over) (Model A), beer consumption (Model B) and spirits consumption (Model C). Wine consumption (Model D), though, shows no significant association with the rate of DWI charges over the period 1963-1996. Comparing these models we observe that the estimated effect parameter for spirits consumption is higher than it is for the consumption of beer, total alcohol or wine. This means that a 1-litre increase in spirits consumption entails a 22% increase in DWI charges while the corresponding figures for beer and total alcohol are, respectively, 12% and 11%. The dummy variables for the years 1969 and

### Table 2: Comparison of models of total alcohol consumption and beverage-specific consumption predicting "driving while impaired charges" in Ontario, 1963-1996.

<table>
<thead>
<tr>
<th>Model</th>
<th>Total Alcohol</th>
<th>Beer</th>
<th>Spirits</th>
<th>Wine</th>
</tr>
</thead>
<tbody>
<tr>
<td>Effect</td>
<td>SE</td>
<td>Effect</td>
<td>SE</td>
<td>Effect</td>
</tr>
<tr>
<td>Total Alcohol</td>
<td>0.099***</td>
<td>0.029</td>
<td>0.200***</td>
<td>0.045</td>
</tr>
<tr>
<td>Spirits</td>
<td>0.099***</td>
<td>0.029</td>
<td>0.200***</td>
<td>0.045</td>
</tr>
<tr>
<td>Beer</td>
<td>0.552***</td>
<td>0.049</td>
<td>0.503***</td>
<td>0.058</td>
</tr>
<tr>
<td>Dummy 69</td>
<td>0.106**</td>
<td>0.049</td>
<td>0.106**</td>
<td>0.050</td>
</tr>
<tr>
<td>Dummy 72</td>
<td>0.451**</td>
<td>0.186</td>
<td>0.883***</td>
<td>0.055</td>
</tr>
</tbody>
</table>

**Noise Parameters:**
- AR(3) 0.83 0.83 0.80 0.81
- MA(3) 0.451** | 0.186 | 0.883*** | 0.055 |

**Tests:**
- Adjusted R-Squared 0.83 0.83 0.80 0.81
- Box-Ljung Q (lag 7) 0.638, p>0.996 2.441, p>0.875 5.202, p>0.635 2.073, p>0.913
- Jarque-Bera Normality 3.22, p>0.200 1.066, p>0.587 2.25, p>0.32 0.957, p>0.620

*** p<0.01, ** p<0.05, * p<0.10
1972 are also significant. The inclusion of these two variables improved the overall fit of the models.

**Discussion**

These results suggest that aggregate measures of alcohol sales are strongly related to rates of drinking driving charges and fatality rates. Thus, they are in agreement with a large body of evidence from many jurisdictions\(^{15,16}\). Additionally, they underscore the value of prevention based on control of aggregate consumption levels in a population\(^{17,15,16}\). A recent WHO study\(^{18}\) indicated that alcohol control measures ranked with such measures as reduced legal limits and Administrative Suspensions in their demonstrated value in preventing deaths and injuries related to drinking driving and other alcohol-related problems.

The observation that beer sales were most strongly related to alcohol-related driver fatalities was consistent with the results of Gruenewald and Ponicki\(^{19}\). Beer has often been considered to be the beverage of moderation, and in Ontario it enjoys a preferential tax structure. However, these data suggest that this tax structure may in fact be contributing to deaths and injuries on our roads. The observation that spirits consumption is most strongly related to DWI charges, however, demonstrates an interesting divergence in the correlates of the two measures. Spirits consumption could represent heavier on-premise consumption, and thus the association may be accounted for by behavioural factors.

Even though beverage-specific associations were significant, it is also clear that total sales were significantly related to both charge and fatality rates. This is the indicator that has most frequently been linked with alcohol-related traffic problems\(^{15}\), and results of this study point to its continued value in this regard.

The present results also suggest that aggregate alcohol consumption measures provide a useful predictor of police activity, in the form of drinking driving charges. Analyses of drinking driving charges can help corroborate the results of the analyses of fatalities, as both should be reflecting the level of drinking and driving in a population and thus be related to measures of alcohol consumption. These observations also point to some of the social benefits that might be expected when alcohol consumption is controlled: in addition to fewer deaths and injuries on the roads, there is the anticipation of important cost savings due to reduced police and court costs.

**References**