WHAT FRACTION OF ALL TRAFFIC DEATHS ARE DUE TO ALCOHOL?

Leonard Evans
GM Research Labs, Warren, Michigan USA

Summary: The vast literature on alcohol's effect on traffic safety does not contain even a moderately satisfactory answer to this question. A flawed published estimate of 23.7% has been quoted widely. This paper summarizes a recent study using Fatal Accident Reporting System (FARS) data and published estimates on how alcohol affects crash risk. By categorizing all traffic fatalities as either non-occupants of vehicles, or occupants killed in single-vehicle, two-vehicle or three- or more vehicle crashes, and developing calculation procedures appropriate for each category, the fraction of all fatalities due to alcohol is inferred. The main finding is that eliminating alcohol would reduce traffic fatalities by \((47 \pm 4)\%\).

INTRODUCTION

The only study in the technical literature that provides a quantitative answer based on analyzing data to the question posed in the title is one published by Reed [1981] under the auspices of the National Academy of Sciences. The estimate obtained was 23.7%. This estimate has been highly influential and much quoted, such as in the following recent (1986 to 1988) examples: "The National Academy of Science's estimate is that about one-fourth of deaths and considerably less of injuries and property damage can be attributed to alcohol" [Ross 1988; p. 78]; "...if every drunk driver could be permanently removed from the roads -- an ideal hypothesis at best -- the wisest estimates suggest that the death toll would decline by only one-fourth" [Ross 1986; p. 169]; "The National Academy of Sciences estimated that if no one drove after drinking, 11,000 fewer persons annually would die in crashes, approximately a 20-25% annual reduction" [Hingson et al. 1988]; "...drunk driving can be held causally responsible for only about a quarter of traffic fatalities.." [Ross 1988; p. 75]; "...alcohol is implicated as a causal factor in a large proportion of serious crashes in the United States and Canada, although this proportion is not nearly as large as the 50% and higher frequency mentioned in the media, but more like a quarter of fatal crashes.." [Ross 1987; p. 475].

Below we present an abridgement based on that to appear in Evans [1991] of a recent study [Evans 1990] to estimate the fraction of traffic fatalities attributable to alcohol.

METHODS AND MATERIALS

Data on fatal crashes are obtained from the Fatal Accident Reporting System (FARS), a computerized data file maintained by the National Highway Traffic Safety Administration containing detailed information on all traffic crashes occurring in the United States since January 1, 1975 in which anyone was killed. Because the contribution of alcohol to traffic fatalities has been changing, we confine our attention to just one year's data, namely, that for 1987.

Blood Alcohol Concentration (BAC, measured as the percent, by weight, of alcohol in the blood) values are available for some, but not nearly all, persons coded in FARS. Availability is higher for drivers than for other road
users, higher for the fatally injured than for survivors, and varies widely from state to state. For example, the percent of fatally injured drivers with known BAC varies from 95.6% in Delaware to 9.3% in Mississippi. In order to avoid, to the extent possible, the types of biases which can arise when missing data are correlated with phenomena being investigated, we focus on drivers fatally injured in states which measure BAC for a large fraction of such drivers. Specifically, we use data from 26 states which measured BAC for over 84% of fatally injured drivers, the average for these states being 88%.

Table 1 shows information on all drivers (of any motorized vehicle, including motorcycles) and non-occupants (essentially pedestrians) killed in traffic crashes in these 26 states in 1987. The six BAC ranges recur, and will be referred to as $i = 1$ (for BAC = 0) through $i = 6$ (for BAC $\geq 0.2\%$). For expository convenience, the first range is designated BAC = 0, rather than the more strictly technically correct BAC < 0.001%.

Starting from the number of fatally injured drivers at a given BAC level, we estimate the number who would still have been killed even if alcohol-free. The risk-increasing effect of alcohol is quantified in terms of a relative risk factor, $R$, defined as

$$R(i) = \frac{\text{Risk that driver with BAC in range } i \text{ causes a crash}}{\text{Risk that driver with BAC = 0.0 causes a crash}}$$

Based on the tabulation in Evans [1990] of data in Borkenstein et al. [1964] we use $R(1) = 1$ (by definition), $R(2) = 0.88$, $R(3) = 1.98$, $R(4) = 10.1$, $R(5) = 31.9$ and $R(6) = 40.9$.

RESULTS

Single-vehicle crashes

Assume that $F(i)$ drivers in BAC range $i$ were killed in single-vehicle crashes. If these drivers had been at zero BAC, then a lesser number, namely $F(i)/R(i)$, would have been killed. Summing this quantity over the six BAC categories gives the number of fatalities prevented by eliminating alcohol, and dividing this by the original number gives the fraction eliminated. Applying this calculation to the data in Table 1 gives the fraction of single-vehicle fatalities attributable to alcohol as 55.2%.

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Table 1. Distributions of Blood Alcohol Concentrations (BAC) of fatally injured persons in the 26 states* in 1987 FARS data with BAC known for over 84% of fatally injured drivers. All values, except those in the bottom row, are percents. From Evans [1990].

<table>
<thead>
<tr>
<th>Blood alcohol concentration, BAC (%)</th>
<th>Drivers killed in crashes involving:</th>
<th>Non-occupants of vehicles</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>One vehicle</td>
<td>Two vehicles</td>
</tr>
<tr>
<td>1 0.00</td>
<td>35.23%</td>
<td>65.67%</td>
</tr>
<tr>
<td>2 0.001 - 0.049</td>
<td>3.35</td>
<td>4.22</td>
</tr>
<tr>
<td>3 0.050 - 0.099</td>
<td>6.75</td>
<td>5.24</td>
</tr>
<tr>
<td>4 0.100 - 0.149</td>
<td>12.11</td>
<td>5.61</td>
</tr>
<tr>
<td>5 0.150 - 0.199</td>
<td>16.80</td>
<td>7.31</td>
</tr>
<tr>
<td>6 &gt;= 0.200</td>
<td>25.76</td>
<td>11.95</td>
</tr>
</tbody>
</table>

All with known BAC 100.00 100.00 100.00 100.00 100.00

BAC unknown 10.55 14.06 13.32 12.12 27.08

Number of fatalities 5677 5016 683 165 3405

* The 26 states, identified by their postal codes, are:

CA CO CT DE HI ID IL IN ME MD MA MN MT
NE NV NJ NM NC OR SD VT VA WA WV WI WY

Multiple-vehicle crashes

The much lower alcohol use by those involved in two-vehicle crashes compared to those involved in single-vehicle crashes, as is apparent in Table 1, has often contributed to a general impression that the role of alcohol in driver...
fatalities was primarily a single-vehicle-crash phenomenon. This impression can be quite deceptive because, while none of the zero BAC drivers killed in single-vehicle crashes died because of alcohol, many of the zero-BAC drivers killed in multiple vehicle crashes did. It is accordingly necessary to model the multiple-vehicle crash process to deduce the contribution of alcohol from the data in Table 1. This is done in Evans [1990] by assuming that the number of crashes between drivers in the ith and jth BAC categories is proportional to the number of vehicles in the ith category times the risk factor for the ith category times the corresponding quantities for the jth category. Applying this model to the data in Table 1 gives that 45.0% of driver deaths in two-vehicle crashes are attributable to alcohol. The 45% consists of a 17.0% contribution from drivers with BAC = 0 and a 28.0% contribution from drivers with BAC > 0. The use of alcohol by other drivers increases the number zero-BAC drivers killed in two-vehicle crashes by 35%.

An extension of the model to three-vehicle crashes gives that 43.8% of drivers killed in such crashes would not have died if alcohol had not been present. The same value is assumed to apply to the small numbers of drivers killed in crashes involving four or more vehicles.

Non-occupants

The question of non-occupants (essentially pedestrians) is more uncertain. If one assumes that the distribution in time of pedestrian risk is similar to that for driver fatalities in single-vehicle crashes, and that vehicles strike pedestrians in proportion to the rate they strike other objects, then eliminating alcohol would reduce pedestrian fatalities in the same proportion it reduces single-vehicle driver fatalities, namely, 55%. However, pedestrian deaths tend to occur at times more like those for driver deaths in two-vehicle, not single-vehicle, crashes. It might therefore be more appropriate to consider drivers crashing into pedestrians at the same rate they crash into other vehicles. Such a calculation estimates that eliminating driver alcohol use would reduce pedestrian fatalities by 26%. However, this calculation ignores alcohol use by pedestrians, an assumption that the data in the last column of Table 1 unmistakably refute. Clearly, alcohol use by pedestrians contributes to pedestrian fatality risk, as has been shown in a case-control study by Blomberg and Fell [1979]. The similarity of the distributions by alcohol use for pedestrians and drivers killed in two-vehicle crashes leads Evans [1990] to conclude that the fraction of pedestrian deaths attributed to alcohol is similar to the fraction for two-vehicle crashes, namely 45%.

Overall fatality reductions if zero alcohol use

The estimates of the fraction of driver fatalities attributable to alcohol for single-vehicle crashes, two-vehicle crashes, three- or more vehicle crashes based on data from 26 states are shown in Table 2. Also shown is the distribution of all 1987 fatalities into these same categories; it is assumed that passenger risk changes in proportion to the risk of their drivers. By weighting the percent attributable to alcohol in each category by the fraction of all fatalities due to that crash category we compute that 49% of the fatalities in the 26 states are attributable to alcohol. In order to obtain an estimate for the US, Evans [1990] applies a correction factor based on discriminant factor analyses [Klein 1986; Fell and Klein 1986; Fell and Nash 1989] which showed that in 1987 in the US 46.6% of fatally injured drivers has
BAC > 0. The corresponding value for the 26 states is 48.9% (Table 1). The closeness of this to the fraction of fatalities attributable to alcohol suggests that a simple multiplicative factor should provide a satisfactory rescaling. Accordingly, all the estimates based on the 26 states were multiplied by 46.6/48.9 = 0.953 to generate the values shown in Table 2. Thus the fraction of US fatalities that would be prevented by eliminating alcohol is estimated to be 46.7%, or (47 ± 4)% based on the error analysis in Evans [1990]. Eliminating alcohol in 1987 would therefore have prevented about 22,000 of the 46,386 fatalities.

Table 2. Fraction of fatalities attributable to alcohol (based on 46,386 traffic fatalities in 1987). From Evans [1990].

<table>
<thead>
<tr>
<th>Source of fatalities</th>
<th>Percent of all fatalities</th>
<th>Pct due to alcohol</th>
<th>No. of fatalities preventable by eliminating alcohol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Occupants killed in:</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1-vehicle crashes</td>
<td>40.24%</td>
<td>55.2%</td>
<td>9,818</td>
</tr>
<tr>
<td>2-vehicle crashes</td>
<td>37.00</td>
<td>45.0</td>
<td>7,363</td>
</tr>
<tr>
<td>&gt; 3-vehicle crashes</td>
<td>6.03</td>
<td>43.8</td>
<td>1,168</td>
</tr>
<tr>
<td>Non-occupants</td>
<td>16.73</td>
<td>45.0</td>
<td>3,329</td>
</tr>
<tr>
<td>Total (or average)</td>
<td>100.00</td>
<td>(49.0%)</td>
<td>(46.7%)</td>
</tr>
</tbody>
</table>

The estimate is based on assuming that if drivers with a given BAC level did not consume alcohol, they would drive at the same risk level as average drivers with BAC = 0 observed at similar places on similar occasions. Although there are clear indications that heavy users of alcohol differ from the general public in ways other than their alcohol use [Donovan, Marlatt and Salzberg 1983; Stutker, Brantley and Allain 1980], and that such differences could lead to different crash rates even when alcohol-free [McCord 1984], there does not appear to be sufficiently firm quantitative information to modify the above estimate. Any such effect would tend to lower the fatality reductions associated with eliminating alcohol.

Other studies report that alcohol has a large role in traffic fatalities. Donelson et al. [1989] conclude that 50% of fatal crashes in British Columbia, Canada, were due, at least in part, to alcohol use among drivers and pedestrians. Data in Stein [1989, Table 13] indicate that 66% of single-
vehicle driver fatalities are attributable to alcohol, somewhat higher than the values in Table 2 for such crashes. A higher value is to be expected in the Stein [1989] data because it refers to an earlier period (1983 - 1985) when alcohol played a larger role (as discussed later).

Effect of eliminating drunk driving rather than alcohol

Setting the maximum BAC equal to the highest of the categories still legal in most (but not all) US states, namely 0.05% to 0.099%, for which \( R(3) = 2.98 \), leads to an overall reduction in fatalities of 41%, compared to the 47% estimate for all drivers at zero BAC [Evans 1990]. That is, all drivers with illegal levels of BAC acquiring a distribution of BAC similar to that presently observed for drivers with BAC between 0.050% and 0.099% would reduce traffic fatalities by 41%. Setting the maximum risk level at other values generates the following percent declines in fatalities: 44% for a maximum risk of 1.5; 39% for a maximum risk of 3; 34% for a maximum risk of 6; 26% for a maximum risk of 10. The results of Borkenstein et al. [1964] suggest that a driver at 0.10% BAC has a risk of causing a crash about 6 times that of a zero BAC driver, suggesting that if all legally drunk drivers changed to marginally legal levels of just under 0.10% BAC, traffic fatalities would decline by 34%.

Changes in the role of alcohol

The simple multiplicative approach used to extrapolate from the 26 states to the US can be used also to monitor changes in the role of alcohol in traffic fatalities. The previously mentioned discriminant analysis applied to 1982 FARS data showed 53.1% of fatally injured drivers had BAC > 0 (compared to 46.6% in 1987). From these data Evans [1990] estimates that eliminating alcohol would have prevented 53.2% of 1982 fatalities compared to 46.7% of 1987 fatalities. Hence, in 1982, alcohol increased fatalities to 2.14 times the zero-alcohol number, compared to 1.88 in 1987, implying a reduction in fatalities of \( 0.26/2.14 = 12.1\% \) from 1982 to 1987 attributable to reduced alcohol use. The decline in the crashes specifically attributable to alcohol (all minus those not attributable to alcohol), from 1.14 to 0.88, represents a 23% decline. The reduction, equivalent to 6400 fewer fatalities in 1987, helps explain why national fatalities did not increase during a time of economic expansion, as predicted by the multivariate model of Partyka [1984]. Any measure which reduces the fraction of fatalities attributable to alcohol from the 1987 value of 47% to, say, 42% (that is, a reduction of 10% in the 1987 value) is calculated to generate an overall fatality reduction of 8.6%.

REFERENCES


Borkenstein, R.F.; Crowther, R.F.; Shumate, R.P.; Ziel, W.B.; Zylman, R. The role of the drinking driver in traffic accidents. Department of Police Administration, Indiana University, 1964.


