Official blame for drivers with very low blood alcohol content: there is no safe combination of drinking and driving

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ABSTRACT

Background Some laboratory studies find that driving is impaired even at blood alcohol content (BAC)=0.01%. However, no real-world traffic studies have investigated whether minimally ‘buzzed’ drivers (BAC=0.01%) are more likely to be blamed for a crash than are the sober drivers they collide with.

Purpose To determine whether official blame for a crash increases significantly at BAC=0.01%.

Methods We examined the relationship between the driver’s BAC and the degree to which he or she was assigned sole official blame (SOB) for the crash. We analysed an official, exhaustive, nationwide US database (Fatality Analysis Reporting System; n=570 731), covering 1994–2011.

Results Even minimally ‘buzzed’ drivers are 46% (24–72%) more likely to be officially blamed for a crash than are the sober drivers they collide with (χ²=20.45; p=0.000006). There is no threshold effect—no sudden transition from blameless to blamed drivers at BAC=0.08% (the US legal limit). Instead, SOB increases smoothly and strongly with BAC (r=0.98 (0.96–0.99) for male drivers, p<0.000001; r=0.99 (0.97–0.99) for female drivers, p<0.000001). This near-linear SOB-to-BAC relationship begins at BAC=0.01% and ends around BAC=0.24%. Our findings persist after controlling for many confounding variables.

Conclusions There appears to be no safe combination of drinking and driving—even minimally ‘buzzed’ drivers pose increased risk to themselves and to others. Concerns about drunk driving should also be extended to ‘buzzed’ driving. US legislators should reduce the legal BAC limit, perhaps to 0.05%, as in most European countries. Lowering the legal BAC limit is likely to reduce injuries and save lives.

BACKGROUND

Each year since World War II, traffic crashes have been the leading source of fatal US injuries (1946–2010).1 When final, official mortality data become available for 2011, fatal unintentional poisonings will probably outnumber traffic fatalities. Nonetheless, for the last two decades for which we have final, official data (1991–2010), total traffic fatalities greatly outnumber every other type of fatal injury: traffic fatalities (832 062), suicides (643 976), homicides (393 512) and unintentional poisonings (345 529).2 Thus, for the approximate period examined in our study, US traffic crashes have been the major cause of fatal injuries.

Intoxicated drivers are a major risk factor for traffic crashes.2–4 Consequently, US laws prescribe strong sanctions for drivers with high blood alcohol content (BAC≥0.08%). In practice, judges, police and the public have treated BAC=0.08% as a sharp, meaningful boundary: drivers above this boundary are harshly punished, while those below are treated leniently.5–10 Henceforth, for brevity, we describe BAC as, for example, 0.08 rather than 0.08%.

Several considerations suggest that low driver BAC (<0.08) might also increase the risk of death and injury. A comprehensive review of 400 laboratory studies11 concluded, “There is no driving-related performance category for which a sudden transition from unimpaired to impaired occurred at a particular BAC level.” “There is no evidence of a threshold effect for alcohol.” Instead, several laboratory studies indicate that impaired driving increases smoothly and continuously with BAC, beginning at BAC=0.01.11 12

Some non-laboratory evidence supports these findings. Two small-scale investigations of Baltimore crashes found no evidence of a threshold effect: there is no abrupt increase in driver culpability at BAC=0.08.11 12 One large-scale study of US crashes found that even minimally ‘buzzed’ drivers (BAC=0.01) are associated with significantly more dangerous crashes than are sober drivers.13 A review of European, Australian and Japanese studies14 found that the risk of injuries and deaths declined when the legal BAC limit was reduced to 0.05. Partly because of findings like these, the U.S. National Highway Traffic Safety Administration launched the ‘Buzzed driving is drunk driving’ campaign,17 18 and the National Transportation Safety Board recommended lowering the US legal BAC limit to 0.05.19

Earlier studies of BAC and driver culpability were limited in several ways: they examined small13 14 20–22 geographically non-representative13 14 20–22 samples. In addition, they did not examine BAC in detailed 0.01 categories13 14 20–22 and did not examine possible culpability associated with minimally ‘buzzed’ drivers (BAC=0.01).13 14 20–22 Finally, earlier studies13 14 20–22 examined a few individual ‘blame factors’ (like speeding) but did not consider many others like driving on the wrong side of the road or driving through red lights.

Our study avoids all five of these limitations—we examine (1) many cases (n=570 731), (2) a nationwide dataset and (3) BAC in 0.01 increments. In addition, (4) we examine (among other groups) minimally ‘buzzed’ drivers and (5) more than 50 blame factors, including driving on the wrong side of the road, driving through red lights, making improper turns, running off the road, etc.23
Using this large-scale, detailed approach, we examine the relationship between the driver’s BAC and the degree to which the driver is officially blamed for the crash. We focus particularly on ‘buzzed’ drivers (BAC=0.01–0.07) and, within this group, on drivers who are minimally ‘buzzed’ (BAC=0.01). To conduct this investigation, we use standard, elementary epidemiological and biostatistical measures, primarily the 95% CI.24–26

METHODS
Two official sources provide information on US traffic fatalities: (1) the National Center for Health Statistics, which describes each cause of death;1 and (2) the Fatality Analysis Reporting System (FARS), which is limited to traffic crashes.27 We used FARS for two reasons: first, FARS provides more recent data (2011 vs 2010). Second, it provides much more detail. For example, only FARS records the driver’s BAC, speed and responsibility for the crash. FARS, available online from 1994 to 2011, covers all police-reported, fatal, US traffic crashes. There is no equivalently exhaustive database for non-fatal traffic crashes. An alternative FARS ‘imputation’ dataset28 that estimates BAC when BAC is unmeasured cannot be used in our analyses. Some of our analyses require detailed BAC in 0.01 increments, but the imputation dataset provides only three broad categories of imputed BAC: BAC=0.00, BAC=0.01–0.09 and BAC=0.10+.29

BAC is not always measured, but it is not clear how unmeasured BAC could bias our findings and conclusions. Nonetheless, we provide an empirical test of the hypothesis that our results are an artefact of unmeasured BAC.

We sought to determine whether the driver’s BAC was related to the driver being solely and officially blamed for the crash. FARS codes the driver’s responsibility for the crash in more than 50 individual ‘driver factors,’ for example, “driver factor #51: driving on wrong side of road.”30 One of these driver factors (#5) is defined as “under the influence of alcohol, drugs or medication”. Thus, both driver BAC and driver factor #5 reflect the presence of alcohol. Driver BAC and driver responsibility would necessarily be correlated if driver factor #5 were included in the analyses. Consequently, we dropped factor #5 from the analysis of every crash.

These driver factors were determined by the police officer(s) who investigated the crash. We found no study that measures the reliability and validity of these police determinations. We sought to address the issue of driver factor validity by identifying factors with high face validity, that is, factors likely to be correctly measured. These factors (which we termed ‘unambiguous driver factors’) are listed below, together with the associated FARS code number:

#28: Failure to keep in proper lane or running off road.
#29: Illegal driving on road shoulder, in ditch or sidewalk or on median.
#33: Passing where prohibited by posted signs, pavement markings, hill or curve, or school bus displaying warning not to pass.
#34: Passing on wrong side.
#40: Passing through or around barrier.
#47: Making right turn from left turn lane; making left turn from right turn lane.
#48: Making improper turn.
#50: Driving wrong way on one-way traffic way.
#51: Driving on wrong side of road.

FARS31 gives detailed examples for each driver factor. For example, factor #51 includes “driving wrong way on rotary intersection”. Throughout this study, we display separate analyses of (a) the relationship between driver BAC and all driver factors and (b) the relationship between driver BAC and unambiguous driver factors.

For each BAC category, we measured sole official blame (SOB):

\[
SOB = \frac{\# \text{ of drivers officially and solely blamed for the crash}}{\# \text{ of drivers officially assigned no blame for the crash}}
\]

Thus, for example, SOB=3 for BAC=0.13 means there are three times as many BAC=0.13 drivers who are officially and solely blamed for the crash as are held blameless. We did not examine the small fraction (7.87%) of crashes where multiple drivers were blamed for the same crash.

The phrase ‘officially blamed’ signifies that the official crash investigator(s) considered that the driver had contributed to the crash, for example, by speeding, driving through a red light, etc.

The phrase ‘SOB’ signifies that only one driver in a crash was officially considered to have contributed to that crash. Our measure, the SOB ratio, is new to the literature.

SOB is not the only intuitively plausible measure of blame. We also examined the percentage blamed for the crash (P). With this measure, for each BAC category, we examine

\[
P = 100 \times \frac{\# \text{ of drivers officially and solely blamed for the crash}}{\text{total } \# \text{ of drivers involved in the crash}}
\]

Algebraically, P and SOB are strongly related: the larger the value of P, the larger the value of SOB. Thus, there is a rank order correlation of 1.00 between the two measures. Both measures are plausible, intuitively meaningful and yield identical conclusions. In this paper, we rely primarily on SOB, but also use P in one analysis.

Many of our analyses take advantage of a ‘natural experiment’ involving a two-vehicle collision between a sober and a drinking driver. Because the two drivers collide in exactly the same circumstances and at exactly the same time, this natural experiment automatically standardises many potentially confounding variables, including

1. atmospheric condition (eg, fog)
2. light condition
3. number of travel lanes
4. relation to traffic junction (eg, intersection)
5. relation to trafficway (eg, shoulder)
6. roadway alignment (eg, curve)
7. roadway function class (eg, urban-local)
8. roadway profile (eg, hillcrest)
9. roadway surface condition (eg, ice)
10. roadway surface type (eg, dirt)
11. traffic control device function (eg, device not functioning)
12. trafficway flow (eg, divided highway)
13. work zone (eg, construction)
14. county
15. minute of crash
16. day of week of crash
17. month of crash
18. year of crash
19. exact date of crash (thus enabling controls for the effects of holiday-related crashes).

To cite a specific example: one such two-vehicle crash could occur in Boston, 33 yards from a downtown bar, in the rain, at midnight, on Valentine’s Day, in 1998.
This natural experiment precisely controls for billions of continuous and dummy variables. For example, the two vehicles collide in exactly the same county (there are 3141 US counties), on exactly the same day of the year (n=365), at exactly the same time of day (n=1440 min), in exactly the same year in our dataset (n=16), etc. Thus, even if one standardises on only 4 of the 19 abovementioned variables (county, day, time of day and year) there are $3141 \times 365 \times 1440 \times 16 = 26\,414\,553\,600$ dummy variables controlled for. Some variables, like age, sex and race of driver, were corrected for less precisely (as described later).

Following official recommendations and our long-standing practice, we calculate CIs and significance levels even though we examine complete counts, not samples. As in previous work, our study design allows examination of numbers of events, rather than of rates.

RESULTS

Figure 1 shows how official blame for a fatal crash is related to the driver’s BAC. For clarity, the BAC value on the horizontal axis has been multiplied by 100; thus a value of BAC=8 on the graph actually represents BAC=8/100=0.08. Each point on this graph indicates the SOB for drivers with a particular BAC. The thin vertical line around each point represents the ‘margin of error’: the 95% CI for the value of SOB. The solid line in each panel describes all blame factors; the dotted line describes unambiguous blame factors.

One can illustrate these general statements by referring to the topmost line, which gives information on all blame factors for male drivers. At BAC=0.08 for this group, SOB is about 5. Thus, for male drivers with BAC=0.08, there are about five times as many drivers who are officially and solely blamed for the crash as are held blameless. To simplify the discussion, we have described this SOB as ‘about 5’. The precise value is 5.70, with a 95% CI of 5.21 to 6.23. In short, at BAC=0.08, SOB=5.70 (5.21–6.23).

Four patterns are evident for the male drivers (figure 1, top panel):

1. Even minimally buzzed drivers are much more likely than sober drivers to be blamed for a crash: SOB for minimally ‘buzzed’ drivers is 2.45 (2.27–2.64) vs 1.54 (1.53–1.56) for sober drivers. Because the two CIs (2.27 to 2.64 and 1.53 to 1.56) do not overlap, there is a statistically significant difference between the SOB for minimally ‘buzzed’ and sober drivers. Because the two CIs are so far apart, the difference between sober and minimally ‘buzzed’ drivers is highly statistically significant: $p<0.000001$; $\chi^2=143.52$; 1 df.

2. SOB does not increase abruptly at BAC=0.08: there is no threshold effect at the legal US limit for intoxicated driving.

3. For BAC from 0.00 to 0.24, the higher the driver’s BAC, the more likely the driver is to blamed for the crash. For this

![Figure 1](https://example.com/figure1.png)

**Figure 1** Sole official blame ratio (SOB), by driver’s sex and blood alcohol concentration, for all* driver factors and for unambiguous driver factors, **USA, 1994–2011.** Driver factor #5** was omitted in this and all other analyses. See ‘Methods’ section for further details and for the formula for the SOB ratio. The solid line for ‘all blame factors’ is higher than the dotted line for ‘unambiguous blame factors’ because many more blame factors are examined. See ‘Methods’ section for the formula for the SOB ratio. Data provided by Fatality Analysis Reporting System. Error bars were calculated using formulas provided by Daly & Bourke.
range, BAC and SOB are almost perfectly correlated ($r=0.98$ (0.96–0.99); $t=24.7$; $n=25$; $p<0.000001$).

4. Above $\text{BAC}=0.24$, SOB holds steady for exceptionally drunk drivers.

These patterns hold when one considers all blame factors (solid line) or unambiguous blame factors (dotted line). The unambiguous blame factors (like driving on the wrong side of the road) are listed in the ‘Methods’ section.

The four male patterns described above are also evident for female drivers (figure 1, bottom panel).

The unmeasured BAC hypothesis

An important feature of figure 1 is the high SOB for ‘buzzed’ versus sober drivers: 3.39 vs 1.62. Thus, for figure 1, the SOB-‘buzzed’/SOB-sober ratio is 3.39/1.62 = 2.09. Thus, SOB for ‘buzzed’ drivers is more than double SOB for sober drivers.

Driver BAC is not always measured, but it is not obvious how unmeasured BAC could produce a high SOB-‘buzzed’/ SOB-sober ratio. Nonetheless, we considered whether unmeasured BAC could elevate SOB for ‘buzzed’ versus sober drivers. According to this ‘unmeasured BAC’ hypothesis, when the proportion of unmeasured BAC is large, the SOB-‘buzzed’/SOB-sober ratio should also be large; conversely, when the proportion of unmeasured BAC is small, the SOB-‘buzzed’/SOB-sober ratio should also be small. Thus, states that have a great deal of unmeasured BAC should generally have large SOB-‘buzzed’/SOB-sober ratios, while states with little unmeasured BAC should generally have small ratios. In short, if the SOB-‘buzzed’/SOB-sober ratio is high because of unmeasured BAC, there should be a positive state-by-state correlation between the proportion of unmeasured BAC and the SOB-‘buzzed’/SOB-sober ratio. In fact, however, this correlation is negative: $r=−0.19$; $n=51$; $t=−1.36$. Thus, the state-by-state analysis yields findings opposite to those predicted by the ‘unmeasured BAC hypothesis’.

Later, we assess additional alternative explanations for our findings.

Relationship between SOB and BAC after standardising for 13 confounding variables

Online supplementary table 1 examines 55 subgroups, which vary according to the driver’s sex, race, Hispanic status, age, etc. Each cell displays SOB and (in parentheses) the 95% CI. Each column provides information on a different BAC category, ranging from sober (on the left) to extremely drunk (on the right). The major rows represent confounding variables that are controlled for. For example, sober male drivers have SOB=1.54 with a 1.53 to 1.56 CI. In contrast, ‘buzzed’ male drivers have SOB=3.41 with a 3.30 to 3.52 CI. Because the two CIs (1.53 to 1.56 and 3.30 to 3.52) do not overlap, the difference between these two SOBs is statistically significant.

The patterns in figure 1 generally persist in online supplementary table 1. In all 55 subgroups, SOB for ‘buzzed’ drivers exceeds SOB for sober drivers; in 53 of the 55 subgroups, SOB for ‘buzzed’ drivers significantly exceeds SOB for sober drivers. As in figure 1, the higher the BAC, the higher the SOB, and the SOB-to-BAC relationship flattens at high BAC.

Relationship between SOB and BAC in two-vehicle collisions: a natural experiment

Online supplementary table 1 standardises on 13 important confounding factors. However, this list is not exhaustive and does not include factors such as county, weather or road surface. To standardise simultaneously on billions of factors, we took advantage of a ‘natural experiment’—we examined two-vehicle collisions. In these collisions, the two vehicles crash at exactly the same time, in exactly the same place, in exactly the same weather, on exactly the same road surface, etc. For example, one such two-vehicle crash could occur in Chicago, 22 yards from a police station, in the snow, at 01:00, on Christmas, in 2009.

Figure 2 examines the natural experiment in two circumstances: (a) all driver factors (top panel) and (b) unambiguous driver factors (bottom panel). For clarity, the value of BAC on the horizontal axis has been multiplied by 100; thus a value of BAC=8 on the graph actually represents BAC=8/100 = 0.08. The height of each bar indicates the SOB for drivers with a particular BAC. The thin vertical lines represent the 95% CIs for the value of SOB. The dark bars in each panel describe drivers who tested positive for alcohol; the light bars describe sober drivers.

We considered four variants of this natural experiment. Variant 1 involves two-vehicle collisions between a sober and a ‘buzzed’ driver. (The leftmost pair of bars describes this variant.) The remaining three variants also involve two-vehicle collisions between a sober and a drinking driver, but the BAC of these drinking drivers changes from variant to variant. In variant 2, the drinking driver’s BAC=0.08–0.15; in variant 3, BAC=0.16–0.23; in variant 4, BAC≥0.24. (The rightmost pair of bars describes this variant.)

Both panels show the same SOB-to-BAC relationship even after billions of factors are standardised. First, when a drinking driver collides with a sober driver, the drinking driver is much more likely to be officially blamed even when that driver is merely ‘buzzed’. This is evident because the dark bars are always significantly higher than the light bars: for each pair of bars, the CIs for the light and dark bars never overlap. Second, the higher the driver’s BAC, the more likely he or she is to be officially assigned sole blame for the crash: the difference between the dark and light bars increases with the driver’s BAC.

The relationship of blame to low-BAC drivers is further explored in figure 3. Like figure 2, figure 3 examines two-vehicle crashes between a sober and a drinking driver. However, unlike figure 2, figure 3 divides low-BAC drivers into eight detailed BAC groups, by 0.01 increments: group 1: the sober driver collides with a BAC=0.01 driver; group 2: the sober driver collides with a BAC=0.02 driver, ..., group 8: the sober driver collides with a BAC=0.08 driver. As in figure 2, the dark bars describe drinking drivers, and the light bars describe sober drivers.

When analysing the natural experiment, we supplemented SOB with another intuitive measure of blame. P is the percentage of two-vehicle crashes where the drinking driver (or the sober driver) is officially blamed for the crash. The patterns for SOB (top panel) and for P (bottom panel) are very similar. For each pair of bars in a panel, the CIs for the light and dark bars never overlap. Thus, the dark bars are always significantly higher than the light bars. In sum, both panels reveal that the drinking driver, no matter how low his or her BAC is, is much more likely than the sober driver to be officially assigned sole blame for the crash.

It is particularly interesting to examine the percentage blamed in a crash between a sober and a minimally ‘buzzed’ driver (figure 3, bottom panel, leftmost pair of bars). For minimally ‘buzzed’ drivers, the percentage blamed is 59.38. For the sober drivers they collide with, the percentage blamed is 40.62. 59.38/40.62=1.46; thus, the minimally ‘buzzed’ driver is 46% more likely to be blamed than the sober driver he or she collides with. This finding can be re-expressed more technically, with CIs and a significance level: 46% (24% to 72%); $\chi^2=20.45$; $p=0.000006$; 1 df.
The crashes in figures 2 and 3 involve two-vehicle collisions between a sober and a drinking driver. We also examined two-vehicle collisions in which both drivers were drinking: one driver’s BAC=0.05–0.07; the other driver’s BAC=0.08. By the standards of almost all European countries, both drivers are legally drunk; by US standards, however, only one of the two drivers is legally drunk. Contrary to what US legislators might expect, the driver not considered drunk by US standards has an SOB just as high as the driver who is considered drunk by US standards: SOB=1.71 (0.49–4.00) for BAC=0.05–0.07 vs SOB=0.67 (0.16–1.40) for BAC=0.08. Because the CIs (0.49 to 4.00 vs 0.16 to 1.40) overlap, there is no statistically significant difference between the SOB of ‘buzzed’ versus drunk drivers in this analysis.

**Relationship between SOB and BAC for individual driver factors**

The previous analyses combined various driver factors. In contrast, table 1 examines common driver factors separately. As in online supplementary table 1, each column describes a different BAC category, ranging from sober (on the left) to extremely drunk (on the right). Each row in this table represents a blame factor that is controlled for. For example, sober drivers who failed to keep in the proper lane had SOB=0.81, with a 0.80 to 0.82 CI. In contrast, extremely drunk drivers who failed to keep in the proper lane had SOB=8.40 with a 7.99 to 8.83 CI.

Table 1 patterns are consistent with our previous findings: (1) SOB and BAC are strongly correlated for most individual driver factors, (2) there is no threshold effect around BAC=0.08 and (3) the SOB-to-BAC relationship flattens at high BAC.

In sum, we used two methods for controlling extraneous variables: method 1 (see online supplementary table 1) mainly controls on driver variables (like sex and race) and vehicle variables (like speed and age of vehicle). Method 2 (figures 2 and 3) controls on the circumstances in which the crash occurred, for example, time and place of crash, weather, road surface and visibility. Regardless of the method used to control extraneous variables, the SOB-to-BAC relationships persist.

**DISCUSSION**

Our study generated two main findings: (1) even minimally ‘buzzed’ drivers (BAC=0.01) are 46% (24–72%) more likely to be officially blamed for a crash than are the sober drivers they collide with ($\chi^2=20.45; \ p=0.000006; \ 1\ df$). (2) There is no threshold effect—no sudden transition from blameless to blamed drivers at BAC=0.08 (the US legal limit for intoxicated driving). Instead, SOB increases smoothly and very strongly with BAC ($r=0.98 \ (0.96–0.99)$ for male drivers, $p<0.000001$; $r=0.99 \ (0.97–0.99)$ for female drivers, $p<0.000001$). This near-linear SOB-to-BAC relationship begins at BAC=0.00 and ends around BAC=0.24.

Many of our analyses (figures 2 and 3) involve two-vehicle collisions between a drinking and a sober driver. In these collisions, the two drivers collide in exactly the same circumstances with respect to time of day, day of week, month of year, weather, road and traffic conditions, lighting, etc. Thus, these two-vehicle collisions constitute a natural experiment, which controls simultaneously for billions of variables. Even after controlling for these confounding variables, our findings persist.

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**Figure 2** Sole official blame ratio (SOB) for two-vehicle collisions between a sober driver and four types of drinking drivers, USA, 1994–2011. The bars in the top panel are higher than in the bottom panel because the top panel examines many more blame factors. Data provided by Fatality Analysis Reporting System. Error bars were calculated using formulas provided by Daly & Bourke. The $\chi^2$ values associated with each comparison are: Top panel: Sober versus: BAC=0.01–0.07: $\chi^2=687.63; \ p<0.000001; \ 1\ df$. BAC=0.08–0.15: $\chi^2=3686.86; \ p<0.000001; \ 1\ df$. BAC=0.16–0.23: $\chi^2=5296.59; \ p<0.000001; \ 1\ df$. BAC=0.24+: $\chi^2=566.75; \ p<0.000001; \ 1\ df$. BAC=0.08–0.15: $\chi^2=2884.52; \ p<0.000001; \ 1\ df$. BAC=0.16–0.23: $\chi^2=4401.2; \ p<0.000001; \ 1\ df$. BAC=0.24+: $\chi^2=2580.07; \ p<0.000001; \ 1\ df$.
Table 1

Sole official blame ratio (95% CI), by increasing blood alcohol content (BAC), for the most common* driver factors

<table>
<thead>
<tr>
<th>Driver Factor</th>
<th>01 – 78</th>
<th>8 – 15</th>
<th>16 – 23</th>
<th>24+</th>
</tr>
</thead>
<tbody>
<tr>
<td>Failure to keep in proper lane or running off road (#28)</td>
<td>0.81 (0.80 to 0.82)</td>
<td>1.98 (1.91 to 2.06)</td>
<td>4.83 (4.67 to 5.00)</td>
<td>6.89 (6.65 to 7.13)</td>
</tr>
<tr>
<td>Driving too fast for conditions or in excess of posted speed limit (#44)</td>
<td>0.64 (0.63 to 0.65)</td>
<td>2.17 (2.08 to 2.26)</td>
<td>7.10 (6.38 to 8.04)</td>
<td>13.63 (12.96 to 14.33)</td>
</tr>
<tr>
<td>Failure to yield right of way (#38)</td>
<td>0.29 (0.29 to 0.30)</td>
<td>0.32 (0.30 to 0.34)</td>
<td>0.45 (0.43 to 0.48)</td>
<td>0.43 (0.41 to 0.45)</td>
</tr>
<tr>
<td>Inattentive (talking, eating, etc.; #6)</td>
<td>0.29 (0.29 to 0.29)</td>
<td>0.60 (0.57 to 0.63)</td>
<td>1.45 (1.38 to 1.52)</td>
<td>2.39 (2.26 to 2.51)</td>
</tr>
<tr>
<td>Operating the vehicle in an erratic, reckless, careless, or negligent manner (#36)</td>
<td>0.16 (0.15 to 0.16)</td>
<td>0.49 (0.46 to 0.51)</td>
<td>1.23 (1.18 to 1.28)</td>
<td>1.65 (1.58 to 1.71)</td>
</tr>
<tr>
<td>Failure to obey traffic signs, traffic control devices, or traffic officers, failure to observe safety zone (#39)</td>
<td>0.18 (0.18 to 0.18)</td>
<td>0.31 (0.29 to 0.33)</td>
<td>0.62 (0.59 to 0.65)</td>
<td>0.78 (0.74 to 0.82)</td>
</tr>
<tr>
<td>Overcorrecting (#58)</td>
<td>0.13 (0.13 to 0.13)</td>
<td>0.30 (0.28 to 0.32)</td>
<td>0.83 (0.79 to 0.87)</td>
<td>1.29 (1.23 to 1.34)</td>
</tr>
<tr>
<td>Other non-moving traffic violation (#92)</td>
<td>0.05 (0.05 to 0.05)</td>
<td>0.17 (0.16 to 0.19)</td>
<td>0.48 (0.46 to 0.51)</td>
<td>0.55 (0.52 to 0.58)</td>
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<tr>
<td>Making improper turn (#48)</td>
<td>0.10 (0.10 to 0.10)</td>
<td>0.22 (0.21 to 0.24)</td>
<td>0.49 (0.46 to 0.52)</td>
<td>0.62 (0.59 to 0.65)</td>
</tr>
<tr>
<td>Non-traffic violation charged-manslaughter or homicide or other assault (#91)</td>
<td>0.04 (0.04 to 0.04)</td>
<td>0.23 (0.22 to 0.25)</td>
<td>0.72 (0.69 to 0.76)</td>
<td>0.68 (0.64 to 0.71)</td>
</tr>
</tbody>
</table>

*Driver factors are listed in descending order of frequency.
†The Fatality Analysis Reporting System codes for driver factors are listed in parentheses. Data provided by Fatality Analysis Reporting System, USA, 1994–2011. Error bars were calculated using formulas provided by Daly & Bourke.

Figure 3

Sole official blame ratio (top panel) and percentage blamed for crash (bottom panel) for two-vehicle collisions between a sober driver and various types of drinking drivers, in 0.01 increments, USA, 1994–2011. All blame factors are examined. Data provided by Fatality Analysis Reporting System. Error bars were calculated using formulas provided by Daly & Bourke (top panel) and Daly & Bourke (bottom panel). The $\chi^2$ values associated with each comparison are:

<table>
<thead>
<tr>
<th>Top panel</th>
<th>Bottom panel</th>
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<tbody>
<tr>
<td>BAC=0.01: $\chi^2=49.67; p&lt;0.000001; 1$ df.</td>
<td>$\chi^2=20.45; p&lt;0.000006; 1$ df.</td>
</tr>
<tr>
<td>BAC=0.02: $\chi^2=71.65; p&lt;0.000001; 1$ df.</td>
<td>$\chi^2=27.80; p&lt;0.000001; 1$ df.</td>
</tr>
<tr>
<td>BAC=0.03: $\chi^2=56.72; p&lt;0.000001; 1$ df.</td>
<td>$\chi^2=22.35; p&lt;0.000002; 1$ df.</td>
</tr>
<tr>
<td>BAC=0.04: $\chi^2=76.37; p&lt;0.000001; 1$ df.</td>
<td>$\chi^2=39.33; p&lt;0.000001; 1$ df.</td>
</tr>
<tr>
<td>BAC=0.05: $\chi^2=131.25; p&lt;0.000001; 1$ df.</td>
<td>$\chi^2=57.67; p&lt;0.000001; 1$ df.</td>
</tr>
<tr>
<td>BAC=0.06: $\chi^2=207.51; p&lt;0.000001; 1$ df.</td>
<td>$\chi^2=108.51; p&lt;0.000001; 1$ df.</td>
</tr>
<tr>
<td>BAC=0.07: $\chi^2=181.22; p&lt;0.000001; 1$ df.</td>
<td>$\chi^2=78.84; p&lt;0.000001; 1$ df.</td>
</tr>
<tr>
<td>BAC=0.08: $\chi^2=330.46; p&lt;0.000001; 1$ df.</td>
<td>$\chi^2=163.71; p&lt;0.000001; 1$ df.</td>
</tr>
</tbody>
</table>

We also controlled on other variables (like the driver’s sex and race), and the age and speed of the vehicle (see online supplementary table 1).

Four alternative explanations for the findings
We consider the policy implications for our study after assessing four alternative explanations for the SOB-to-BAC relationship:

1. This relationship might somehow be an artefact of unmeasured BAC. Our state-by-state analysis yields findings opposite to those predicted by this ‘unmeasured BAC’ hypothesis. Hence, this hypothesis is currently implausible.

2. This relationship might occur because investigating officers wrongly blame a driver solely because that driver has a high BAC. This type of bias might hold when the officer examines ambiguous, difficult-to-measure driver factors. But investigator bias seems implausible when the officer examines unambiguous, easy-to-measure driver factors, for example, “driving wrong way on one-way trafficway”. The SOB-to-BAC relationship remains strong for these unambiguous driver factors (eg, figure 1). Hence, the investigator bias hypothesis seems implausible.

3. This relationship might occur because investigating officers are more likely to measure a driver’s BAC when that driver is clearly responsible for the crash. Given this “differential BAC measurement” explanation, the SOB-to-BAC relationship should no longer hold when one restricts analysis to crashes where all drivers have measured BAC. Figures 2 and 3 (where all drivers have measured BAC) display a strong SOB-to-BAC relationship. Hence, the “differential BAC measurement” hypothesis seems implausible.

4. This relationship might occur because important confounding variables were uncontrolled. The natural experiments in figures 2 and 3 control for billions of confounding variables. Our findings persist after these and additional variables (see online supplementary table 1) are controlled for. It is conceivable that some confounding variables, currently uncontrolled for, could explain our findings, but this presently seems implausible.

At present, the above hypotheses seem inadequate. The strong, near-linear SOB-to-BAC relationship (r=0.98 for BAC=0.00–0.24) does not appear to be artifactual but seems to reflect a causal process: even minimal alcohol levels impair driving.

Much research has documented the dangers of drunk driving and the culpability of drunk drivers. This research has prompted legal sanctions for drunk drivers, campaigns like ‘Friends don’t let friends drive drunk’ and the founding of groups like ‘Mothers Against Drunk Driving’ (MADD).

There has been much less concern about ‘buzzed’ drivers. This may not be surprising because almost all research on ‘buzzed’ drivers occurs in the laboratory, and it may not be safe to generalise from artificial laboratory conditions to the real world of traffic crashes.

Our study appears to be the first large-scale effort to explore the real-world relationship between the driver’s BAC (in 0.01 increments) and the driver’s culpability in a traffic crash. Our findings support the conclusions of laboratory studies: even minimally ‘buzzed’ drivers are much more likely than sober drivers to be officially blamed for a traffic crash.

It now seems appropriate to consider some preliminary conclusions for public policy:

1. Advertising campaigns against ‘buzzed’ drivers should be expanded and repeated, perhaps with slogans like ‘Friends don’t let friends drive buzzed’.

2. MADD should expand its concern to ‘buzzed’ drivers.

3. Many states sanction under-age drivers who are ‘buzzed’, but do not do so for drivers aged 21 and over. Perhaps some laws originally developed for ‘buzzed’ minors should also be applied to ‘buzzed’ adults.

4. Studies of Australian, European and Japanese drivers suggest that lowering the legal BAC limit to 0.05 reduces injuries and saves lives. Recently, an official US Agency recommended that the US BAC limit should also be reduced to 0.05. Our study supports this recommendation.

It is widely recognised that drivers with high BAC are exceptionally dangerous, and researchers and legislators are properly concerned about drunk drivers. Our findings suggest that institutions and individuals should extend these concerns to ‘buzzed’ drivers.


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Official blame for drivers with very low blood alcohol content: there is no safe combination of drinking and driving

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Inj Prev published online January 7, 2014
doi: 10.1136/injuryprev-2013-040925

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Published online January 7, 2014 in advance of the print journal.

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