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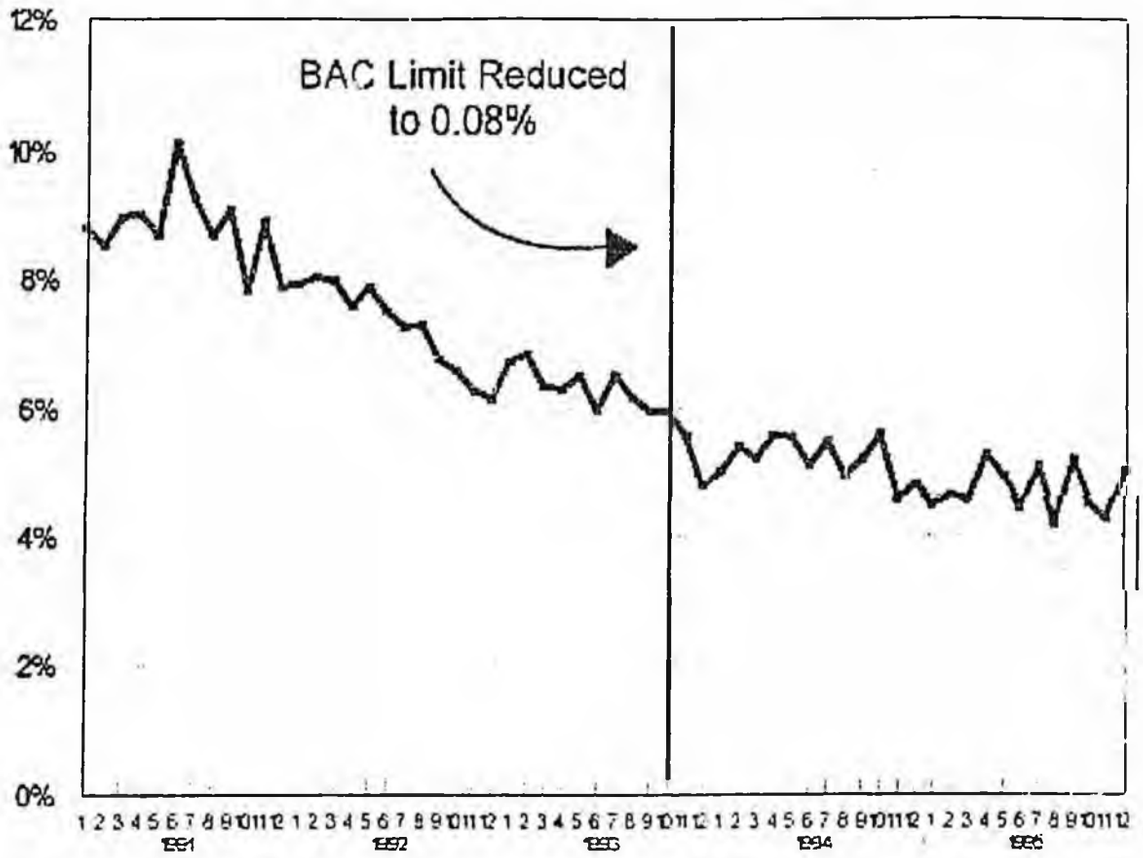

Figure 8 Percent of all North Carolina crashes involving alcohol, 1991 - 1995.

Because of the variety of factors that influence motor vehicle crashes in general, and those involving alcohol in particular, it is necessary to conduct more sophisticated, time-series analyses to determine whether an intervention has had an effect. Accordingly, a number of time series models were fit to the number of various types of motor vehicle crashes occurring in North Carolina by month from January 1991 through December 1995. These models were used to estimate any changes in the number of alcohol-related crashes that coincided with implementation of the lower BAC limit. Structural time series models were fit to the data using the software package STAMP (Structural Time Series Analyser, Modeler and Predictor) developed at the London School of Economics and ESRC Centre in Economic Computing (Harvey, 1989).

The components of structural time series models consist of a level, a trend, seasonal factors, effects due to various "regression variables" and intervention effects (see Harvey, 1989, for a thorough discussion of these models). The level, trend, and seasonal factors can either vary stochastically over time, to accommodate the possibility that they do not remain constant, or be constrained to take on fixed values. Regression variables can include autoregressive terms (lagged values of the response variable) as well as other explanatory factors associated with the response variable. In the models that follow, two basic types of intervention effects were considered. One includes a step shift in the level of the series at the point of intervention; the other hypothesizes a change in the trend or slope (rather than an abrupt shift) of the series beginning at the time of intervention. The objectives of model development are to construct a model that produces essentially uncorrelated residuals, has statistically significant parameters, and fits the data series as well as possible.

As an illustration of the modeling procedure, consider the following model fit to the data series of monthly alcohol-related crash frequencies. The model was fit using a log transformation, so the response variable was $\log_e$ (alcohol related crashes)[6]. The model contains a stochastic level, stochastic slope, and stochastic seasonal factors. Three regression variables were included: an autoregressive term at lag 7, the log of all crashes (to control for amount of travel), and a variable that represents the number of weekends in each month (since alcohol-related crashes are more common on weekends). The intervention variable was a unit step-function occurring in October 1993. Results from this model are shown in table 2.

Table 2. Parameters for model of North Carolina alcohol-related crashes ($\log_e$), 1991 - 1995

Parameter	Estimate	s.e.	t-ratio	p-value
Level*	-3.23	2.23	-1.450	.156
Trend*	-.007	.0014	-4.661	<.0001
$\log_e$ (A-R crashes, at lag 7)	.469	.121	3.850	.0001
$\log_e$ (all crashes)	.644	.181	3.556	.001
Weekends	.053	.010	5.55	<.0001
Intervention (Lower BAC limit)	-.008	.025	-.330	.744

* level and trend estimates represent final estimates at end of series.

Test for Seasonality $\chi^2_{(11)} = 33.79$, $p = .0004$

Residual Autocorrelations	*Goodness-of-Fit*
Q(5) = 4.30	$R^2 = .874$
Q(10) = 11.55	$R^2_D = .780$
Q(15) = 12.38	$R^2_S = .624$

For simplicity, estimates of the 11 seasonal parameters are not shown, but rather only an overall test for seasonality. There is a significant seasonal component in alcohol-related crashes during the time period from 1991 through 1995.

Information concerning residual autocorrelation is presented by the three values of the Ljung and Box Q-statistic. This statistic Q(k) is based on the sum of squares of the first k residual autocorrelations and is approximately distributed as χ^2 with $k - \tau$ degrees of freedom, where τ is the number of stochastic components in the model. Thus, values of Q(k) that remain at a value of k or smaller tend to indicate that the residuals are sufficiently uncorrelated. Thus, for Table 2 above,

$$Q(k) = Q(5) = 4.30 \simeq 5 = k$$

[6] Time-series analyses often use log-transformations because data transformed in this way exhibit more desirable mathematical properties.

and similarly for Q(10) = 11.55 $\simeq$ 10 and Q(15) = 12.38 $\simeq$ 15. These suggest that the residuals in the model for alcohol-related crashes are reasonably uncorrelated. Note that k = 5, 10 and 15 are selected to be representative of the possible range of residual autocorrelations.

Three goodness-of-fit measures are also shown for the model. R^2 is a measure of the overall fit of the model, part of which is due to the trend and seasonal factors. R^2_D is a measure of the goodness-of-fit of the detrended series (that is, with any general trend removed) and R^2_S the fit of the deseasonalized series (i.e., with seasonal fluctuations removed).

The estimated intervention effect shown in table 2 is quite small and is not statistically significant (p = .744). This estimate represents a decrease in the value of the logarithm of alcohol-related fatal crashes by .008 beginning in Oct. 1993 and persisting through the end of the series.

When the change in slope or trend (in October, 1993), rather than a step shift, was modeled, the estimated effect was .006. Thus, the effect is a slight increase in the (downward) slope of the series, but again, the estimate is not statistically significant (t = .951, p = .348).

The models described above represent the *number* of alcohol-related crashes per month as a function of the monthly frequencies of all crashes, seasonality, general trend and number of weekends per month. We also tried an alternative approach, modeling the *proportion* (or percent) of all crashes that were alcohol-related to see if changes could be detected that coincided with the 0.08% legislation. Specifically, we constructed a data series where P_t = percent of all crashes in month t that were alcohol-related, and time series models were fit to P_t, $\log_e(P_t)$, and logit $(P_t) = \log_e(P_t/(100-P_t))$ Models fit to each of these three data series were of the same structure and produced similar estimates of intervention effects. Hence, only results for the logit models are reported below.

Because the new BAC limit may have affected only more serious crashes, which are most likely to be alcohol-related, we conducted additional analyses to examine the percent of all fatal and serious injury crashes that were alcohol-related. Although reporting of alcohol involvement in North Carolina crashes is considered to be quite good, surrogate measures of alcohol-involved crashes are sometimes used to supplement analyses that are based on officers' judgments about alcohol involvement. Hence, additional analyses were conducted using each of the following as the 'response' variable:

- percent of all crashes that occurred during nighttime hours (between the hours of 8:00 p.m. and 4:00 a.m.), and
- percent of all fatal and serious injury crashes occurring during nighttime hours.

The results obtained when fitting models to logit transforms of each of the series described above are presented in table 3.[7] Two separate models were fit to each data series – one with a step shift at time of intervention (October 1, 1993) and one with a change in slope at time of intervention. None of these effects was statistically significant in any of the models.

[7] More extensive description of these models is given in Appendix A.

Table 3. Parameters for logit models of various indicators of alcohol-involved North Carolina crashes, 1991 - 1995.

Outcome Variable	Modeled intervention effect	Estimate	s.e.	p-value
Percent of crashes involving alcohol – *all levels of severity*	Shift in level	-.038	.038	.320
	Change in trend	.001	.009	.866
Percent of crashes involving alcohol – *severe and fatal crashes only*	Shift in level	.023	.058	.698
	Change in trend	-.0001	.003	.986
Percent of crashes occurring at night – *all levels of severity*	Shift in level	-.022	.022	.308
	Change in trend	.001	.003	.762
Percent of crashes occurring at night – *serious and fatal crashes only*	Shift in level	.050	.040	.222
	Change in trend	.003	.002	.288

Comparison of North Carolina Crash Trends to Other States

Although none of the analyses indicate that the lower BAC limit had an effect on alcohol-related crashes, it was thought that perhaps the effect of the new law might have been to prevent an upturn in alcohol-involved crashes that appeared to be afoot nationally. It is possible that the rate of decline in alcohol-related crashes was already so great in North Carolina when the new law came into effect that it could not produce an added benefit. We reasoned that perhaps having this law in place as the broader trend in alcohol-related crashes leveled might serve to mitigate that effect in North Carolina. Accordingly we compared the trend in alcohol-related fatal crashes in North Carolina with that in eleven other states that have had consistently high rates of testing for alcohol among fatally injured drivers (> 80% for each year 1991 - 1995).[8] The mean testing rate for these 11 states was 89.9% (vs. 85.3% for NC) for the five year period.

Data on BAC's of drivers killed in motor vehicle crashes in North Carolina and the 11 other states were obtained from the Fatality Analysis Reporting System (FARS). The data covered the time period from January 1990 through December 1995. Over this time period, 26.1% of drivers killed in motor vehicle crashes in North Carolina were reported to have BAC's of 0.10% or higher. In the other states this

[8] The states selected were Colorado, Connecticut, Hawaii, Illinois, Massachusetts, Montana, New Mexico, Oregon, Rhode Island, Washington, and Wisconsin. Among these states, Oregon, Hawaii, and New Mexico have 0.08% BAC limits. However, only the New Mexico law, which also changed in 1993, presents a problem for this analysis. The law in Oregon did not change during the analysis period and Hawaii's change only applied to the final few months of the period. Including New Mexico in this analysis has a slight tendency to work against finding an effect of the North Carolina law. However, because of its relatively small population, excluding New Mexico from the analysis would not materially change the results.

percentage ranged from 30.8% (Massachusetts) to 44.1% (Montana). The overall rate of alcohol involvement for the 11 states combined was 36.8%.

Three monthly data series were created:

- the percent of all fatally injured drivers in North Carolina having BAC's $\geq$ 0.10%
- the percent of all fatally injured drivers in the 11 comparison states with BAC's $\geq$ 0.10%
- the logit transform of the proportion of all killed drivers with BAC's $\geq$ 0.10% among the 12 states that were North Carolina drivers

Time series models were then fit to each of these data series. The data series for percent of fatally injured North Carolina drivers with BAC $\geq$ 0.10% was essentially a random series (i.e., there were no significant autocorrelations). In this case the basic time series model reduced to a regression line fit to the data points. The estimated model parameters are shown in table 4. When added to the model, neither a step shift (p = .728) in October 1993, nor a change in trend component (p = .765), was statistically significant.

Table 4. Regression statistics for percent of fatally injured North Carolina drivers with BAC $\geq$ 0.10% by month, 1990 - 1995.

Parameter	Estimate	s.e.	t-statistic	p-value
Intercept	31.90	1.16	27.57	<.0001
Trend	-.159	.028	-5.79	<.0001

Goodness-of-Fit
R^2 = .324
R^2_D = .500

The data series for the percent of fatally injured drivers with BAC's > 0.10% in the group of comparison states was also an essentially random series with a slight downward trend. The autocorrelation function, however, suggested that the data contained some seasonal variation. Thus a model that contained a fixed level, fixed slope and stochastic seasonal effects was fit to this series. Results are summarized in table 5.

Table 5. Regression statistics for percent of fatally injured drivers in 11 comparison states with BAC $\geq$ 0.10% by month, 1990 - 1995.

Parameter	Estimate	s.e.	t-statistic	p-value
Level	40.64	.713	56.96	< .0001
Trend	-.107	.017	-6.25	< .0001

Test for Seasonality $\chi^2_{(11)} = 17.27$, p = .100

Residual Autocorrelations	*Goodness-of-Fit*
Q(5) = 5.00	$R^2 = .383$
Q(10) = 11.25	$R^2_D = .471$
Q(15) = 17.38	$R^2_S = .199$

Thus both series show general decreases in alcohol involvement over time, though the rate of decrease is slightly greater for the North Carolina series (-.159 vs -.107).

A more direct way of examining alcohol-related fatalities in North Carolina relative to those in the comparison states is to consider the proportion of all fatally injured drivers with BAC > 0.10% who were North Carolina drivers. A model was fit to the logit transform of this proportion. Parameter estimates for the best fitting model to this series are shown in table 6.

Table 6. Parameter estimates for best fitting model for North Carolina alcohol-related (BAC $\geq$ 0.10%) fatalities relative to those in 12 States, 1990 - 1995.

Parameter	*Estimate*	*s.e.*	*t-statistic*	*p-value*
Intercept	-1.95	.276	-7.06	< .0001
Trend	-.004	.002	-2.10	.039
Autoregressive Lag 1	.147	.119	1.23	.236
Autoregressive Lag 5	-.325	.119	-2.74	.008

Residual Autocorrelations	*Goodness-of-Fit*
Q(5) = 6.71	$R^2 = .165$
Q(10) = 10.58	$R^2_D = .495$
Q(15) = 16.20	

This series also displays a slight downward trend (.004) in the proportion of alcohol-related crashes involving North Carolina drivers during the period from 1990 through 1995. Intervention effects added to the model did not approach statistical significance for either a shift in level (p=.862) or a change in trend (p=.509).

These results confirm earlier analyses, again showing that alcohol-related crashes have been declining in North Carolina over the past several years but that no specific effects are found that can be attributed to the lowered *per se* illegal BAC limit.

Analyses of BAC Data for Fatally Injured Drivers in North Carolina

Evaluations of drinking-driving interventions often look only at fatal crashes. There are two reasons to do this. First, having a much greater involvement of alcohol, fatal crash rates are probably more sensitive indicators of drinking-driving. Second, measurement of alcohol involvement is generally better in fatal crashes.

Hence, in addition to the data extracted from FARS, information on BAC's of killed drivers was also obtained from the North Carolina Medical Examiner's (ME) office. These data covered the time period January 1991 - December 1995. From these data, two monthly time series were constructed and analyzed. The first was the monthly percent of all fatally injured drivers who had BAC's $\geq$ 0.10%. This is essentially the same as one of the data series extracted from FARS, although the beginning of the time interval is 1991 rather than 1990. Where the time intervals overlap, the agreement between the two series is close but not identical.

The behavior of the ME data series is quite similar to that from FARS. Namely, the data series is essentially a random series with no significant autocorrelation structure. A straight line fit to the data contains a significant negative (or decreasing) trend, $p < .0001$. Neither a shift in level nor a change in trend effect was statistically significant, $p = .113$ and $p = .325$, respectively.

The second data series was a month-by-month series of mean BACs for fatally injured drivers in North Carolina crashes whose BAC's were0.10% or higher. The mean of these monthly means was 0.21% and over the 60 month interval the values ranged from 0.16% to 0.26%. This series did contain some significant autocorrelations but did not exhibit any long term trends. A model fit to this series contained a fixed level and autoregressive terms at lags 5 and 6. Adding a linear trend term to the model yielded an estimated trend of .00011 with a standard error of .00016 ($p = .460$). Similarly, neither a shift in level nor a change in trend intervention was significant, with p-values of .254 and .598, respectively.

In summary, the proportion of fatally injured drivers having BAC's $\geq$ 0.10% has continued its decline through 1995, but with no abrupt changes that can be attributed to the 0.08% law. The mean BAC of fatally injured drivers with BAC's $\geq$ 0.10%, on the other hand, has remained relatively constant with an overall mean of 0.21%.

The failure to find an effect that might be attributed to the lower BAC limit in North Carolina, considering a variety of indicators of alcohol involvement, suggests that the law has not had the intended effect. There are a number of possible reasons for this. First, and perhaps most likely, is simply that reducing the legal limit does not affect drinking-driving behavior. There are other possible explanations. It may be that the proportion of the drinking-driving population that such a law would affect had already changed their behavior before the limit was lowered in North Carolina, where drinking-driving is less common than in other states. Or, similarly, given the dramatic decline in alcohol-related crashes that was occurring in North Carolina during the early 1990s, it may be that any possible effects of reducing the BAC limit were simply obscured by a broad change in drinking-driving behavior that was already occurring.

Yet another possible explanation for the failure of an effect to materialize for the lower BAC limit is that this new, lower level was not sufficiently well publicized. There was relatively little media attention to the 0.08% law, either when it was being considered, when it passed, or when it was enacted. On the other hand, beginning about 14 months after the BAC limit was lowered, there was a great deal of publicity about DWI enforcement in conjunction with the "Booze-it-and-Lose-it" campaign, which featured sobriety

checkpoints in every North Carolina county. Most publicity about DWI enforcement in North Carolina does mention the BAC limit of 0.08%, though there was no particular mention that the limit was lower than it had been previously.

One important consideration in the analysis of crashes where alcohol involvement is judged rather than measured is the possibility that the new law may have increased officers' sensitivity to alcohol involvement, either individually or, perhaps, via organizational policy (having signaled to law enforcement agencies that drinking-driving was of heightened concern to the legislature). In the present situation, increases in officers' sensitivity to alcohol involvement would work against our finding an effect of the law. If the proportion of alcohol-involved crashes actually decreased, while officers' diligence in reporting alcohol involvement increased, the latter would tend to mask the former. However, the failure to find any change in alcohol involvement in fatal crashes or surrogate measures of alcohol involvement suggests that real effects of the 0.08% law are probably not being masked by changes in alcohol detection where officer judgment is central.

Another possible explanation for the failure to detect an effect of the new law is that it was not being enforced. If persons with BACs of 0.08-0.09% were not being arrested, or if those arrested at that level were not being prosecuted or convicted, that information would begin to spread and would dilute, or eliminate, any possible effect of the new law. To address this possibility, changes in DWI arrests and convictions following implementation of the 0.08% law as well as possible effects on the court system were examined.

Changes in DWI Arrests and Convictions

It was expected that the number of arrests for DWI would increase following enactment of the 0.08% law. For example, roadside survey data from Ohio and Minnesota indicate that lowering the illegal BAC from 0.10% to 0.08% would have increased the number of nighttime drivers who are in violation of the DWI law by 44% to 52% in those states (Foss & Perrine, 1990; Foss, Beirness & Sprattler, 1994).

We had hoped to examine the trend in DWI arrests as part of this study. This would have been complicated by the variety of overlapping special enforcement efforts that have occurred in North Carolina during the 1990s, but these could likely have been dealt with satisfactorily. However, a serious disruption in the availability of driver history file data occurred as the North Carolina Division of Motor Vehicles revised their data system. As a result we were not able to track arrest and conviction data as we had hoped.

An HSRC study using data obtained before the disruption, however, does provide an indication of changes in DWI arrests that occurred following implementation of the new BAC limit (Foss, Martell & Stewart, 1995). The proportion of persons arrested with BACs below 0.10% increased 20-fold immediately after the lower BAC limit took effect, going from less than 1% to approximately 10% of DWI arrests. Arrests of persons with 'marginally' illegal BACs of 0.10-0.11% appear to have increased somewhat as well. However, the overall number of arrests did not increase. Whether this reflects a general downward shift in BACs among the driving population, or that fact that officers' time was more often spent arresting more prevalent types of drinking drivers – those with lower, but still illegal, BACs – is not known. In view of data reported above showing no apparent change in drinking-driving as a result of the new law, it appears that the latter explanation is more likely.

In sum, the 0.08% BAC law did not affect the size of the case load in the North Carolina Substance Abuse Treatment system. However, the make-up of the population of individuals screened for alcohol/substance abuse problems did change by virtue of an influx of persons arrested with lower BACs, who were less likely to be diagnosed as needing treatment for alcohol use problems. Hence, although

persons with BACs of 0.08-0.09% may not have been arrested in proportion to their prevalence, they were by no means being overlooked by law enforcement officers.

Changes in DWI Case Loads for Prosecutors and the Courts

It is of interest to know what effect the new law has had on the criminal justice system. Although the study of California's 0.08% BAC limit indicated little effect on case loads, there was still some concern that an overload might result in North Carolina. In addition, it is possible that persons with low BAC arrests were less likely to be charged or convicted, which might undermine the effect of the new law. To determine whether any of these effects may have occurred, we conducted key informant interviews with county prosecutors (or their representatives) from six counties selected to provide a rough representation of the state.

Figure 9 shows the counties where interviews were conducted. These represent both urban and rural counties as well as the three naturally occurring geographic regions of the state: the western/mountain region, the more heavily populated and industrialized Piedmont (central) region, and the eastern/coastal region.

Among the main issues pursued were (1) whether the new law produced a notable increase in the workload for prosecutors; (2) what, if any, effect the law had on the way cases were prosecuted; (3) whether prosecutors were less likely to charge persons arrested with low BACs; or (4) whether judges appeared to have viewed cases with marginal BACs at time of arrest (i.e., 0.08-0.09%) any differently from the way they viewed marginal BACs (0.10-0.11%) prior to the law.

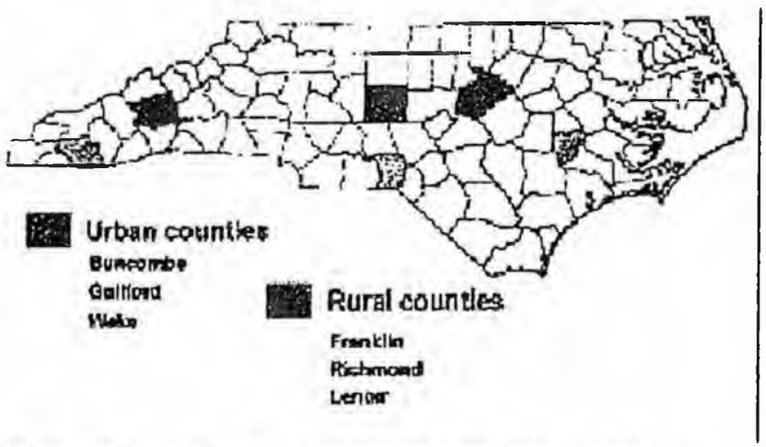

Figure 9 Counties where prosecutors were interviewed.

These interviews produced no evidence that the new law had increased the perceived number of arrests, or that persons with BACs of 0.08-0.09% were not being charged or convicted. Because there was no apparent effect of the 0.08% law on prosecutors' case loads, procedures, or conviction rates, we did not pursue discussions with representatives from a larger sample of counties.

❑ COMPARISON OF NORTH CAROLINA ALCOHOL-RELATED FATAL CRASHES WITH THOSE IN OTHER STATES

As a final set of analyses for this study, we examined several indicators of alcohol involvement in North Carolina fatal crashes compared to fatal crashes in the 37 U.S. states that did not have an 0.08% BAC limit at any time during the period 1991 - 1996. These analyses looked at the six criterion variables reported in the NHTSA preliminary study of the effects of 0.08% laws in the first five states to enact such laws (described below; NHTSA, 1994).

Alcohol use, and its involvement in crashes, has been on the decline for many years in the U.S. Therefore, it is necessary to include an appropriate comparison group (state or states) when examining changes in alcohol involvement in crashes across time to evaluate the effect of an intervention, such as the reduction of the BAC limit. Although there is some appeal to choosing a comparison group that is 'similar' to the state under consideration, it is difficult to know the relevant characteristics upon which states should be matched. Hingson et al. (1996) have been criticized for, among other things, their choice of comparison states (Scopatz, 1998). Although there is merit to the arguments advanced by both sides on this issue, it is probably impossible to convincingly argue that a particular state is the best (or even an appropriate) match to any other state. Consequently, rather than comparing alcohol involvement in North Carolina crashes with those of any particular state or subset of states, we elected to compare North Carolina with all states that had a BAC limit of 0.10% during the entire period we examined (January 1, 1991 – December 31, 1996).[9]

As mentioned above, there are shortcomings in every indicator of alcohol involvement in crashes. If we rely only on police reports of alcohol involvement, there is the likelihood that some alcohol-related crashes are misjudged as not involving alcohol. If we rely only on data where a driver's BAC was objectively measured, a large and unrepresentative proportion of crashes are excluded from analysis. To address this problem, several years ago the National Highway Traffic Safety Administration developed a technique to estimate alcohol involvement in fatal crashes where no objective measure of alcohol was obtained (Klein, 1986). Using discriminant function analyses it is possible to estimate, with a substantial degree of precision, the likelihood that a crash involves a drinking driver, given other characteristics of the crash, the driver and the vehicle he/she is driving. These estimates[10] of alcohol involvement are used by the NHTSA in their analyses of alcohol involvement in fatal crashes and are included in publicly distributed crash data files. The estimates provide an indication of whether a driver involved in a fatal crash had a non-zero BAC (i.e., $\geq$ 0.01%) and also the probability that the driver's BAC was in excess of 0.10%, the legal limit in most states. We examined two criterion variables, using Klein's estimation procedures, for all drivers involved in fatal crashes:

- Any alcohol involvement by a driver (BAC $\geq$ 0.01%) and
- Whether there was evidence of alcohol in excess of 0.10% for a driver.

For completeness, and to parallel various other studies of alcohol use by drivers in fatal crashes, we also looked at the following four variables, comparing North Carolina with the 37 other states:

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[9] The following states had an 0.08% BAC limit in effect for at least some portion of the period from 1991 to 1996 and were, therefore, excluded from the analyses: Alabama, California, Florida, Hawaii, Kansas, Maine, New Hampshire, New Mexico, Oregon, Utah, Virginia, Vermont.

[10] It is important to note that although we refer to these as estimated values, since they result from use of an estimation procedure, a large proportion of these data represent an actual measurement. When a measurement is present, the 'estimated BAC' is the measured value. Only in those instances where no BAC measurement is available do the data actually include estimated values.

- Police-reported alcohol involvement
- Single vehicle nighttime crashes (a traditional proxy or surrogate measure for drinking-driving)
- Single vehicle nighttime crashes by male drivers (another commonly used proxy measure for drinking-driving)
- Estimated alcohol involvement (based on police report, driver record of previous alcohol citation, and measured BAC)

As noted above, each of these measures taken alone has shortcomings. The most appropriate way to address this problem is to look at each of the measures to see whether a consistent picture emerges. If the 0.08% law has a clear and strong effect, that should be detectable using any one of the measures–and the effect should appear with all of them. Should there be inconsistencies in results among the measures, we believe that based on the strengths and weaknesses of each, more credence should be given to findings based on the two variables based on the statistical estimation procedures. The other four measures are less robust in that, in one way or another, they incorporate only some of the information that the estimates include.

The most appropriate, though statistically complex, way to examine the effect of a point-in-time intervention, such as enactment of a law, is through the use of statistical modeling procedures to examine a series of data points, as was done in the analyses reported above. However, prior to conducting detailed time-series analyses for each of the several indicators of alcohol-involvement in fatal crashes for North Carolina and the 37 comparison states, we decided to first do a simple before-after comparison. We planned to conduct time-series analyses using only those indicators that showed a clear effect in the simple before-after comparison.

The following analyses consider all drivers involved in fatal crashes between 1991 and 1996, as reported in the NHTSA Fatality Analysis Reporting System (FARS). This provides data for a 33 month period prior to implementation of the 0.08% law in North Carolina and 39 months following its enactment. For ease of comparison with other analyses in the literature, we used the same statistical measures as those employed by Hingson et al. (1996), that is, a ratio of relative risks of alcohol involvement comparing North Carolina to the other 37 states.[11]

Driver BAC of 0.01% or Greater

During the 33 months prior to enactment of the 0.08% law, 24.4% of drivers involved in a fatal crash in North Carolina had an estimated BAC of 0.01% or greater. That declined to 20.1% in the 39 months immediately following enactment of the lower BAC limit, which is a statistically significant decline of 17.4% ($p < .001$). The risk ratio for alcohol involvement at this level before vs. after enactment of the law is 1.21, with a 95% confidence interval of 1.14 to 1.29. Among the 37 states without an 0.08% BAC limit, there was a decrease in estimated alcohol involvement, from 28.1% to 24.5%, a decline of 12.8%, which is also statistically significant ($p < .001$). The before-after risk ratio for these 37 states is 1.15, with a 95% confidence interval of 1.13 to 1.16. The comparison of the change in these states vs. North Carolina, given by the ratio of these two risk ratios, is 1.06. Although this reflects a 6% greater decline in North Carolina, the 95% confidence interval for this ratio is .98 to 1.14, indicating that the difference in declines between North Carolina and the other sta es is not statistically significant.

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[11] We wish to gratefully acknowledge the assistance of Dr. Tim Heeren, Boston University, who provided detailed information on their calculations.

Hence, the conclusion is that the proportion of drivers involved in fatal crashes who had a BAC above 0.01% declined significantly, and to about the same degree in both North Carolina and the other 37 states.

Table 7. Drivers age 21 or older in fatal crashes with estimated BAC of 0.01%, 1991 - 1996, North Carolina vs. 37 states without 0.08% BAC limit before and after enactment of 0.08% limit in North Carolina.

	North Carolina		Other 37 States	
	≥ 0.01%	< 0.01%	≥ 0.01%	< 0.01%
Before (1/1/91 to 9/30/93)	24.4% (1,014)	75.6% (3,147)	28.1% (24,027)	71.9% (61,487)
After (10/1/93 to 12/21/96)	20.1% (1,093)	79.9% (4,337)	24.5% (26,272)	75.5% (81,005)
Decline	17.4%*		12.8%*	
Risk Ratio (before/after)	1.21		1.15	
95% Confidence Interval	[1.14, 1.29]		[1.13, 1.16]	
* $p < .001$	$RR_{NC}/RR_{37} = 1.06$, 95% CI = .98 to 1.14			

Driver BAC of 0.10% or Greater

We would not necessarily expect that lowering the BAC limit to 0.08% would reduce the proportion of drivers who had any alcohol in their system, which the previous analysis examined. Many drivers with a positive – but low – BAC are below both the former and new BAC limits. If the law is effective, however, it should reduce the proportion of drivers with higher BACs. In particular, we would expect a decrease in the proportion of drivers with BACs above 0.10% in North Carolina compared with states that retained a 0.10% BAC limit. We turn to that analysis now, the results of which are summarized in Table 8.

Table 8. Drivers age 21 or greater in fatal crashes with estimated BAC ≥ 0.10%, 1991 - 1996, North Carolina vs. 37 comparison states.

	North Carolina		Other 37 States	
	≥ 0.01%	< 0.01%	≥ 0.01%	< 0.01%
Before (1/1/91 to 9/30/93)	22.2% (924)	77.8% (3,237)	23.8% (20,383)	76.2% (65,131)
After (10/1/93 to 12/21/96)	18.3% (991)	81.7% (4,439)	20.7% (22,211)	79.3% (85,066)
Decline	17.8%*		13.1%*	
Risk Ratio (before/after)	1.22		1.15	
95% Confidence Interval	[1.14, 1.30]		[1.13, 1.17]	
* $p < .001$	$RR_{NC}/RR_{37} = 1.06$, 95%, CI = .97 to 1.15			

Prior to enactment of the 0.08% law, 22.2% of drivers involved in a fatal crash in North Carolina had an estimated BAC of 0.10% or greater. That declined to 18.3% in the 39 months immediately following enactment of the lower BAC limit, a decline of 17.8% ($p < .001$). The risk ratio for alcohol involvement at this level before vs. after enactment of the law is 1.22, with a 95% confidence interval of 1.14 to 1.30. There was a somewhat smaller decrease in alcohol involvement at this level in the other 37 states, from 23.8% to 20.7%. This 13.1% decrease is also statistically significant ($p < .001$). The before-after risk ratio for these 37 states is 1.15, with a 95% confidence interval of 1.13 to 1.17. The direct comparison of the change in these states vs. North Carolina, given by the ratio of these two risk ratios, is 1.06. The 95% confidence interval for this ratio is .97 to 1.15, indicating again that the difference in declines between North Carolina and the other states is not statistically significant.

The changes in the percent of persons with estimated BAC above 0.10% are nearly identical to the changes in persons having any alcohol (BAC above 0.01%). Both measures provide the consistent finding that the decline in drivers with a positive BAC, or a high BAC, in North Carolina was slightly greater than in the other states, but not significantly so.

Police-reported Alcohol Involvement

A fairly direct measure of alcohol involvement in crashes is the investigating officer's report of whether there is evidence of alcohol use by a driver. Although police officers appear to be quite good at determining whether a driver has been drinking, a variety of factors can interfere with their ability to accurately determine alcohol use. Perhaps the greatest problem is the difficulty in determining low levels of alcohol use, for which there are few obvious indicators. Another problem is that factors at the crash scene, for example, the need to deal quickly with seriously injured persons, may inhibit the officer's ability to fully assess whether a driver has been drinking. Nonetheless, this is an indicator that is commonly used to measure whether alcohol is involved in a crash. Table 9 presents results of the analysis of this variable for North Carolina and the 37 other states.

Table 9. Police-reported (PR) alcohol involvement 1991 - 1996, North Carolina vs. 37 comparison states.

	North Carolina		Other 37 States	
	PR-Alcohol	**No Alcohol**	**PR-Alcohol**	**No Alcohol**
Before (1/1/91 to 9/30/93)	17.6% (731)	82.4% (3,430)	19.8% (16,953)	80.2% (68,561)
After (10/1/93 to 12/21/96)	13.4% (725)	86.6% (4,705)	17.1% (18,325)	82.9% (89,125)
Decline	24.0%*		14.0%*	
Risk Ratio (before/after)	1.32		1.16	
95% Confidence Interval	[1.22, 1.41]		[1.14, 1.18]	
* $p < .001$	$RR_{NC}/RR_{37} = 1.13$, 95% CI = 1.03 to 1.25			

Prior to enactment of the 0.08% law, police officers reported that 17.6% of drivers in fatal crashes in North Carolina had been drinking. That declined to 13.4% in the 39 months immediately following enactment of the lower BAC limit, a rather dramatic decline of 24%. The risk ratio for police-reported alcohol involvement before vs. after enactment of the law is 1.32. There was a smaller decrease in police reports of alcohol involvement in the other 37 states (14.0%). The before-after risk ratio for these 37 states is 1.16. The ratio of these changes between North Carolina and the other states is 1.13, indicating a significantly greater decline in North Carolina than in states that did not have an 0.08% BAC limit.

It is instructive to look at the changes in police-reported alcohol involvement by quarter for the period 1991 through 1996 shown in Figure 10.a. It is apparent that although a simple before-after comparison of the proportions of drinking drivers in crashes reported by police suggests a decline following implementation of the 0.08% BAC limit in North Carolina, that is an inappropriate conclusion. The reduction in police-reported alcohol involvement in North Carolina relative to the other states began in the second quarter of 1992, 18 months prior to implementation of the lower BAC limit, and approximately a year before legislation to lower the limit was introduced in the North Carolina General Assembly. During 1991, police reports of alcohol involvement in North Carolina fatal crashes were nearly the same as in the 37 states that did not reduce their BAC limits. It is that high rate, rather than a decrease following enactment of the 0.08% BAC limit, that produces a significantly greater decline in North Carolina than in the other states from the 33 months prior to the 0.08% law to the 39 months following its implementation.

Figure 10a

Police-reported Alcohol Use by Drivers in Fatal Crashes
by Quarter, North Carolina vs. 37 Other States

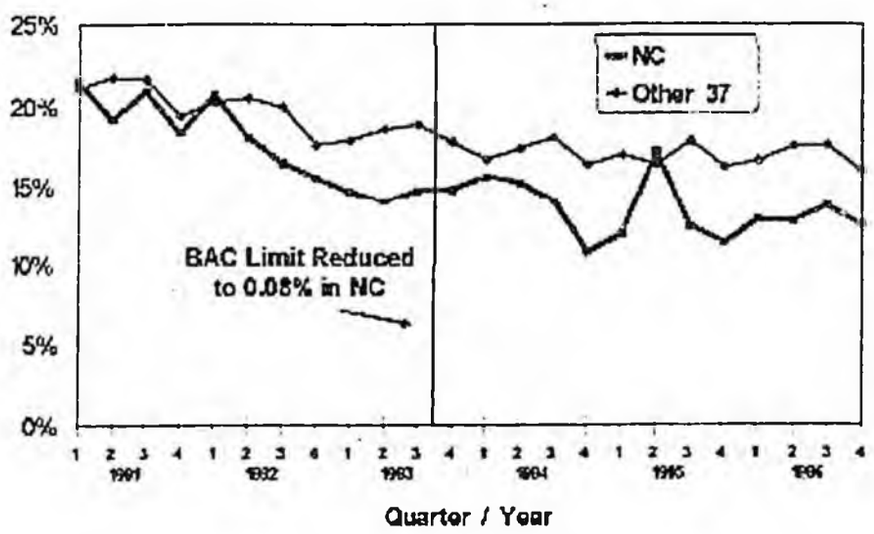
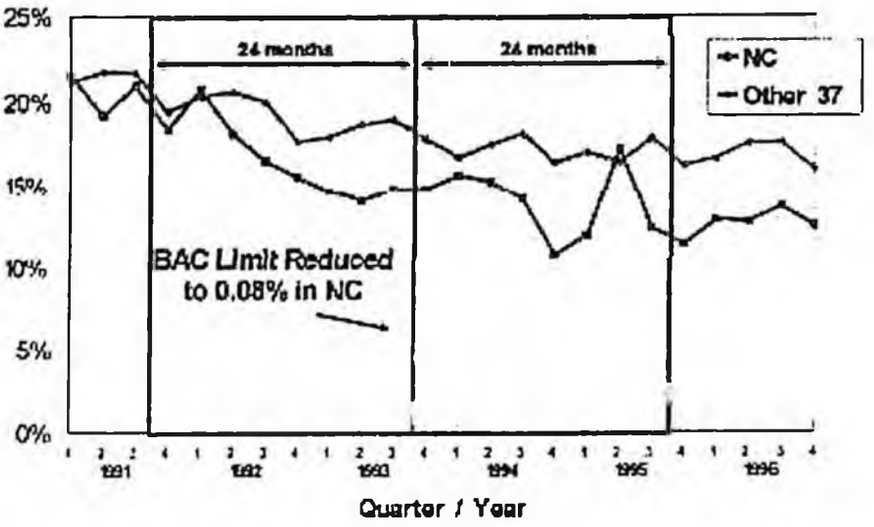


Figure 10b

Police-reported Alcohol Use by Drivers in Fatal Crashes
by Quarter, North Carolina vs. 37 Other States



Clearly there was a change in alcohol involvement, as reported by police officers. However, in view of its timing, it is not reasonable to believe that the change resulted from the lower BAC limit. The divergence between North Carolina and the other states occurred prior to the law. Selection of a different time period for analysis – for example, 24 months prior to and 24 months following enactment of the lower BAC limit – more accurately conveys what occurred prior to the new law (see Figure 10.b.). These before-after time periods are also matched for seasonal effects–covering identical months of the year. The ratio of relative risks comparing North Carolina to the other states for this four year period is 1.07 [.95, 1.20]. That is, there appeared to be a somewhat greater decline in police-reported alcohol use by drivers in fatal crashes, but the difference is not statistically significant.

Another pertinent consideration here is that the North Carolina "Booze-It-and-Lose-It" program was implemented in November, 1994. This effort included the conduct of 3,185 sobriety checkpoints throughout the state between November, 1994 and July, 1995, in conjunction with extensive media coverage of this enforcement activity. The dip in the percent of police-reported alcohol involvement in crashes shown in Figure 10 is coincident with the period during which the Booze-It-and-Lose-It program was at the peak of activity.[12] It is not possible to include the effects of this program in the simple before-after analyses reported here, as was done with earlier time-series analyses. However, it is clear from other time-series analyses (Foss & Stewart, 1998) that there was a reduction in alcohol-involved fatal and serious injury crashes for approximately eight months as a result of the Booze-It-and-Lose-It program. Hence, some of the post-1993 decline in alcohol-involvement in fatal crashes may be attributable to this program. That further undermines our confidence in the effect of the 0.08% BAC limit.

Single Vehicle Nighttime Crashes

Prior to development of the algorithm to estimate alcohol involvement for individual drivers involved in fatal crashes, it was common practice to use surrogate or proxy measures of alcohol involvement. That was a crude way of accomplishing what the estimation procedure does in a more statistically sophisticated fashion. Because crashes that occur at night are more likely to involve alcohol, and those that are single-vehicle crashes are even more likely to be alcohol-related, the incidence of such crashes has been used as an indicator of the extent of drinking-driving. Table 10 presents results of the analysis of single vehicle nighttime (8 p.m. to 4 a.m.) crashes among drivers over age 21 for North Carolina and the 37 other states.

Prior to enactment of the 0.08% law, 16.6% of fatal crashes in North Carolina were single vehicle nighttime crashes. That declined to 15.0% in the 39 months immediately following enactment of the lower BAC limit, a decline of 9.6%. The risk ratio for SVN to other type crashes before vs. after enactment of the law is 1.11. There was a nearly identical decrease in SVN crashes in the other 37 states, from 17.0% to 15.2%, a decline of 10.4% ($p < .001$). The before-after risk ratio for these 37 states is 1.12. The ratio of these changes between North Carolina and the other states is .99, indicating a virtually identical decline in SVN crashes.

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[12] However, there is no apparent explanation for the sharp increase during the 2nd quarter of 1995. That increase reflects only 15 cases out 456 crashes, and does not appear nearly so dramatic in other measures of alcohol involvement.

Table 10. Drivers in single vehicle nighttime (SVN) crashes 1991 - 1996, North Carolina vs. 37 comparison states.

	North Carolina		Other 37 States	
	SVN	**Other**	**SVN**	**Other**
Before (1/1/91 to 9/30/93)	16.6% (691)	83.4% (3,470)	17.0% (14,513)	83.0% (71,001)
After (10/1/93 to 12/21/96)	15.0% (815)	85.0% (4,615)	15.2% (16,320)	84.8% (90,957)
Decline	9.6%†		10.4%*	
Risk Ratio (before/after)	1.11		1.12	
95% Confidence Interval	[1.01, 1.99]		[1.10, 1.14]	
† $p < .05$	$RR_{NC}/RR_{37} = .99$, 95% CI = .90 to 1.09			
* $p < .001$				

Single Vehicle Nighttime Male Driver Crashes

Another, somewhat more refined, proxy measure of alcohol involvement is a single vehicle nighttime crash by a male driver. Table 11 presents results of the analysis of these crashes for North Carolina and the 37 other states.

Table 11. Drivers in single vehicle nighttime male (SVN-M) driver crashes 1991 - 1996, North Carolina vs. 37 comparison states.

	North Carolina		Other 37 States	
	SVN-M	**Other**	**SVN-M**	**Other**
Before (1/1/91 to 9/30/93)	12.7% (530)	87.3% (3,631)	13.7% (11,712)	86.3% (73,802)
After (10/1/93 to 12/21/96)	11.7% (633)	88.3% (4,797)	12.1% (12,988)	87.9% (94,289)
Decline	8.5%‡		11.6%*	
Risk Ratio (before/after)	1.09		1.13	
95% Confidence Interval	[.99, 1.20]		[1.11, 1.16]	
‡ $p < .01$	$RR_{NC}/RR_{37} = .97$, 95% CI = .87 to 1.08			
* $p < .001$				

Prior to enactment of the 0.08% law, 12.7% of fatal crashes in North Carolina were single vehicle nighttime male driver crashes. That declined to 11.7% in the 39 months immediately following enactment of the lower BAC limit, a decline of 8.5%. There was a somewhat greater decrease in SVN-M crashes in

the other 37 states (11.60%). The ratio of these changes between North Carolina and the other states is .97 [.87, 1.08], indicating a non-meaningful difference in these changes.

Estimated Alcohol Involvement

In its examination of the first five states that reduced their BAC limit to 0.08%, the NHTSA used a variable described as 'estimated alcohol,' which was based on three factors: Police-reported alcohol involvement, evidence of a previous alcohol violation on the driver's record, and a positive measured BAC value. The report of this analysis does not give a detailed explanation of how this variable was created. We attempted to conduct a similar analysis as follows: "Estimated driver alcohol use" was considered to be positive if the driver had one or more DWI convictions on his/her record, *or* if there was an alcohol-related charge, *or* if the results of an alcohol test registered a BAC of $\geq$0.01%. Table 12 presents results of the analysis of these crashes for North Carolina and the 37 other states.

Table 12. Drivers' estimated alcohol involvement in fatal crashes 1991 - 1996, North Carolina vs. 37 comparison states.

	North Carolina		Other 37 States	
	Yes	**No**	**Yes**	**No**
Before (1/1/91 to 9/30/93)	25.0% (1,041)	75.0% (3,120)	24.7% (21,155)	75.3% (64,359)
After (10/1/93 to 12/21/96)	20.4% (1,110)	79.6% (4,320)	21.9% (23,458)	78.1% (83,819)
Decline	18.3%*		11.6%*	
Risk Ratio (before/after)	1.22		1.13	
95% Confidence Interval	[1.15, 1.30]		[1.12, 1.15]	
* $p < .001$	$RR_{NC}/RR_{37} = 1.08$, 95% CI = 1.00 to 1.17			

Prior to enactment of the 0.08% law, 25.0% of drivers in fatal crashes in North Carolina were estimated to have been drinking. That declined to 20.4% in the 39 months immediately following enactment of the lower BAC limit. For the other 37 states, estimated drinking declined by 11.61%. The ratio of these changes between North Carolina and the other states is 1.08, indicating a greater relative decrease in estimated alcohol involvement for North Carolina. Again, however, inspecting this variable for 24 months prior to and following the lowered BAC limit suggests that the change seen above results not so much from the effects of the law as from the fact that drinking-driving in North Carolina was comparable to that in the other states in 1991 and early 1992, but then declined relative to other states during the 18 month period prior to enactment of the 0.08% limit. Comparing only the 48 months immediately surrounding the reduction of the BAC limit, the ratio of relative risks is 1.05 [.95, 1.15], a non-significant ($p > .20$) difference.

Summary of Before-After Analyses

Table 13 provides a summary of the findings of the various analyses reported above. For completeness it also includes analyses for the 48 month period October 1, 1991 - Sept. 30, 1995. The 48-month period

was examined to more closely parallel the periods reported in the initial analyses by NHTSA (1994) and to equalize seasonal effects in the before-after periods. The only two measures that show a significantly greater decrease in North Carolina than in the states that retained a BAC limit of 0.10% during 1991-1996 are police-reported alcohol involvement and estimated alcohol involvement.[13] Considering analyses of time periods more proximate to the change in the North Carolina BAC limit, and taking seasonality into account, these findings disappear.

Table 13. Summary of findings from FARS data, North Carolina vs. 37 other states, 72- and 48-month analysis periods

Criterion Measure	Analysis Period			
	1991-96 (33 months before, 39 months after)		48 Months (24 mos. before, 24 months after)	
	Ratio of RRs	95% CI	Ratio of RRs	95% CI
Alcohol > 0.01%	1.06	.98, 1.14	1.04	.94, 1.14
Alcohol > 0.10%	1.06	.97, 1.15	1.02	.92, 1.13
PR-Alcohol	**1.13**	**1.03, 1.25**	1.07	.95, 1.20
SVN	0.99	.90, 1.09	0.97	.92, 1.16
SVN-M	0.97	.87, 1.08	0.93	.81, 1.06
Est. Alcohol	**1.08**	**1.00, 1.17**	1.05	.96, 1.15

Comparison of North Carolina with other states

North Carolina has a reputation for being tough on drinking drivers as is reflected in the comprehensiveness of its DWI laws. It was one of only three states to receive an A- rating by MADD in its recent review of state DWI laws. In addition, beginning in late 1994, North Carolina implemented an extensive high visibility DWI enforcement program (Booze-It-and-Lose-It), which resulted in 3,185 DWI checkpoints being conducted throughout the state between November of 1994 and July, 1995. For these and perhaps other reasons, it may be that North Carolina is an atypical state in terms of drinking-driving.

It is difficult to know whether any characteristics on which a state may differ from others with respect to traffic safety laws or programs is a meaningful one – a factor that should be taken into account when deciding whether any findings from that state should be generalized to other states. We can, however, examine whether various indicators of drinking-driving are dramatically different in North Carolina when compared to the rest of the nation. To address this issue, Table 14 compares North Carolina with the 37 states on each of the six criterion measures examined above prior to enactment of the 0.08% law. It is clear that there are some statistically meaningful differences. For example, 1.7% fewer drivers involved in fatal crashes in North Carolina between 1991 and 1993 had a high BAC ($\geq$ 0.10%); 2.3% fewer were reported by the investigating officer to have been drinking. On the other hand, there were negligible and non-significant differences on several other measures.

[13] It is important to keep in mind that these are not independent findings, since police-reported alcohol involvement is one of the elements of the 'estimated alcohol' measure.

In sum, although there are some statistically significant differences between North Carolina and other states, the magnitude of these differences is relatively small. Hence, it would not appear that during the early 1990s North Carolina was so atypical with respect to drinking-driving, that we should hesitate to generalize findings from this or other studies of drinking drivers, to the U.S. in general.

Table 14. Comparison of North Carolina with 37 comparison states on six measures of drinking-driving in fatal crashes for 1991 - 1993.

Measure	NC	37 States	Difference	z
BAC Over .01%	24.1%	27.9%	-3.8%	5.54*
BAC Over .10%	22.0%	23.7%	-1.7%	2.65*
Police-Reported Alcohol	17.4%	19.7%	-2.3%	4.11*
SVN	16.3%	16.8%	-0.5%	0.88
SVN-M	17.1%	18.2%	-1.1%	1.57
Estimated Alcohol	24.8%	24.5%	0.2%	0.35

*Note. z-test for difference of proportions. $p < .01$

❑ CONCLUSION

There appears to have been little clear effect of the lower BAC limit in North Carolina. Survey data indicate that the general public believes the new law was well-publicized. Although awareness of the new lower limit was not particularly high nearly 18 months after the law took effect, frequent drinkers did evidence a substantial degree of awareness that the law had changed and about what the new BAC limit was. As is typical in North Carolina, enforcement of the lower limit was vigorous and strict. Hence, it appears that the most likely explanation for the lack of a demonstrable effect of the lower BAC limit is that the drinking-driving population in North Carolina at the time the lower limit took effect was simply unresponsive to this change. Whether that is because, following a substantial reduction in drinking-driving behavior, the remaining drinking-drivers in North Carolina represented a 'hard core' that cannot be affected by such broad policies, or that this particular policy simply does not have the potential to measurably affect drinking drivers in general, is unknown.

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Appendix A

Detailed presentation of stochastic time series models fit to various types of alcohol-related North Carolina crashes as summarized in Table 3 .

Note. The models for percent of alcohol-related fatal or serious injury crashes (table 3.b.) contain no stochastic components. Hence, these reduce to simple regression models. These models also contain no seasonal factors. As a result residual autocorrelations are only computed through lag 14, and, hence, Q(14) is presented for these models rather than Q(15) as is reported for other series. Similarly since no seasonal patterns were found, no value of R^2_S is computed for these models.

Table 3. Parameters for logit models of various indicators of alcohol-involved North Carolina crashes, 1991 - 1995.

3. a. PERCENT OF CRASHES INVOLVING ALCOHOL – all levels of severity

Components of Model:

- Stochastic level, trend, seasonal
- Autoregressive term at lag 7,
- Number of weekend days per month

Intervention (1)	*estimate*	*s.e.*	*t-ratio*	*p-value*
Shift in level	-.038	.038	-1.007	.320
		Residual Autocorrelations	*Goodness-of-Fit*	
		Q(5) = 2.26	R^2 = .941	
		Q(10) = 6.88	R^2_D = .679	
		Q(15) = 10.64	R^2_S = .549	

Intervention (2)	*estimate*	*s.e.*	*t- io*	*p-value*
Change in trend	.001	.009	.168	.866
		Residual Autocorrelations	*Goodness-of-Fit*	
		Q(5) = 1.98	R^2 = .940	
		Q(10) = 8.88	R^2_D = .673	
		Q(15) = 14.09	R^2_S = .541	

3. b. PERCENT OF CRASHES INVOLVING ALCOHOL – severe and fatal crashes only.

Components of Model:

- Fixed level, fixed trend

Intervention (1)	*estimate*	*s.e.*	*t-statistic*	*p-value*
Shift in level	.023	.058	.390	.698
		Residual Autocorrelations	*Goodness-of-Fit*	
		Q(5) = .442	R^2 = .759	
		Q(10) = 7.00	R^2_D = .470	
		Q(14) = 7.86		

Intervention (2)	*estimate*	*s.e.*	*t-statistic*	*p-value*
Change in trend	-.0001	.003	-.017	.986
		Residual Autocorrelations	*Goodness-of-Fit*	
		Q(5) = .426	R^2 = .758	
		Q(10) = 7.13	R^2_D = .468	
		Q(14) = 8.09		

Table 3. Results for Logit Models (Continued)

3. c. PERCENT OF CRASHES OCCURRING AT NIGHT – all levels of severity

Components of Model:

- Stochastic level, trend, seasonal
- Autoregressive term at lag 4
- Number of weekend days per month

Intervention (1)	*estimate*	*s.e.*	*t-statistic*	*p-value*
Shift in level	-.022	.022	-1.033	.308
		Residual Autocorrelations	*Goodness-of-Fit*	
		Q(5) = 3.25	R^2 = .760	
		Q(10) = 5.88	R^2_D = .694	
		Q(15) = 11.26	R^2_S = .432	

Intervention (2)	*estimate*	*s.e.*	*t-statistic*	*p-value*
Change in trend	.001	.003	.305	.762
		Residual Autocorrelations	*Goodness-of-Fit*	
		Q(5) = 3.63	R^2 = .733	
		Q(10) = 5.72	R^2_D = .659	
		Q(15) = 12.03	R^2_S = .368	

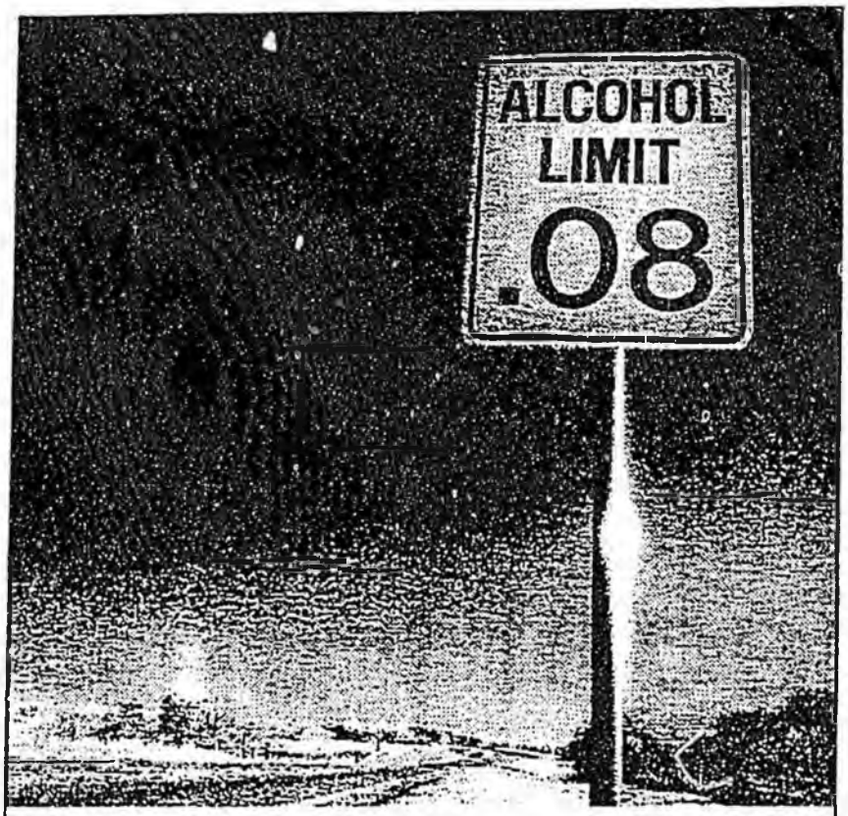
3. d. PERCENT NIGHTTIME CRASHES – serious and fatal crashes only

Components of Model:

- Fixed level, fixed trend, stochastic seasonal
- Number of weekend days per month

Intervention (1)	*estimate*	*s.e.*	*t-statistic*	*p-value*
Shift in level	.050	.040	1.240	.222
		Residual Autocorrelations	*Goodness-of-Fit*	
		Q(5) = 3.26	R^2 = .610	
		Q(10) = 7.68	R^2_D = .633	
		Q(14) = 11.15	R^2_S = .446	

Intervention (2)	*estimate*	*s.e.*	*t-statistic*	*p-value*
Change in trend	.003	.002	1.075	.288
		Residual Autocorrelations	*Goodness-of-Fit*	
		Q(5) = 2.30	R^2 = .611	
		Q(10) = 8.58	R^2_D = .633	
		Q(15) = 12.48	R^2_S = .447	



TO ALL THE SIGNS THAT MAKE DRIVING A LITTLE SAFER, WE'D LIKE TO ADD ONE MORE.

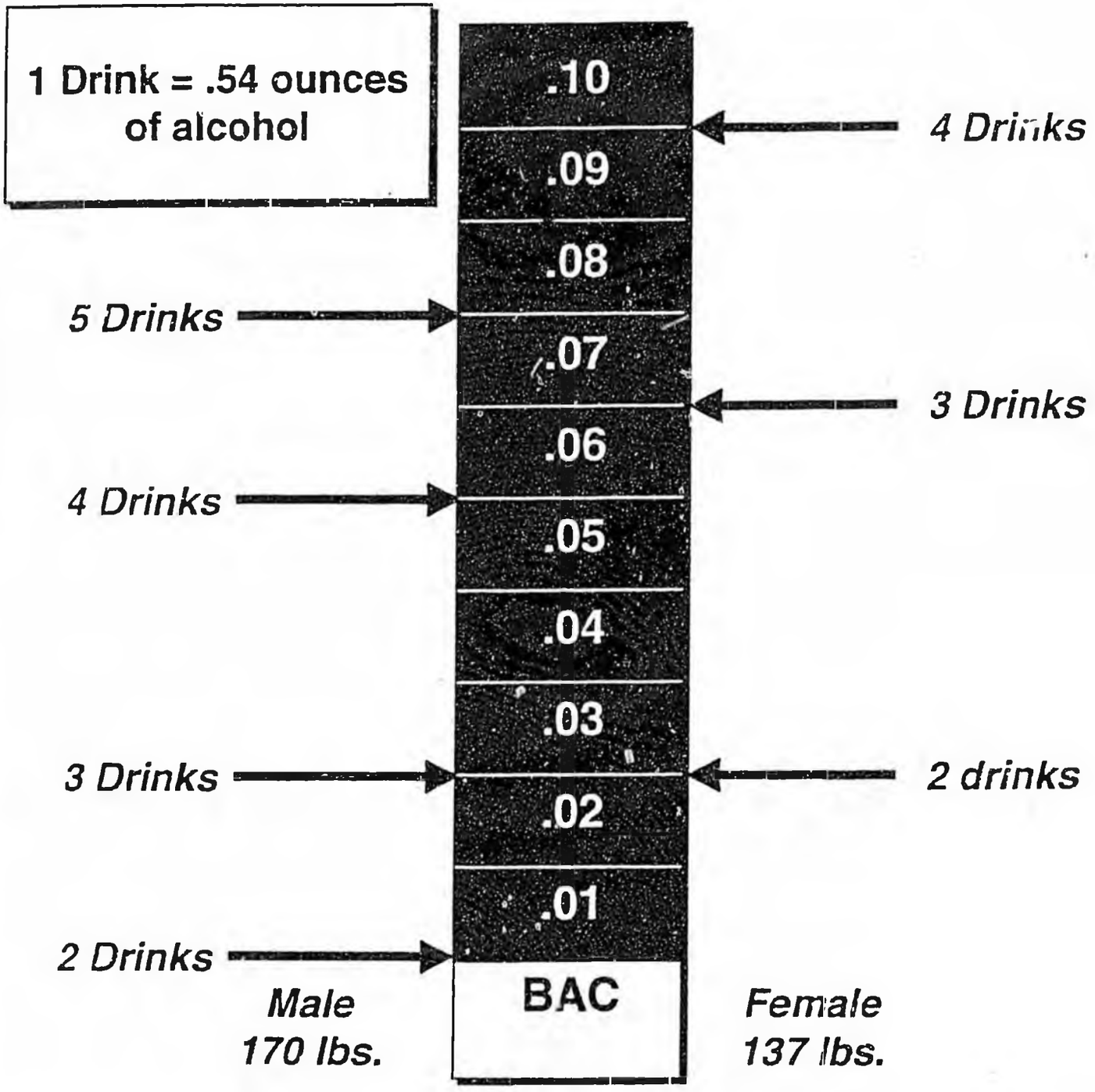
Even though your ability to drive a car is seriously impaired at a blood alcohol level of .08, most states only prosecute at .10 or higher. We'd like every state to make .08 the blood alcohol limit. If you want to help, please call or write your state legislators. Together we can make this a sign of life.

MADD

Mothers Against Drunk Driving

.08
Illegal Per Se

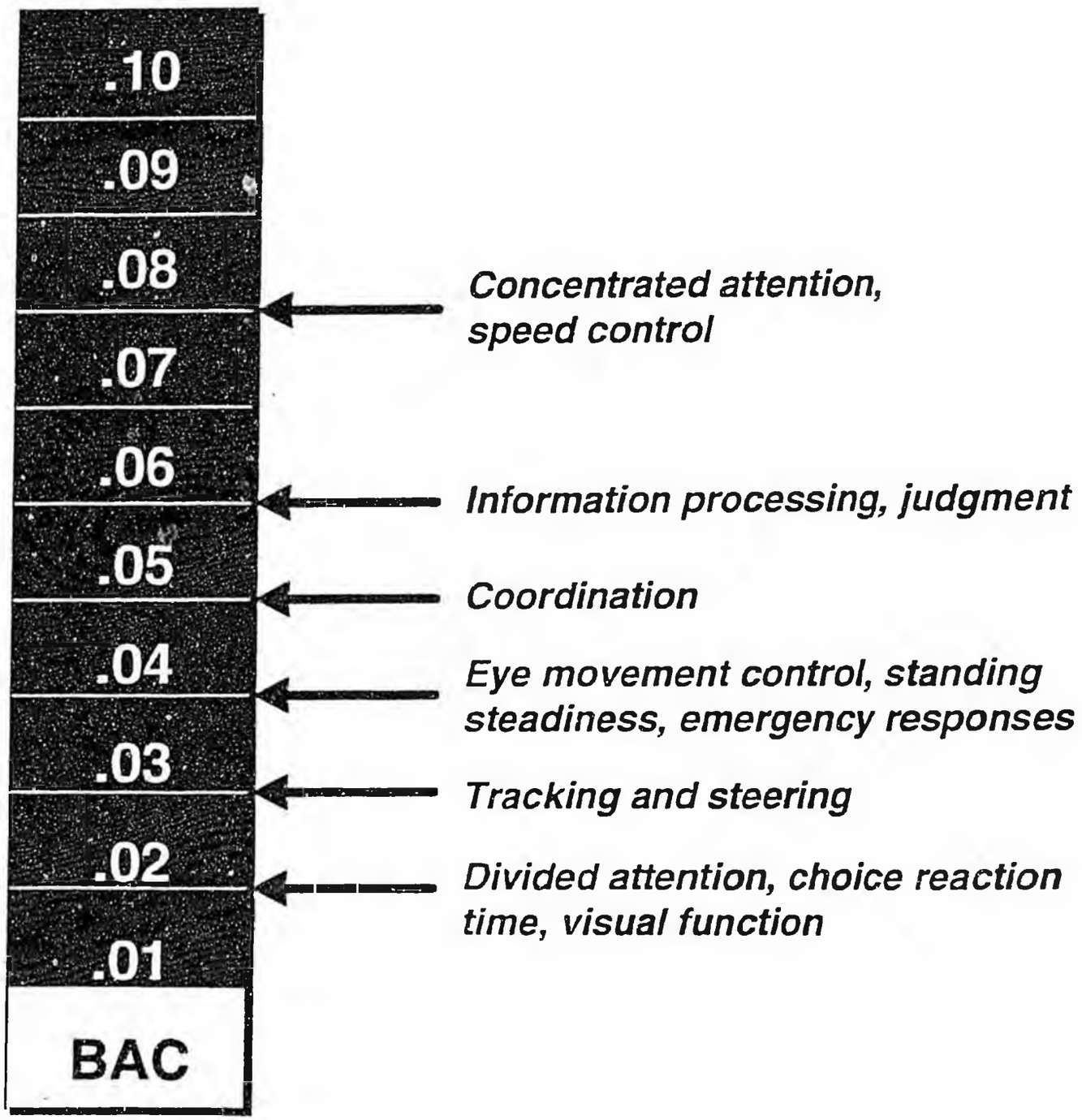
Number of Drinks and BAC in Two Hours of Drinking



.08 Illegal Per Se

- Driving at .08 BAC or above constitutes the violation in and of itself (no other factors are needed as evidence).
- *Articulable suspicion* for making the stop and "probable cause" for making the arrest must still be demonstrated.
- *Burden of proof* is less for the prosecutor.

BAC and Impairment



Alcohol Limits for Drivers
A Report to Congress
NHTSA-USDOT February 1991

- No "safe" BAC level
- All States should have "Per Se" laws
- .08 should be adopted
- Multilevel system of administrative, civil, and criminal penalties should be considered

Driving Under the Influence: A Report to Congress on Alcohol Limits

- **Enact .08 BAC as per se criminal offense**
- **Accompany lower limits with PI&E**
- **Repeal laws that create presumption drivers *not* under influence at any BAC above .00**
- **"Don't drink and drive"**
- **"Don't drive if you have been drinking"**

National Highway Traffic Safety Administration
United States Department of Transportation

July 1992

Effectiveness of .08 Laws

- **Impact of .08 in five states, NHTSA, 1995**
  - Significant reductions in A/R fatal crashes in 4 out of 5 states ranging from 4% (CA) to 40% (VT)
- **Effect of .08 in 5 states, Boston University, 1996**
  - 5 States with .08 matched to 5 states with .10 showed 16% reduction in driver fatalities at .08+ and an 18% reduction in driver fatalities at .15+ due to .08 laws.

Effectiveness of .08 Per Se

- NHTSA evaluated effects of .08 in California
- Results:
  - 81% knew BAC limit was stricter
  - Increase in DUI arrests
  - 12% reduction in A/R fatalities
  - Some of effects due to ALR

BAC Limits in Other Countries

Country	Illegal Per Se
Canada	.08
Great Britain	.08
Australia	.05
Austria	.08
Switzerland	.08
Netherlands	.05
Norway	.05
Finland	.05
Sweden	.02

Who Supports Lower BAC Levels?

- **AMA** — American Medical Association
- **NSC** — National Safety Council
- **NCUTLO** — National Committee on Uniform Traffic Laws and Ordinances
- **AAAM** — Association for the Advancement of Automotive Medicine
- **NIAAA** — National Institute for Alcohol Abuse and Alcoholism
- **NHTSA** — National Highway Traffic Safety Administration

.08 Per Se

- **Will .08 affect problem drinker drivers (BACs ≥ .15)?**
  - **Significant reductions in the proportion of fatally injured drivers with BACs ≥ .20 occurred in California after .08 went into effect**
  - **Significant reductions in the proportion of fatally injured drivers with BACs ≥ .15 occurred in Boston University 5 state study due to .08 law**
  - **.08 serves as a general deterrent, if accompanied with PI&E even for drinkers who reach high BACs**

The .08 Per Se Law Will:

- Increase the arrest and conviction rates for impaired drivers at .10 and above
- Raise the perceived risk of arrest for driving after drinking
- Improve public awareness about how much alcohol it takes to be dangerously impaired
- Bring the U.S. closer to per se limits of most industrialized nations

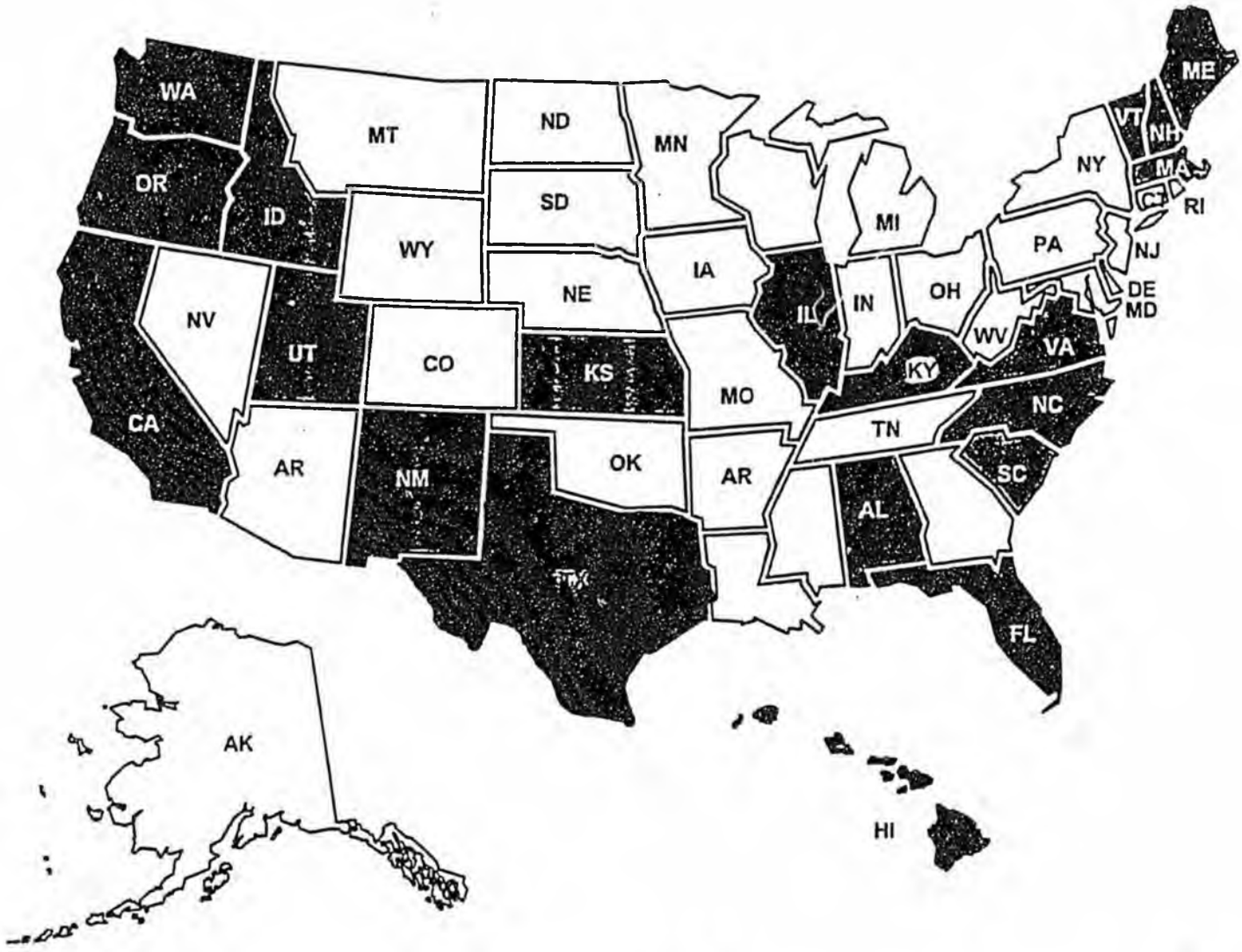
Cost/Benefit of .08 Laws

- Minimal costs to implement
- Small increase in arrests, but not enough to overburden the courts
- Same rules of enforcement apply (articulable suspicion; probable cause)
- Law sends a message to the public that the State is getting tougher on impaired driving
- Potential benefits far outweigh any costs

.08 In Summary ...

- Is not just a couple of drinks after work
- Is a level at which critical driving skills are impaired
- Is a level above which the risk of crash is increased substantially
- Is a level which most industrialized countries have adopted
- Is a proven effective measure which will reduce alcohol-related fatalities

States With BAC Per Se Laws



.08 BAC (AL, CA, FL, HI, ID, IL, KS, ME, NC, NH, NM, OR, UT, VA, VT, WA)

.10

No Per Se Law (MA, SC)

Alcohol-Related Relative Risk of Driver Fatalities and Driver Involvement in Fatal Crashes in Relation to Driver Age and Gender: An Update Using 1996 Data*

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ABSTRACT. *Objective:* To re-examine and refine estimates for alcohol-related relative risk of driver involvement in fatal crashes by age and gender as a function of blood alcohol concentration (BAC) using recent data. *Method:* Logistic regression was used to estimate age/gender specific relative risk of fatal crash involvement as a function of the BAC for drivers involved in a fatal crash and for drivers fatally injured in a crash, by combining crash data from the Fatality Analysis Reporting System with exposure data from the 1996 National Roadside Survey of Drivers. *Results:* In general, the relative risk of involvement in a fatal vehicle crash increased steadily with increasing driver BAC in every age/gender group among both fatally injured and surviving drivers. Among 16-20 year old male drivers, a BAC increase of 0.02% was estimated to more than double the relative risk of fatal single-vehicle crash injury. At the midpoint of the 0.08% - 0.10% BAC range, the relative risk of a fatal single-vehicle crash injury varied between 11.4 (drivers 35 and older) and 51.9 (male drivers, 16-20). With only very few exceptions, older drivers had lower risk of being fatally injured in a single-vehicle crash than younger drivers, as did women compared with men in the same age range. When comparable, results largely confirmed existing prior estimates. *Conclusions:* This is the first study that systematically estimated relative risk for drink-drivers with BACs between 0.08% and 0.10% (these relative risk estimates apply to BAC range midpoints at 0.09%.) The results clearly show that drivers with a BAC under 0.10% pose highly elevated risk both to themselves and to other road users. (*J. Stud. Alcohol* 61: 387-395, 2000)

BASED ON extensive research over several decades, we now have overwhelming evidence showing that even blood alcohol concentration (BAC) levels as low as 0.02% impair driving-related skills. One such line of evidence grows out of laboratory research with dosed subjects (Moskowitz and Robinson, 1987; see also National Institute on Alcohol Abuse and Alcoholism, 1997, chapter 7). Confirming evidence also comes from field research that compares the BACs of crash-involved with noncrash-involved drivers to determine the relative risk of crash involvement (for a review, see Perrine et al., 1989; Zador, 1991).

According to National Highway Traffic Safety Administration (NHTSA) information, as of September 1999, 31 states defined driving with a BAC above 0.10% as a crime per se, while another 17 states plus the District of Columbia set their per se limit at 0.08%. (Under a per se law it is a crime to drive with a BAC at or above the proscribed level; two states, Maryland and South Carolina, do not have a per se law but a presumptive limit.) Due to a combination of legal measures, enforcement actions and changes in voluntary behavior patterns, alcohol-related fatalities have been declining for nearly 2 decades, both in absolute numbers and as a proportion of all fatalities. Nonetheless, there were still 15,936 alcohol-related traffic fatalities in the United States that accounted for nearly 38% of total traffic fatalities in 1998 (NHTSA, 1999), indicating that much more needs to be done.

The objective of the present research is to re-examine and refine relative fatal crash risk estimates, in a systematic fashion using more recent data. It extends similar prior work by the first author, in three important ways. First, we estimate relative risk for the policy-relevant BAC range of 0.08% to 0.10%. Second, we estimate relative risk for six driver groups: (1) driver fatalities in single-vehicle crashes, (2) driver involvements in single-vehicle fatal crashes, (3) driver fatalities in two-vehicle crashes, (4) driver involvements in two-vehicle fatal crashes, (5) driver fatalities in all crashes and (6) driver involvement in all fatal crashes. Third, we employ statistical methods to estimate both the effect of sampling roadside exposure and the effect of multiple imputation of missing BACs on the uncertainty of relative risk estimates.

Method

Data sources

Driver exposure data: the 1996 Roadside Survey. The 1996 National Roadside Survey (96NRS) of weekend nighttime drivers in the 48 contiguous states followed the same principles as its two predecessors (in 1973 and 1986). A

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sample of noncommercial operators of four-wheel motor vehicles was interviewed and breath-tested during a roughly 1-month period in the fall of 1996. Counties with a population of less than 20,000 were not sampled, and in counties with larger populations, roadways with average daily traffic below 2,000 were excluded from the surveys (for details, see Lestina et al., 1999). Using a geographically stratified multistage cluster sample, drivers were selected for interviews and breath tests. This survey was designed based on the National Automotive Sampling System/Crashworthiness Data System (NASS/CDS) (NHTSA, 1995). The first stage of the design comprised 24 primary sampling units (PSUs) employed by NASS/CDS, six each in the Northeast, South, West and Midwest regions. The second stage comprised a total of 46 police jurisdictions: 11-12 per region. At the third stage, square grids with sides roughly equal to 1 mile were superimposed on the sampled jurisdictions and then randomly sampled to obtain the requisite number of squares (this procedure was modified for areas with low road density). Once a square was chosen, the survey was conducted at the first safe area found in it by the survey team leader. Driver selection represented the final stage: the first driver who approached the site after an interviewer became available was stopped for the next interview. Field operations were conducted on Friday and Saturday nights during two 2-hour periods at separate sites: at one site between 10 pm and midnight, and at the other between 1 am and 3 am. Data from the 96NRS is only representative of locations and periods when drinking and driving is most prevalent (i.e., not of all times or roadways in the 48 contiguous states).

We adjusted driver sampling weights from the 96NRS for nonrespondents, and used the adjusted weights to approximate the statistical distribution of drivers on weekend nights (exposure), by gender, age (16-20, 21-34 and ≥ 35) and % BAC (0.000, 0.001-0.019, 0.020-0.049, 0.050-0.079, 0.080-0.099, 0.100-0.149 and 0.150+). For details on nonresponse adjustments, see Lestina et al. (1999) and Zador et al. (in press).

Data on drivers in fatal crashes. The Fatality Analysis Reporting System (FARS) is a census of all fatal motor vehicle crashes that occur on public trafficways in the United States and result in a fatality within 30 days. Although FARS is maintained by NHTSA of the U.S. Department of Transportation, the data in FARS are obtained through cooperative agreements with agencies in each state's government and are managed by regional contracting officer's technical representatives located in the 10 NHTSA regional offices. For basic data elements associated with a fatal vehicle crash, reporting is usually of very high quality with relatively few missing values, however, there is one exception: even in recent years, BACs were not available for many drivers involved in fatal crashes. To deal with this problem, NHTSA has employed a statistical method since the early 1980s for imputing missing BACs (Klein, 1986). More recently, the method of multiple imputation (Rubin, 1987) was adopted to handle the problem of missing BACs on FARS (Rubin et al., 1999). Under multiple imputation, each missing value is replaced by a small number of imputed values (10, in the present case) that are generated by a statistical procedure designed to reflect the statistical properties of the missing driver BACs. We used the 10 complete-data versions of FARS in our statistical analyses. Note that, although the data files for the multiple imputation method are available, NHTSA is not yet using the multiple imputation method for its published alcohol estimates. The same method used in previous years is to be used for the 1998 FARS estimates.

We selected drivers of four-wheel passenger vehicles who were 16 years of age and over and were involved in fatal crashes during 1995 or 1996 in 1 of the 48 contiguous states (NHTSA, 1995-96). The crash had to have occurred on a weekend night in a county with a 1990 population of at least 20,000; outside of special jurisdictions; and on a paved road that was not classed as an interstate, other urban freeway or expressway. There were only two notable differences between the exposure and the crash screening criteria, and both were disregarded to increase the sample size for drivers retained for the analyses. First, we accepted crashes that occurred between midnight and 1 AM, since those crashes were excluded from the exposure sample only to permit the survey team to change location, and not because BAC distribution between midnight and 1 AM was thought to be different. Second, we did not restrict crashes to the weekend nights during which the surveys were conducted. Including weekend nights for the whole year increased sample sizes almost 12-fold and introduced no substantial difference in the distribution of driver BACs since driver BACs varied little between the survey period and the rest of the year. We classified the drivers meeting these selection criteria by the number of crash-involved vehicles (one, two, and any number of vehicles) and by whether the driver was just involved in the crash or was also fatally injured in the crash. We thus defined six driver groups for analysis: drivers fatally injured in single-vehicle crashes, drivers involved in fatal single-vehicle crashes, drivers fatally injured in two-vehicle crashes, drivers involved in fatal two-vehicle crashes, drivers fatally injured in a motor-vehicle crash and drivers involved in a fatal motor-vehicle crash. We classified the six groups of driver fatalities and involvements by gender, age group and BAC, in the same way we classified the exposure sample.

Statistical methods

Using odds ratios and logistic regression to estimate relative risk. Following Zador (1991), we base our methods on the intuitive notion that comparisons between the frequency distribution of fatal-crash involvement by gender, age and BAC, and the frequency distribution of roadside exposure by gender, age and BAC, can provide a good yardstick for measuring the effect of these factors on the relative likelihood of fatal-crash involvement per unit of driving exposure. Since the 96NRS did not provide a national estimate for total miles

TABLE 2. Logistic regression coefficients in models for risk of driver fatalities and driver involvement in single-vehicle crashes, in two-vehicle crashes and in all crashes as a function of variables for age, gender and interactions of age, gender and BAC. Data from the 96NRS and the 1995-96 FARS.

		Single-vehicle crashes		Two-vehicle crashes		All crashes	
Variable	Parameter	Fatalities	Involvements	Fatalities	Involvements	Fatalities	Involvements
Age 16-20	Coefficient[a]	−1.547	−0.572	−2.184	−0.873	−1.077	0.085
	SE	0.072	0.063	0.060	0.057	0.065	0.057
Age 21-34	Coefficient	−2.352	−1.205	−2.643	−1.187	−1.654	−0.331
	SE	0.042	0.028	0.051	0.034	0.036	0.025
Age 35+	Coefficient	−2.540	−1.656	−2.425	−1.291	−1.672	−0.591
	SE	0.043	0.039	0.037	0.036	0.036	0.039
Female	Coefficient	−0.580	−0.509	−0.065	−0.265	−0.351	−0.356
	SE	0.069	0.053	0.054	0.043	0.053	0.042
BAC < .019, age 21+	Coefficient	−2.861	−1.889	−1.593	−2.004	−2.031	−1.925
	SE	0.375	0.126	0.121	0.134	0.137	0.106
BAC[a], age 16-20	Coefficient	0.044	0.039	0.032	0.031	0.041	0.035
	SE	0.007	0.006	0.005	0.005	0.006	0.005
BAC, age 16-20, female	Coefficient	−0.014	−0.015	−0.006	−0.015	−0.016	−0.016
	SE	0.006	0.005	0.006	0.005	0.006	0.005
BAC, age 21-34	Coefficient	0.029	0.024	0.023	0.019	0.026	0.020
	SE	0.001	0.001	0.001	0.001	0.001	0.001
BAC, age 35+	Coefficient	0.027	0.024	0.020	0.018	0.023	0.020
	SE	0.001	0.001	0.001	0.001	0.001	0.001
Model diagnostic							
Heterogeneity factor		1.6979	1.7774	1.8783	3.3159	2.0918	3.7070
Max-rescaled R^2		0.6844	0.4935	0.6524	0.3142	0.5297	0.3171
H-L goodness-of-fit, p		0.1998	0.6806	0.0317	0.0001	0.4008	0.0002
Normality of residuals, p		0.2813	0.0606	0.5701	0.4175	0.2189	0.0165

[a]BAC represents driver BAC as a continuous variable.
[b]A positive (negative) parameter indicates that variable and risk change in the same (opposite) directions.

was adequately represented by the models in Table 2 for three of the driver groups: drivers involved in a fatal single-vehicle crash, drivers killed in a single-vehicle crash and drivers killed in any vehicle fatal crashes. While the Hosmer-Lemeshow test statistic ($p = .032$) rejected the hypothesis of model fit for fatally injured drivers in two-vehicle crashes, the regression model explained 65% of all explainable relative risk variation, and the standardized Pearson residuals were normally distributed. Overall, we deem model fit acceptable for driver fatalities in two-vehicle crashes. In contrast, the models performed poorly for the two remaining driver groups—drivers in fatal crashes involving two vehicles or drivers in fatal crashes involving any number of vehicles.

We explored, in considerable detail, the way our models broke down for fatal two-vehicle crashes. We examined model fit statistics for the models in Table 2 and for several other model specifications, including specifications obtained by stepwise regression (for a summary of results for a few of the dozens of models that were examined, see the Appendix). The results showed clearly that sober driver involvement in two-vehicle crashes is not closely related to driver involvement at positive BACs, and we discovered that only the inclusion of indicator variables representing overall sober driver risk, and sober driver risk by age and gender, would produce acceptable model fit. This result was, in fact, not too surprising—for two reasons. First, in crashes involving more than a single vehicle, some drivers may be innocent (and probably sober) victims whose vehicles were struck by a high BAC at-fault driver. Second, in multivehicle crashes, crash configuration and vehicle occupancy become important determinants of relative risk. However, we decided not to use regression models that included sober driver risk variables (e.g., main effect for zero BAC, zero BAC by age interaction, etc.; see Appendix) because it was not clear how these models can be used to estimate relative risk with BAC = 0 as the baseline. Therefore, relatively poor model fit notwithstanding, we believe that the relative risk estimates presented from the model parameter estimates in Table 2 provide reasonable, albeit conservative, approximations of the true relative risk, even for driver involvement in multivehicle fatal crashes. Additional research will be needed to improve model fit for these driver groups.

Table 3 shows model-based estimates for factor of proportionate increase in relative risk associated with an increase of 0.02% in BAC level for each driver group, by age and gender. Of noteworthy mention, it was estimated that each 0.02 percentage point increase in the BAC of a driver with a nonzero BAC more than doubled the risk of receiving a fatal injury in a single-vehicle crash among male drivers aged 16-20, and nearly doubled the comparable risk among the other driver groups. Proportionality factors were estimated from age-specific regression coefficients of BAC in Table 2, except that for female drivers aged 16-20 the estimates were adjusted for the effect of being female. For the relative risk estimates in subsequent tables, relative risk was

In general, the pattern of results for the other driver groups was quite similar to the pattern described above (see Zador et al., in press). There are two major differences among the other driver groups: (1) For fatally injured drivers, relative risk increased more slowly with increasing BAC in two-vehicle than in single-vehicle crashes. As indicated earlier, this was to be expected since in multivehicle fatal crashes some involved drivers were likely to be no more than marginally at-fault. (2) Since most fatally injured drivers were killed in a single-vehicle or in a two-vehicle crash, the overall rate of increase in relative risk was bracketed by the rates of increase for single-vehicle and two-vehicle crashes.

Discussion

Confirmatory findings

This study generally confirmed that the relative risks of fatal injury and fatal crash involvement increase steadily with increasing driver BAC within each of the six driver age and gender groups studied. The only exception was that among drivers 21 and over, relative risk was lower at near-zero positive BAC than at zero BAC. The classic Grand Rapids study by Borkenstein et al. (1974) found a similar "dip" in the risk curve. Hurst (1973) showed that controlling self-reported drinking frequency eliminates the Grand Rapids dip. The customary interpretation of these results is that the anomalous dip probably results from differing alcohol tolerance between crash-involved and noncrash-involved drivers. Since drinking frequency data were not available in our study, we were unable to estimate risk curves by drinking frequency. With few exceptions, relative risk was found to decrease with increasing driver age at every BAC level, for both men and women—a finding that extends similar age trends reported for more moderate BACs by Zador (1991).

The current study also confirms the substantially higher relative risk for involvement in a single-vehicle crash of young drivers at a zero BAC as previously reported by Mayhew et al. (1986). In addition, female drivers exhibited substantially lower relative risk than male drivers of the same age. To a somewhat lesser extent, both sets of findings were also true for most of the other five driver groups studied.

In this study, lower and upper 95% confidence bound estimates for relative risk as a function of driver BAC take into account both the sampling variation of the roadside driver exposure sample and the effect of multiple BAC imputations performed by Rubin and Schaffer (1998) for NHTSA. Not surprisingly, relative risk confidence intervals are wide (e.g., lower and upper confidence bounds were 16.5 and 164 for male drivers ages 16-20 killed in single-vehicle crashes with a BAC between 0.08% and 0.10%; these relative risk estimates apply to BAC range midpoints at 0.09%). We note that the width of 95% confidence intervals increases with increasing BACs for mathematical reasons (both relative risk and its confidence bounds depend exponentially on the corresponding logistic regression parameters). We also note that, allowing for comparable variation in prior estimates, the relative risk estimates presented here are largely in line with estimates published elsewhere. (Relative risk estimates presented in this article differ in several ways from similar estimates in Zador [1991]. In the earlier study, the baseline BAC group was defined to include drivers at or below a BAC of 0.01%, age groups and BAC groups were defined differently, driver fatalities were included from only 29 states with low rates of missing BACs, missing BACs were not imputed, and the numeric BAC values were not used in analyses except to classify drivers.)

New findings

This is the first study that estimated relative risk from compatible data sources using the same methods for six groups of drivers involved in fatal crashes that were defined by the number of crash-involved vehicles and by whether the driver was only involved or also fatally injured in the crash. Drivers killed in single-vehicle crashes are of particular interest for assessing the *pure* effect of drink-driving because in single-vehicle crashes: (1) driver fault is not shared, (2) crash configuration is less of a factor, (3) vehicle occupancy is not relevant and (4) the seating position of the fatally injured occupant is fixed. In two-vehicle crashes, the possibility that fault may be split between two drivers, one or both of whom may have a (possibly different) positive BAC, would seem to make it difficult to estimate the pure effect of BAC on crash risk. It was all the more gratifying to find that the relative risk of a fatal driver injury depends on driver BAC in almost the same way for single-vehicle crashes and two-vehicle crashes, provided that the relative risk model of two-vehicle crashes statistically accounted for the possible roles of not at-fault sober drivers (see Appendix). In this study, we focused on the general effect on relative risk of a positive driver BAC, rather than on its pure effect. Our main statistical model for estimating relative risk did not, therefore, adjust relative risk estimates for the overrepresentation of sober (probably not-at-fault) drivers. Consequently, the model we used in this study appears to have generally underestimated the pure effect of positive driver BAC on relative risk, except for drivers in single-vehicle crashes.

As noted earlier, this study confirmed that relative risk and driver age are inversely related at every BAC. However, somewhat surprisingly and in part contrary to Zador (1991), we also found that for the 16-20 age group, women had lower relative risk than men at every BAC. For BACs of 0.02% and over, this lower relative risk was roughly comparable to relative risk among adult drivers aged 21 to 34—an important finding because of the increasing nighttime presence of young female drinking drivers observed in the 96NRS. That most recent survey found more, although not significantly more, female than male drinking drivers in the 16-20 age group. Perhaps the lower relative risk could be attributed to

surprising that, in every age group, the regression coefficients of BAC for driver involvement in fatal two-vehicle crashes are substantially higher in the model that incorporates a zero-BAC term than in the corresponding model that does not (this finding is actually a mathematical consequence of the fact that zero-BAC coefficients are always positive). It is surprising, however, that in every age group the regression coefficients of BAC in the model for driver involvement in fatal two-vehicle crashes that incorporates a zero-BAC term are only slightly smaller than similar age-group regression coefficients for fatally injured drivers in single-vehicle crashes. This suggests that positive BAC affects single-vehicle fatalities and two-vehicle crash involvement to roughly the same extent, provided that not-at-fault sober drivers are suitably accounted for. However, until confirmed by additional research, this finding must be considered more as a hypothesis than a definitive conclusion. Note, however, that similar suggestions were also made in Zador (1991).

Acknowledgments

The authors would like to express their thanks to JoAnn Wells and Chuck Farmer, from the Insurance Institute for Highway Safety, for assistance with the roadside survey data, and to Doug Duncan, consultant to Westat, Inc., for data processing. Paul J. Tremont, Ph.D., was the contracting officer's technical representative for this project.

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American Journal of Public Health

Reprint

Public Health Briefs

Lowering State Legal Blood Alcohol Limits to 0.08%: The Effect on Fatal Motor Vehicle Crashes

Ralph Hingson, ScD, Timothy Heeren, PhD, and Michael Winter, MPH

ABSTRACT

Objectives. This study was undertaken to determine whether reductions in alcohol-related fatal crashes following adoption of 0.08% legal blood alcohol limits were independent of general regional trends.

Methods. The first five states that lowered legal blood alcohol limits to 0.08% were paired with five nearby states that retained a 0.10% legal standard. Within each pair, comparisons were made for the maximum equal available number of pre- and postlaw years.

Results. States adopting 0.08% laws experienced 16% and 18% relative postlaw declines in the proportions of fatal crashes involving fatally injured drivers whose blood alcohol levels were 0.08% or higher and 0.15% or higher.

Conclusions. If all states adopted 0.08% legal blood alcohol limits, at least 500 to 600 fewer fatal crashes would occur annually. (*Am J Public Health.* 1996;86:1297–1299)

Introduction

In 1994, 16 589 people died and nearly 297 000 persons were injured in alcohol-related traffic crashes.[1] Several different types of studies have reported that driver impairments begin at blood alcohol levels well below the 0.10% legal standard in most states. Experimental laboratory studies have shown that at 0.08%, a level reached by a 150-lb person consuming four drinks an hour on an empty stomach, there is reduced peripheral vision, poorer recovery from glare, poor performance on complex visual tracking, and reduced divided attention performance.[2] Driver simulation and road course studies have revealed poor parking performance, impaired driver performance at slow speeds, and steering inaccuracies[3]; roadside observational studies have identified speeding and breaking performance deterioration.[4] A national comparison of drivers in single-vehicle fatal crashes with drivers not in fatal crashes but stopped at roadside surveys indicated that each 0.02% increase in blood alcohol level nearly doubles the risk of fatal crash involvement. In all age and sex groupings, the fatal crash risk at a blood alcohol level of 0.05% to 0.09% was at least nine times greater than that at zero blood alcohol.[5]

To reduce alcohol-related fatal traffic crashes, 14 states have lowered the legal blood alcohol limit from 0.10% to 0.08%. Johnson and Walz[6] monitored six different measures of driver involvement in alcohol-related fatal crashes in the first five states to adopt 0.08% laws. Nine of the 30 pre- to postlaw comparisons identified statistically significant decreases. However, comparison areas were not included to assess whether the postlaw declines were independent of general regional trends. Thus, this study was undertaken to assess whether, relative to nearby states, states adopting a 0.08% legal limit experienced a reduction in the proportion of fatal crashes involving (1) fatally injured drivers with blood alcohol levels of 0.08% or higher and 0.15% or higher, and (2) any driver with a blood alcohol level at 0.08% or higher and 0.15% or higher.

Methods

Prior to 1992, five states had lowered the legal blood alcohol limit from 0.10% to 0.08%: Utah (August 1983), Oregon (November 1983), Maine (August 1988), California (January 1990), and Vermont (July 1991). Each of these states was paired with a nearby state that retained a 0.10% legal limit. Within each pair, comparisons were made for the maximum equal number of available pre- and postlaw years. Thus, Utah was compared with Idaho from August 1976 to July 1991, Oregon with Washington from November 1976 to October 1991, Maine with Massachusetts from August 1984 to July 1993, California with Texas from January 1986 to December 1993, and Vermont with New Hampshire from July 1990 to June 1993.

To minimize potential bias resulting from variation in testing policies, the analysis initially focused on fatally injured drivers with blood alcohol levels of 0.08% or greater. During the analysis period, blood alcohol test results were available from the US Fatal Accident Reporting System for 81% of fatally injured drivers

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This paper was accepted April 12, 1996.

TABLE 2—Proportion of Fatal Crashes with a Fatally Injured Driver Whose Blood Alcohol Was 0.15% or More, Before and After the Passage of 0.08% Legal Blood Alcohol Limits in 5 States

0.08% Law States and Comparison States	Proportion before 0.08% Law (n)	Proportion after 0.08% Law (n)	% Change in Proportion (RR − 1)	Ratio of RRs (95% CI)
Oregon (0.08%)	0.22 (992/4455)	0.18 (769/4186)	−17% (0.83)	0.79 (0.70, 0.88)
Washington	0.20 (1266/6184)	0.21 (1158/5390)	+5% (1.05)	
Utah (0.08%)	0.10 (220/2252)	0.12 (245/2085)	+20% (1.20)	0.91 (0.72, 1.15)
Idaho	0.11 (232/2057)	0.15 (265/1773)	+33% (1.33)	
Maine (0.08%)	0.19 (198/1024)	0.15 (143/942)	−21% (0.79)	0.77 (0.61, 0.97)
Massachusetts	0.15 (493/3241)	0.15 (418/2703)	+2% (1.02)	
California (0.08%)	0.16 (3009/19370)	0.14 (2291/16278)	−9% (0.91)	0.82 (0.76, 0.89)
Texas	0.15 (1780/11924)	0.16 (1804/10961)	+10% (1.10)	
Vermont (0.08%)	0.19 (36/186)	0.19 (34/181)	−3% (0.97)	1.23 (0.68, 2.23)
New Hampshire	0.17 (48/280)	0.14 (30/222)	−21% (0.79)	
Overall law effect				0.82 (0.77, 0.87)

Note. RR = relative risk; CI = confidence interval.

Second, unlike previous studies, this analysis included comparison states to control for regional fatal crash trends.

Third, 0.08% law states may have been more concerned about alcohol-impaired driving and more responsive to legislative initiatives to reduce the problem. They were more likely to have other stringent laws that have been shown to reduce alcohol-related fatal crashes. All 0.08% law states had criminal per se laws in effect prior to the study, compared with only two comparison states: Texas and Vermont. The comparison states of Idaho and Washington introduced criminal per se laws during the study. It is likely that the 0.08% law effects were independent of criminal per se laws. Before the 0.08% law, reductions in alcohol-involved fatal crashes were seen both in pairs of states where both 0.08% law states and comparison states had criminal per se legislation throughout the study and in pairs where comparison states adopted the law during the study period.

All five 0.08% law states also had administrative licence revocation laws during the study, three of which were implemented within 1 year of the state's 0.08% law. Administration licence revocation laws have been associated with 5% declines in fatal crashes.[9] Among the control states, only New Hampshire had this law during the study period. This restricted our ability to separate the effects of 0.08% legislation from administrative licence revocation laws. Maine was the only 0.08% law state to implement an administrative licence revocation law prior to the study period and hence the only state where post-0.08% law reductions in alcohol-involved fatal crashes could be clearly separated from the effects of administrative licence revocation laws passed during the study period.

Finally, this analysis focused only on fatal crashes. Studies of other traffic laws indicate that the magnitude of their impact can be influenced by accompanying educational and enforcement efforts.[10–12] Studies of 0.08% laws are needed that not only assess the laws' impact on fatal crashes but also measure how effectively the laws are implemented.

On balance, the results of this study suggest that 0.08% laws, particularly in combination with administrative licence revocation, reduce the proportion of fatal crashes involving drivers and fatally injured drivers with blood alcohol levels of 0.08% or higher and 0.15% or higher. This legislation warrants consideration in other states. □

Acknowledgments

This study was supported by grants from the National Institute on Alcohol Abuse and Alcoholism, the US Centers for Disease Control and Prevention, and the Massachusetts Governor's Highway Safety Bureau.

The study is dedicated to Lori Lynn Webb and Mitch Pewitt, both of whom died, and Kara Webb Hensel and Millie and Roy Webb, who were seriously injured, in a crash involving a driver with a 0.08% blood alcohol level.

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Lowering State Legal Blood Alcohol Limits to .08%: The Effect on Fatal Motor Vehicle Crashes

DISCUSSION

- High levels of blood alcohol testing of fatally injured drivers favors accuracy of the results:
  - 88% of fatally injured drivers in .08% states
  - 75% in comparison states
- Testing levels were the same in pre and post law years

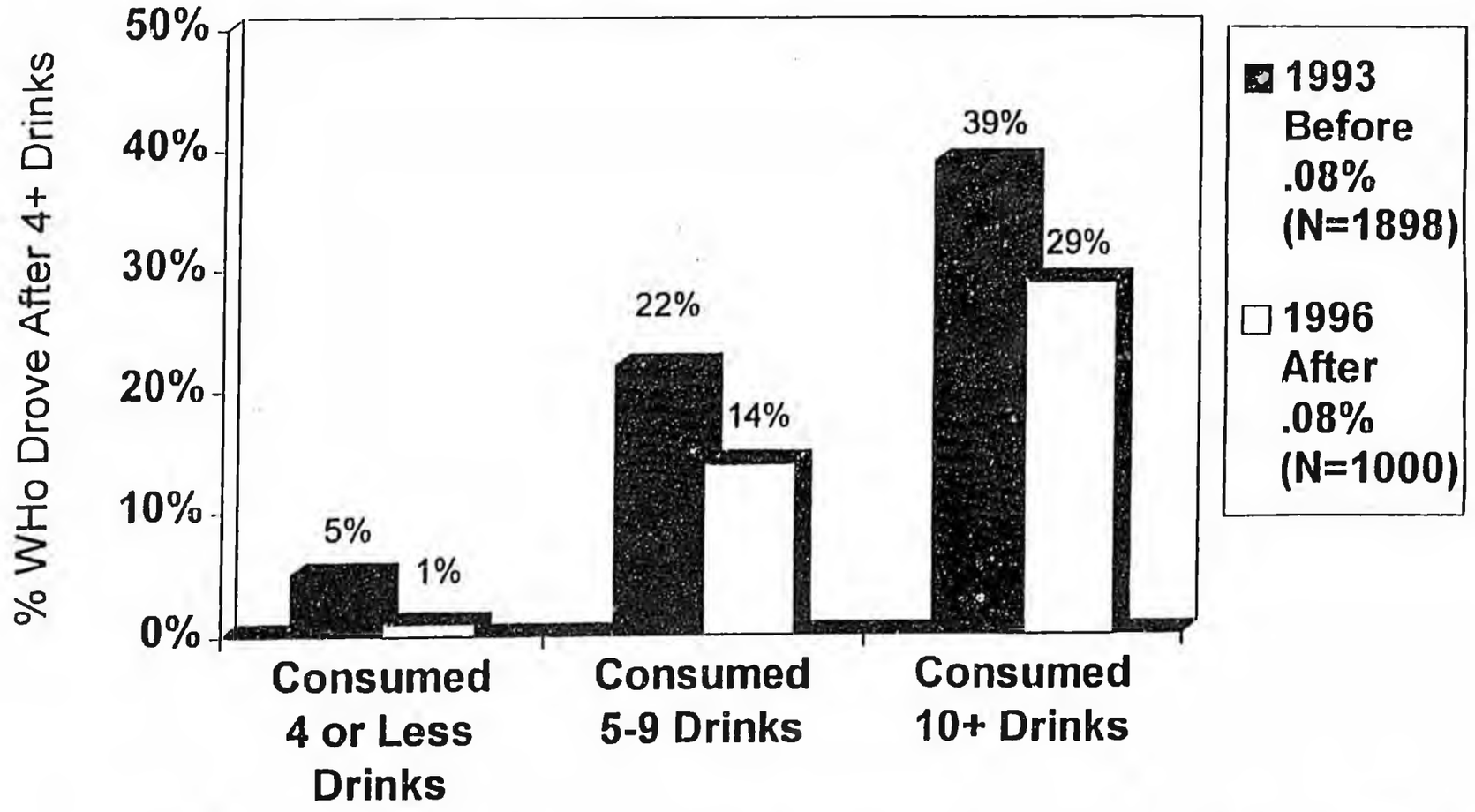
Lowering State Legal Blood Alcohol Limits to .08%: The Effect on Fatal Motor Vehicle Crashes

RESULTS

- Overall .08% Law states experienced a statistically significant 16% relative post-law reduction in the proportion of fatal crashes involving fatally injured drivers at .08% or higher and at .15% and higher
- Four out of five .08% Law states showed a reduction relative to control states in the proportion of fatal crashes with fatally injured drivers at BAC's .08% or higher and .15% or higher

Perceptions of Massachusetts Adults Age 21+

% Who Drove after 4 or More Drinks According to Single Days Highest Alcohol Consuption in the Past Month

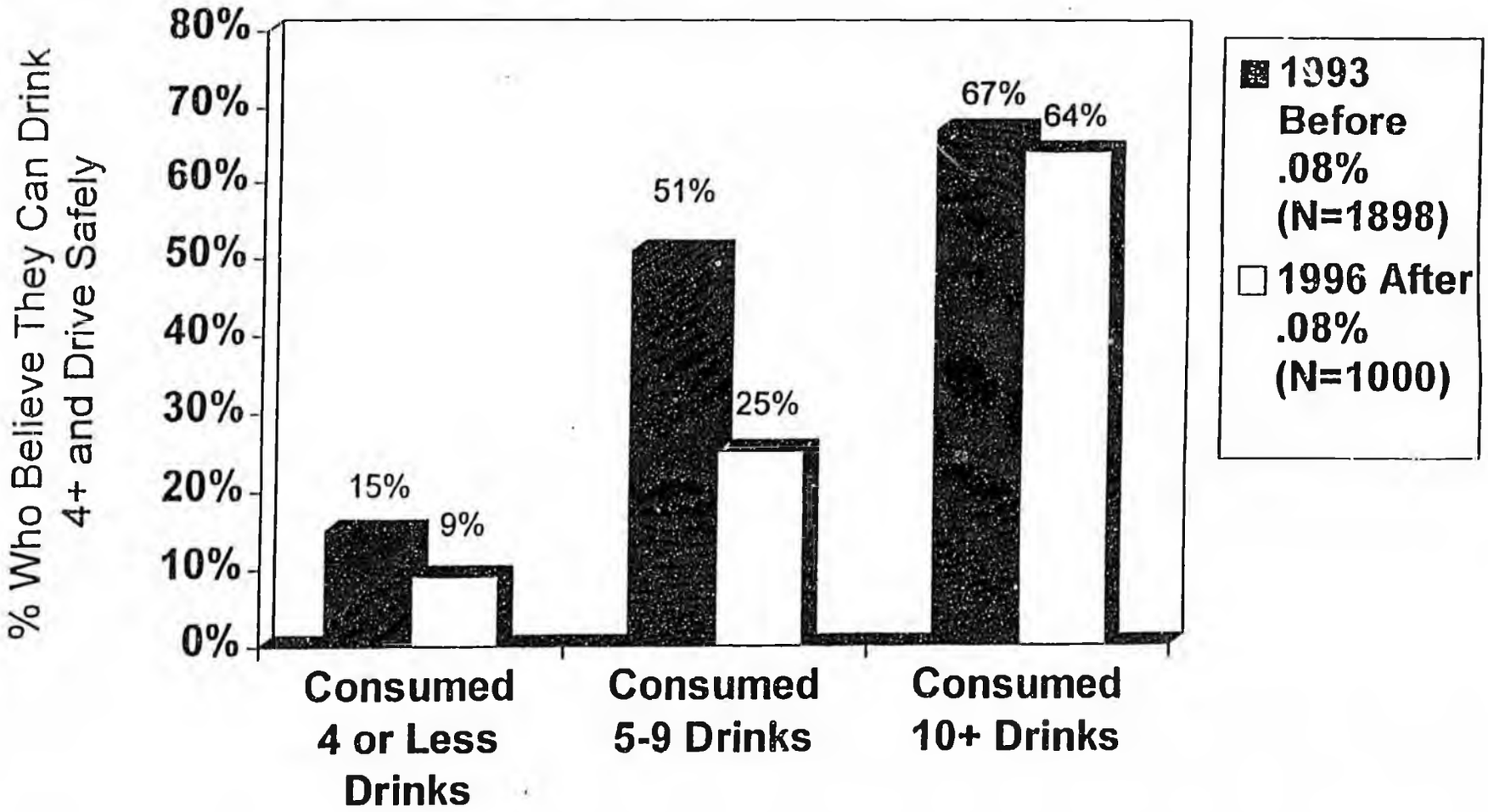


• After the .08% law there were declines in the proportions of persons who drove after 4+ drinks among light and heavy drinkers.

Source: Massachusetts Governor's Highway Safety Bureau 1993 and 1996 Statewide Telephone Survey

Perceptions of Massachusetts Adults Age 21+

One Can Drink 4 or More Drinks and Drive ***Safely*** According to Single Days Highest Alcohol Consuption in the Past Month

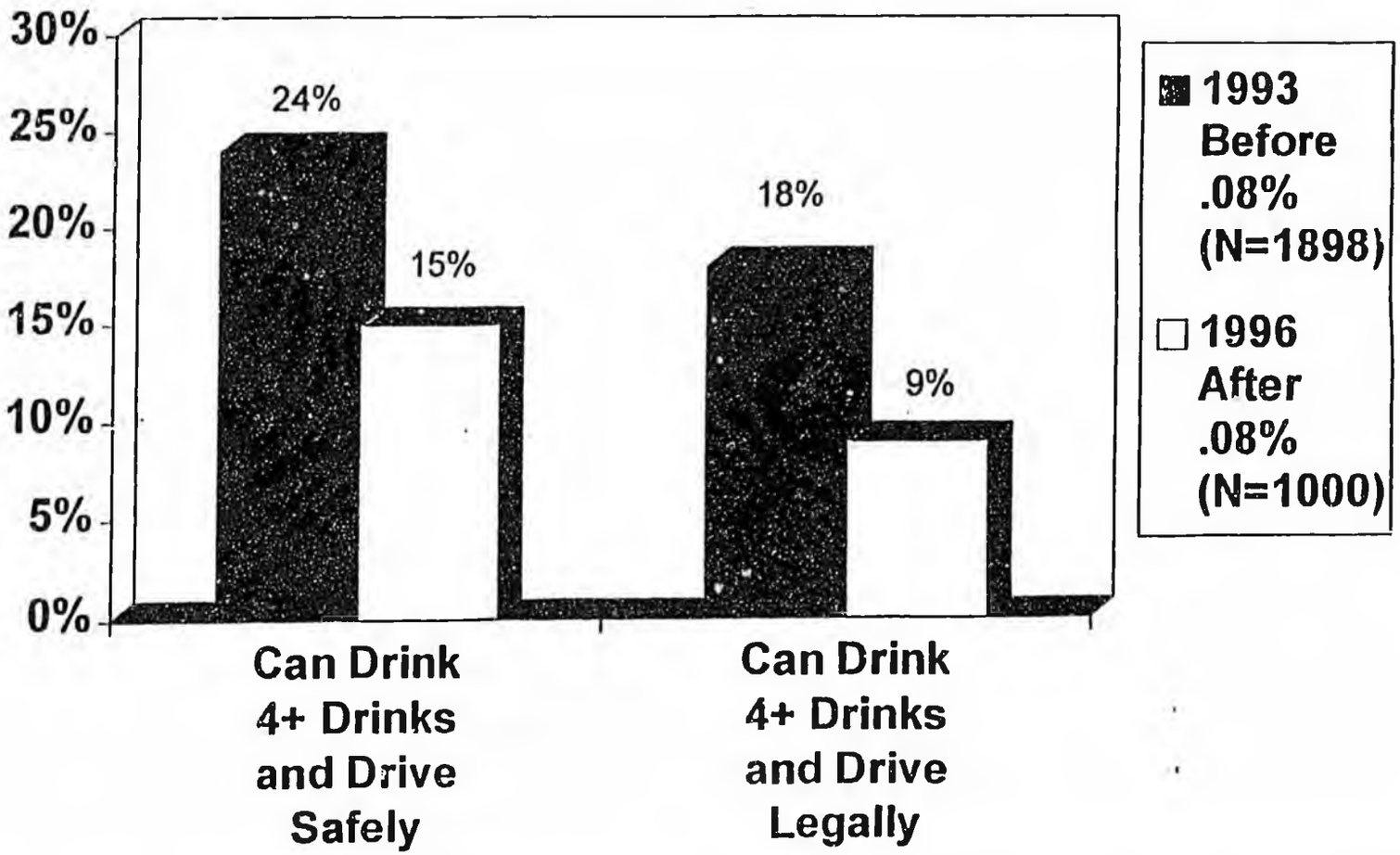


- The proportion of drivers who believed they could drink 4+ drinks and drive safely declined after the .08% law in all but the very heaviest drinkers

Source: Massachusetts Governor's Highway Safety Bureau 1993 and 1996 Statewide Telephone Surveys

Beliefs of Massachusetts Adults Age 21+

Before and After the legal BAL was Lowered from .10 to .08%



• After the .08% law, there were declines in the proportion of drivers who believed they could drive safely and legally after 4 or more drinks.

Source: Massachusetts Governor's Highway Safety Bureau 1993 and 1996 Statewide Telephone Surveys

Point: There could have been other reasons than the .08 law for the declines in fatally injured drivers with BACs $\geq$ .08 and .15 in these five .08 states. Were these other factors controlled for?

Counterpoint: All factors that could have accounted for the .08 effects were not controlled for. This is impossible to do in real world evaluations of this kind. For example, all .08 states had ALR laws in effect during the study while only one of the comparison states had ALR. Indeed, there may have been other factors that contributed to the decline in the .08 states other than the law itself.

On the other hand, some things were controlled: any regional effects (economy, etc) by using neighboring states; any urban/rural/population effects by using states with similar populations; any BAC testing rate effects by using states with high BAC testing rates.

Point: Two .08 states (UT and VT) actually had increases in the proportion of fatally injured drivers with BACs $\geq$ .08 in the before and after analyses. If .08 is so effective, why did this happen in two out of five states?

Counterpoint: It could be stated that if it weren't for the .08 law, those increases may have been greater. In most analyses of this nature, there will be states that do not show the desired effect (e.g. it happened in all of our MDA 21 studies) for one reason or another. The .08 law may not have been publicized or enforced as much. What is important is the cumulative effect of the five states, and that was a significant decrease. Similar findings occurred in NHTSA's analyses of ALR states and MDA 21 states in determining their effects. The overall effect in those studies, however, was also positive.

ABI Criticisms

ABI: "According to their research, in 1992 blood alcohol tests were available in 81% of all fatal accidents. We find that number to be unusually high because according to NHTSA, the BAC testing levels were nearly half of what MADD Incorporated claims they were."

Answer: The Hingson study states that "During the analysis period, blood alcohol test results were available from the US Fatal Accident Reporting System for 81% of fatally injured drivers in the study states."

Hingson's statement is correct. ABI is talking about BAC tests on all drivers in all states being less than 50%. Hingson is talking about BAC tests on fatally injured drivers from the 10 states during the study period.

WHY .08 BAC ?

"...afe alcohol levels should be set by health experts, not the lobby for Hooter's and Harrah's. The ...utenberg-[DeWine]-Lowey amendment isn't a drive toward prohibition, but an uphill push toward health consensus." – ***The Wall Street Journal***, September 9, 1997

"Legislation to lower the BAC definition of intoxication to 0.08 percent would be an important contribution toward reducing impaired driving on our highways." – James Hall, **National Transportation Safety Board**

"What this bill will do is send a strong signal that excessive drinking and driving do not mix. They are unacceptable and will not be tolerated by society. So I am delighted, on behalf of the Clinton Administration, to endorse this legislation. And I urge swift passage by the Congress. President Clinton is ready to sign it today." – **U.S. Secretary of Transportation Rodney E. Slater**, October 23, 1997

"We know that drinking, plus driving, spell death and disaster...The problem is bigger than the individual states...It's a grave national problem, and it touches all our lives. With the problem so clear-cut and the proven solution at hand, we have no misgivings about this judicious use of federal power." – **President Ronald Reagan**, July 18, 1984, upon signing the National Minimum Drinking Age bill

"Drunk drivers are deadly threats no matter where they speed or weave in this country. Yet a driver who is certifiably drunk in Virginia can roll to a "sobriety" of sorts merely by crossing into Maryland. That is a life-threatening inconsistency that exists around the country because there is no uniform standard of drunkenness on the roads. There ought to be a national standard [of drunk ...ving], and such a proposition is now before Congress, with support from across the political ...pectrum...Congress can bring still better sense to highways by approving a uniform, nationally understood definition of a dangerous driver." – ***The Washington Post*** editorial, November 8, 1997

"Lower Threshold for Drunken Driving – the force of law nudges people to drink more responsibly. That's a critical and little recognized benefit of a .08 law. Four drinks in one state makes you no less drunk than four drinks in another. The abundant evidence justifies a national response." – ***The Baltimore Sun*** editorial, October 25, 1997

"A .08 blood-alcohol concentration is more than enough to make you a hazard on the road, and making it the threshold for DWI would strengthen the hand of the police once they pull over erratic drivers. And that would make Maryland roads safer...The national trend is clear enough – sooner or later Maryland will have the tougher DWI standard. We might as well make it sooner, and make our roads that much safer." – ***Annapolis Capital*** editorial, November 7, 1997

"Drunk Driving remains a national shame. Despite progress over the years, 41% of all motor vehicle fatalities – more than 17,000 lives lost – involve alcohol. Yet the current legal BAC in most states is .10, the highest in the industrial world...[We] believe enactment of S.412...is a necessary and important step. Laws which set the legal BAC limit at .08 are a needed part of the combination of programs and policies which must be in place if we are to win the fight against drunk driving." – Gerald Scannell, President, **National Safety Council**

"...he drunk driving problem has not been solved and will not be solved until safety becomes a top priority, not only in Washington, but in every state." – Katherine P. Prescott, President, **Mothers Against Drunk Driving**

confident of our company's wholehearted support of your joint initiative." – Michael Dineen, Vice President, **Kemper Insurance**

"Too many innocent victims have fallen prey to the irresponsibility of drivers who have gotten behind the wheel when impaired...[S. 412] should be included in the ISTEA reauthorization bill." – Stephen Brobeck, Chairman, **The Coalition for Consumer Health and Safety**

"Yes to National Drunken Driving Law – Congress uses the threat of withheld funds too often, in our opinion, to focus its will upon states. In this case, however, the states would merely be required to set an intoxication standard that reflects research on how alcohol affects driving." – ***Omaha World-Herald*** editorial, October 29, 1997

"'The Safe and Sober Streets Act of 1997' would encourage American drinkers to be more careful about drinking when they drive. It would help reduce the number of intoxicated drivers on the highways and decrease the carnage from drunk driving." – George A. Hacker, Alcohol Policies Project, **Center for Science in the Public Interest**

"We already know that more than 17,000 lives were lost in 1997 on our nation's highways due to drunk driving. And we know that laws which allow less BAC will save lives." – Mary Jac Rauh, M.P.H., Assistant Director, **Rural Health Projects, Inc.**, Oklahoma

"Complaints from the beverage industry that the new limits would target social drinkers and not 'coholics are ridiculous and dangerous. All that matters is whether the person behind the wheel as had too much to drink. Whether he or she is a social drinker is irrelevant." – ***The Toledo [OH] Blade*** editorial, November 30, 1997

"NHTSA has, for many years recommended that states adopt a .08 BAC standard. The Alliance has strongly supported this recommendation. Medical evidence clearly indicates that at .08 BAC an individual is seriously impaired and should not operate a motor vehicle." – David Farmer, Senior Vice President, **Alliance of American Insurers**

"The NFPA supports your initiative to provide for a national standard to prohibit the operation of motor vehicles by intoxicated individuals. According to NFPA statistics, an estimated 550 civilian fire deaths occurred last year in highway vehicles. Many of these are caused by motor vehicle operators who are intoxicated. There must be a stop to the irresponsibility that kills thousands of Americans each ... ar." – George Miller, President & CEO, **National Fire Protection Association**

"S. 412 represents a necessary step forward in the campaign to educate and successfully deter people from drinking and driving and to secure the safety of motorists, bicyclists, and pedestrians on our highways and streets. As a society, we must make very clear that there is 'no such thing as a drunk driving accident'" – Patrick Schultz, **Tri State Transportation Campaign**

"When confronted with a controversial issue, it's sometimes enlightening to consider the markup of the two sides in the controversy...On one side are the people who make and sell booze...On the ther side are governmental, safety and business organizations whose interest lies in reducing the number of deaths and injuries on the highways...[they] favor cutting the legal BAC to .08...Their interest also happens to be the public interest, and the public policy they advocate is the right one." – ***The Times of Trenton*** (NJ) editorial, August 21, 1997

FACTS AND MYTHS SURROUNDING THE .08 BAC ISSUE

MYTH: "If you do have one or two beers with a slice of pizza prior to driving home, MADD wants you arrested. Social drinking at a tavern would be made nearly impossible for most customers, save those with chauffeurs." – ABI, *Chicago Tribune*, April 27, 1997

FACT: This claim is completely unfounded and untrue. According to the National Highway Traffic Safety Administration, a 170 pound male can drink at least four 12-ounce cans of beer, four five-ounce glasses of wine, or four mixed drinks within one hour on an empty stomach before reaching .08 BAC. A 137 pound female can drink three to four drinks of the same size on an empty stomach before reaching that same level, a level at which all driving skills are affected. This is hardly social drinking or just a few beers with pizza.

MYTH: "Want to know the difference between .07 and .08? Pardon my language, but if I spit in this glass, that would be the amount of liquid needed to go from legal to illegal." – Rick Berman, ABI General Counsel, *testimony given at New Jersey Senate Task Force*, August 19, 1997.

FACT: .08 is four to five drinks in an hour for a 170 pound man and three to four drinks in an hour for a 137 pound woman. That's not social drinking, nor is it a drop of spit in a wine glass. With these types of comments, Mr. Berman spits in the face of drunk driving victims. His continuing ludicrous comments and increasingly outrageous behavior on behalf of a narrow self serving special interest show not only his lack of knowledge about the drunk driving issue but a complete lack of sensitivity for victims.

The real issue is one of intoxication. No matter how many drinks it takes for a person to reach .08 BAC, when that person reaches .08, he or she is dangerously impaired and is 16 times more likely to be involved in a single-vehicle alcohol-related fatal crash than a person with a .00 BAC level. At .10, a person is 32 times more likely to be involved in such a crash. The real issue isn't how much alcohol it takes to reach .08. The real and more important issue is, at .08 BAC, people are too impaired to be driving safely.

MYTH: "MADD's proposal to lower the threshold for drunk driving arrests to .08 BAC attacks social drinkers and completely ignores the real problem – drunk drivers." – ABI, PR Newswire article, May 7, 1997

FACT: MADD is concerned about the hard-core or habitual drinking driver, but the truth is that approximately 85 percent of all alcohol-related traffic fatalities are caused by first-time offenders or people who have not re-offended in the past three years.

Our volunteers throughout the nation spend hours trying to pass laws, educate the public, support victims, and monitor DUI court cases. Money does not drive our mission, saving lives does.

MYTH: "MADD insists drunk driving is on the rise but fails to point out all highway traffic fatalities increased by 4 percent. Alcohol-related fatalities as a percentage of all fatalities stayed virtually the same." – ABI, *USA Today*, June 19, 1997

FACT: In the past, even as all traffic fatalities and miles travelled increased, alcohol-related traffic fatalities decreased. In 1995, there were 17,274 alcohol-related traffic deaths compared with 16,589 in 1994. This represented the first increase in a decade. In 1996, 17,126 people were killed in alcohol-related traffic crashes. There was no statistically significant change in the percentage of alcohol-related traffic fatalities. Alcohol-related traffic fatalities among people ages 15-20 increased for the first time since 1990. The nation has reached a plateau in the fight against drunk driving.

Nearly one quarter (3,732) of the 17,126 alcohol-related traffic deaths in 1996 involved drivers with BAC levels below .10. That's 3,732 lives. MADD thinks that's a problem worth solving. A .08 BAC law in every state would save an estimated 500 to 600 lives each year.

MYTH: "MADD foments fear by claiming *every* person killed in a drunk driving accident is a victim. Yet, according to the Transportation Department, drunken drivers themselves account for more than half the fatalities." – ABI, *USA Today*, June 19, 1997

FACT: First of all, drunk driving is not an accident – it is a violent crime. A person makes the conscious decision to drink alcohol and then drive. It is no accident. Second, this outrageous statement is infuriating. The family members and friends of people who died while drinking and driving are also victims of this preventable and tragic crime. Their lives are also shattered and forever altered by the death of a loved one. They too have lost a precious family member. The ABI's discount of these grieving victims of the drunk driving problem further demonstrates its total lack of compassion. But then, saving lives is not the ABI's goal – selling alcohol is.

MYTH: "A couple of drinks steadies a person, and might improve someone's driving ability." – Richard Bellshot, Camden County, New Jersey tavern owner, *New Jersey Senate Task Force Hearing*, August 19, 1997

FACT: Impairment begins at levels as low as .02. By the time a person reaches a BAC level of .08, critical driving skills such as steering, braking, lane changing, judgement, and emergency response are definitely impaired.

MYTH: ".08 BAC laws do not save lives. Lowering the legal BAC limit will have no effect on drivers who already ignore the current law." – *ABI web page*, August 1997

FACT: In Dr. Ralph Hingson's study published last year in the *American Journal of Public Health*, .08 BAC laws were proven to reduce the proportion of fatal crashes involving fatally injured drivers whose BAC levels were .15% and higher by 18 percent. Clearly, .08 BAC laws are a deterrent to all drinking drivers, regardless of BAC level.

MYTH: "By threatening to revoke highway funds, the proposed .08% federal legislation would force these states to implement policy changes already turned down by their own legislatures." – ABI web page, August 1997

FACT: The Safe and Sober Streets Act of 1997 aims to set an illegal BAC limit that is safe and sane. Science has proven that drivers at .08% are critically impaired.

In many states where .08 BAC legislation has been proposed and defeated, the bills have gained strong support from the public, the media and a majority of legislators. A small handful of legislators, under pressure from the alcohol and hospitality industries, have succeeded in defeating this lifesaving legislation.

MYTH: "To study the effect of .08% states, Hingson paired .08% states with what he termed "nearby" .10% states. Inexplicably, one of these "nearby" pairs consisted of California and Texas...In short, Hingson's method is flawed, the results do not replicate, and there is no evidence to suggest that .08% laws have had any effect." – *ABI web page*, August 1997

FACT: "Texas was compared with California because it is the closest state to California of comparable population and number of large urban centers. In addition, the demographics are comparable." – Dr. Ralph Hingson, 1997

"The comparison states were selected on the basis of geographic closeness, size and BAC testing rates. These were about the only five states (the five states studied in the survey) that could have been selected as comparisons based upon the study criteria for matching." – NHTSA, 1997

MYTH: "A driver who exceeds the legal limit by a one-hundredth of a percent of blood alcohol receives the same penalty as someone driving at two or three times the maximum BAC!...The ABI has consistently supported an escalated penalty system." – *ABI web page*, August 1997

FACT: Whether a drunk driver kills someone while driving impaired at .08% BAC or at .15% BAC the victim is still just as dead. Driving at BAC levels of .08% and higher is unsafe and threatens the lives of America's motorists. It should be illegal to drive at .08

United States General Accounting Office

GAO

Report to Congressional Committees

June 1999

HIGHWAY SAFETY

Effectiveness of State .08 Blood Alcohol Laws

G A O

Accountability • Integrity • Reliability

GAO/RCED-99-179

GAO

United States
General Accounting Office
Washington, D.C. 20548

Resources, Community, and
Economic Development Division

B-280883

June 23, 1999

The Honorable John McCain
Chairman
The Honorable Ernest F. Hollings
Ranking Minority Member
Committee on Commerce, Science,
and Transportation
United States Senate

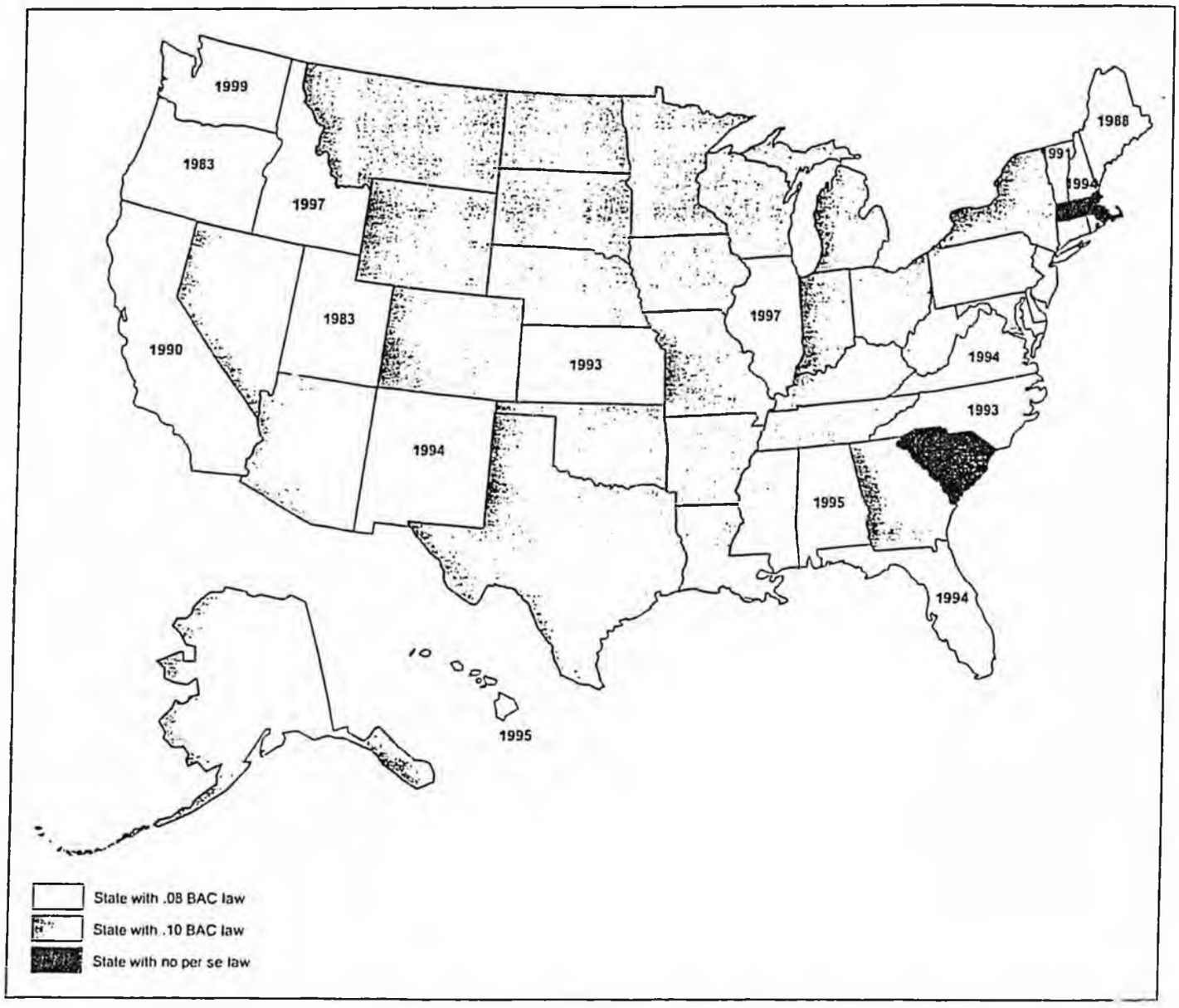
The Honorable Bud Shuster
Chairman
The Honorable James L. Oberstar
Ranking Democratic Member
Committee on Transportation and Infrastructure
House of Representatives

In 1997, someone in the United States died in an alcohol-related motor vehicle crash every 32 minutes. For years, the Congress and the states have grappled with and sought solutions to the problem of drunk driving. Most states have laws making it illegal for people to drive with a specified level of alcohol in their blood, usually set at .10 blood alcohol concentration (BAC)—the level at which a person's blood contains 1/10th of 1 percent alcohol. However, 16 states have more stringent laws setting the limit at .08 BAC. In 1998, the Clinton administration endorsed a bill that would have required all states to enact and enforce .08 BAC laws or face reductions in federal highway funds. The Senate approved this bill; the House took no action.

The Transportation Equity Act for the 21st Century directed GAO to evaluate the effectiveness of state .08 BAC laws in reducing the number and severity of crashes involving alcohol.[1] To accomplish this objective, we reviewed (1) the policies and positions of the Department of Transportation's (DOT) National Highway Traffic Safety Administration (NHTSA) on .08 BAC laws and other drunk driving countermeasures and (2) seven published studies on the effect of .08 BAC laws on the number and severity of crashes involving alcohol, including three studies released on April 28, 1999.

[1]The Transportation Equity Act for the 21st Century also directed us to study the effectiveness of .02 BAC laws for drivers under 21 in reducing the number and severity of crashes involving alcohol. The National Highway System Designation Act of 1995 required all states to enact and enforce such laws or face reductions in federal highway funds. However, as agreed to by your staff, we will not address the impact of .02 BAC laws, since all 50 states and the District of Columbia now have laws establishing BAC levels of .02 or less for drivers under 21.

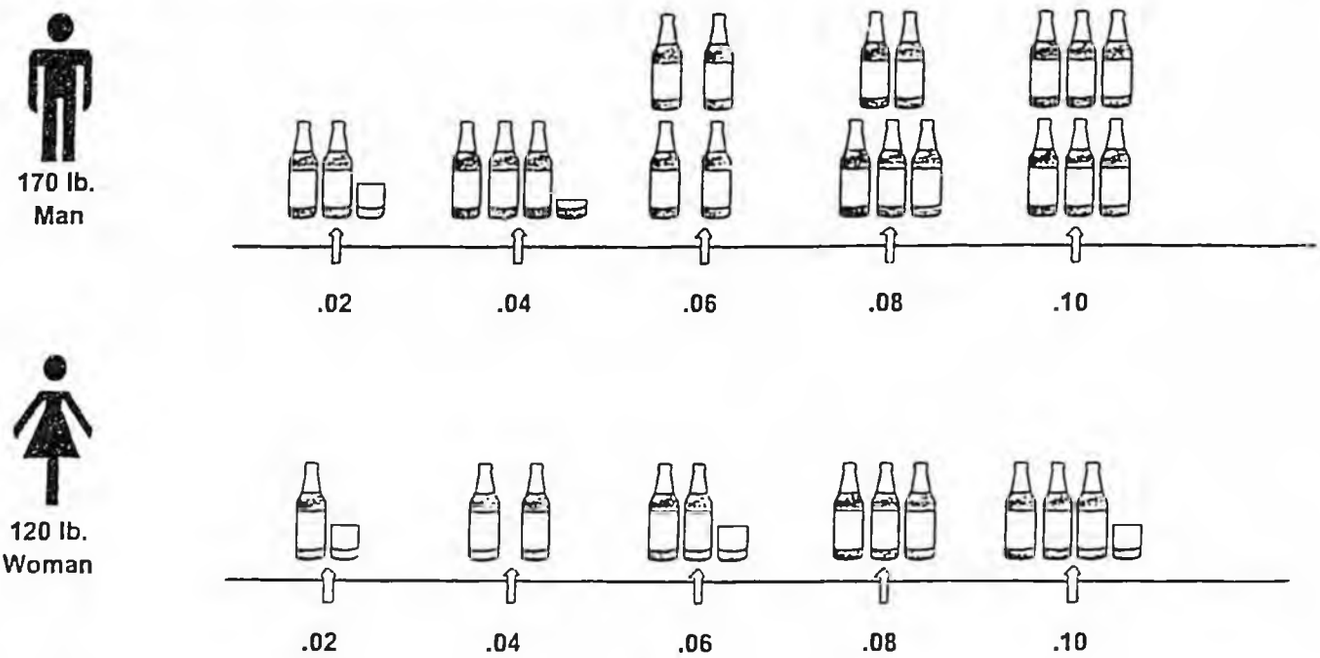
Figure 1: State Blood Alcohol "per Se" Laws



Note: States with .08 BAC laws are shown with the year the law became effective.

Source: GAO's illustration based on information from NHTSA.

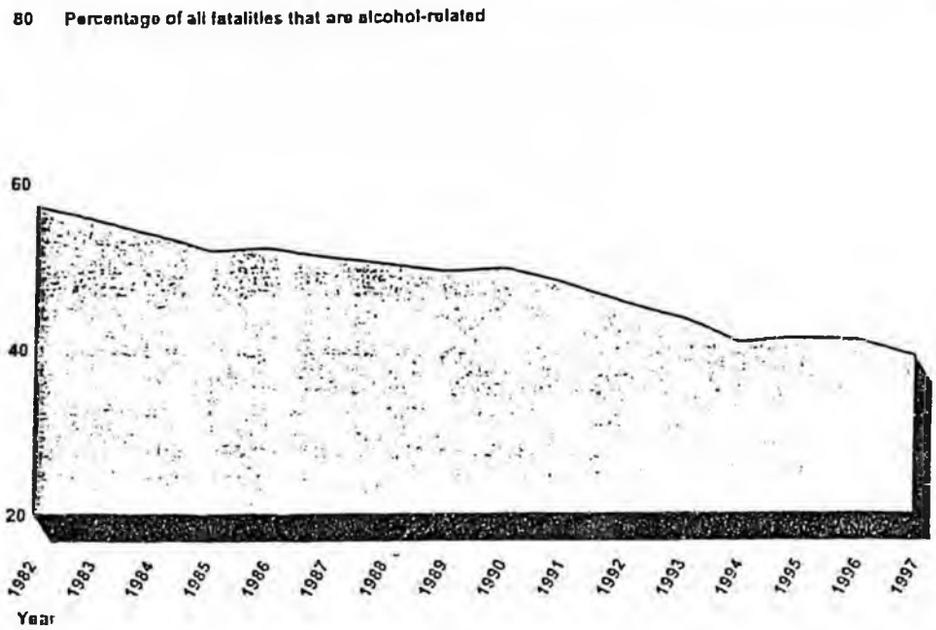
Figure 2: Alcohol Consumption and Blood Alcohol Levels



Source: GAO's illustration based on NHTSA's BAC estimator.

Alcohol use is a significant factor in fatal motor vehicle crashes. In 1997, the most recent year for which data are available, there were 16,189 alcohol-related fatalities, representing 38.6 percent of the nearly 42,000 people killed in fatal crashes that year. In the states with .08 BAC laws, alcohol was involved in 36 percent of all traffic fatalities, lower than the national average and the 39.5-percent rate of alcohol involvement in the

Figure 3: Alcohol-Related Fatalities, 1982-97



Source: GAO's illustration based on NHTSA's Traffic Safety Facts, 1997

Each state reports, and NHTSA collects and publishes, data on fatal crashes through the Fatal Accident Reporting System (FARS), a comprehensive national database of all crashes in which a person dies within 30 days of the crash. These data include (1) the number of fatalities that occur in all crashes and (2) the number of drivers involved in fatal crashes. FARS also includes whether crashes involved drivers who had been drinking. However, FARS has limitations regarding alcohol involvement in crashes—for example, fewer than half of the drivers at the scene of fatal accidents are tested for alcohol. To address the missing data, NHTSA developed a statistical model, first used in 1982, to estimate alcohol involvement in cases in which data are not available. The model provides estimates in three broad categories—sober (.00 BAC), "low BAC" (.01- .09 BAC), and "high BAC" (.10 BAC and above).[4] Therefore, certain questions—such as how many fatal crashes involve drivers with .08 BAC

[4]When cataloguing fatalities in crashes in which more than one driver had been drinking, FARS uses the driver with the higher BAC.

Since 1992, when it first recommended in a report to the Congress that all states have .08 BAC laws, NHTSA's position has changed from urging the states to pass .08 BAC laws to favoring that states be required to do so. The latter position was embodied in the President's endorsement of a Senate bill entitled the Safe and Sober Streets Act. This bill would have required all states to enact and enforce .08 BAC laws by October 1, 2001, or lose 5 percent of certain federal highway funds the first year and 10 percent each succeeding year. The Senate approved this bill on March 4, 1998, but the House took no action before the 105th Congress adjourned.[7]

As figure 4 shows, NHTSA has a number of reasons why it believes all states should adopt .08 BAC laws.

Figure 4: NHTSA's Reasons Why All States Should Adopt .08 BAC Laws

- Virtually all drivers are substantially impaired at .08 BAC with regard to critical driving tasks.
- The risk of being in a crash increases substantially when a driver reaches .08 BAC.
- .08 is a reasonable level to set the limit.
- The public supports lower BAC limits.
- Other industrialized nations have .08 or lower BAC laws.
- Lowering the limit to .08 is a proven effective countermeasure that will reduce crashes and save lives.

One of NHTSA's principal arguments for nationwide adoption of .08 BAC laws is that the medical evidence of drivers' impairment at that level is substantial and conclusive. According to NHTSA, and as shown in figure 5, reaction time, tracking and steering, and emergency responses are impaired at even low levels, and substantially impaired at .08 BAC. As a result, the risk of being in a motor vehicle crash increases when alcohol is involved, and increases dramatically at .08 BAC and higher levels. In contrast to NHTSA's position, industry associations critical of .08 BAC laws contend that .08 BAC is an acceptable level of impairment for driving a motor vehicle and that these laws penalize "responsible social drinking." These associations also believe that .08 BAC laws do not address the problem of drunk driving because many more drivers using alcohol are reported at the "high" BAC levels (above .10 BAC) than the lower BAC levels.

[7]The Senate approved this bill as an amendment to its surface transportation reauthorization bill. However, these provisions were not included in the House bill and were not included in the final version of the Transportation Equity Act for the 21st Century.

May 1998, the NHTSA Administrator stated, "The traffic safety administration is aware of four published studies, . . . [and] each study has shown that lowering the illegal blood alcohol limit to .08 is associated with significant reductions in alcohol-related fatal crashes." In a fact sheet distributed to state legislatures considering these laws, NHTSA stated that the agency's "analysis of five states that lowered the BAC limit to .08 showed that significant decreases in alcohol-related fatal crashes occurred in four out of the five states *as a result of the legislation*" (emphasis added). NHTSA used these study results to encourage states to enact .08 BAC laws, testifying in one instance before a state legislature, "We conservatively project a 10-percent reduction in alcohol-related crashes, deaths, and injuries" in the state.

Seven Studies Have Examined the Effectiveness of .08 BAC Laws

Seven studies have been published assessing the effect of .08 BAC laws on motor vehicle crashes and fatalities in the United States. Four studies published between 1991 and 1996 assessed the effectiveness of .08 BAC laws in the five states that enacted them between 1983 and 1991. On April 28, 1999, NHTSA released three additional studies. Table 1 summarizes the seven studies that examine .08 BAC laws.

results. Therefore, these studies did not provide conclusive evidence that .08 BAC laws by themselves have resulted in reductions in drunk driving crashes and fatalities. A task force of the New Jersey State Senate examined this evidence and, in a report issued in December 1998, reached a similar conclusion.[8]

The California Studies

NHTSA has cited California's experience as evidence of the effectiveness of .08 BAC laws. For example, in a publication promoting the need for .08 BAC laws, NHTSA stated that "alcohol-related fatalities significantly decreased after the state's BAC limit was lowered to .08 in 1990." In another publication, it said "California's .08 law was analyzed by NHTSA, [and] . . . the state experienced a 12% reduction in alcohol-related fatalities, although some of this can be credited to the new administrative license revocation law."

While NHTSA's 1991 study by Research and Evaluation Associates (see table 1) did find a 12-percent decline in alcohol-related fatalities after the .08 BAC law took effect, the study had important limitations. For example, the authors had available to them only 1 year of data for the period after the law went into effect, an unusually short period of time to analyze trends, and the authors acknowledged this limitation. California also had a license revocation law—under which a person deemed to be driving under the influence has his or her driving privileges suspended or revoked—take effect 6 months after the .08 BAC law. Although the authors concluded that this law had no effect, they stated that they were unable to accurately account for the separate effects of the two laws.

A more comprehensive, methodologically sound study of California was released by the state's Department of Motor Vehicles in 1995. In contrast to the 1991 review, this study was based on 4 years of data after the law became effective and found mixed results. The study concluded that the .08 BAC law was not associated with any statistically significant reductions in crashes resulting in fatalities or serious injuries in which drivers were reported to have been drinking, but that reductions did occur in accidents that took place during hours in which alcohol involvement is probable, such as nighttime crashes between 2 and 3 a.m. The study found

[8]State of New Jersey, Senate Task Force on Alcohol-Related Motor Vehicle Accidents and Fatalities, Dec. 11, 1998. Created by the leaders of the New Jersey State Senate, the task force was composed of elected officials and representatives from the state's judicial, medical, academic, and law enforcement communities. The task force was charged with, among other things, evaluating the available studies, and determining whether reducing the BAC limit to .08 would reduce the number of alcohol-related accidents and fatalities in New Jersey. The task force concluded that "the impact of laws that reduce the per se BAC level from .10 to .08, in isolation, is inconclusive" and that the effect of public education and awareness campaigns and license revocation laws "can be greater than changing the legal BAC."

to several or to the rest of the nation.

- Three of the five states had license revocation laws take effect within 10 months of their .08 BAC laws. This study made no effort to separately analyze the relative contribution of the two types of laws to any subsequent decline in fatal motor vehicle crashes in those three states. Thus, in at least three states, the authors' findings could as easily apply to the license revocation law as the .08 BAC law. The authors acknowledged this limitation, but it is rarely cited in NHTSA's literature and public statements endorsing this study and its findings.

- The study's conclusion that 500 to 600 fewer fatal crashes would occur annually if all states had .08 BAC laws is unfounded. The study does not explain how this estimate was derived or how the reduction could be credited to .08 BAC laws since the .08 BAC and license revocation laws went into effect within 10 months of each other in three of the five states. The authors told us that the estimate assumed that all states without .08 BAC laws would experience a reduction of up to 10 percent in alcohol-related crashes after enacting the laws. However, the study provides no basis for assuming that reductions of that magnitude would occur. Even this particular study found that while three of the five states experienced reductions greater than their comparison state, two of the five did not. NHTSA's April 1999 study of the effect of .08 BAC laws in 11 states (see table 1) characterized this conclusion as "unwarranted."

NHTSA Staff Study

In 1994, NHTSA staff conducted a study that examined FARS data in the first five states that enacted .08 BAC laws (see table 1). NHTSA has often cited this study as evidence of the effectiveness of .08 BAC laws. For example, a December 1997 publication with the National Safety Council said, "... significant reductions in alcohol-related fatal crashes were found in 4 out of the 5 states ranging from 4% to 40%...."

The staff study examined 6 measures of alcohol involvement, ranging from fatal crashes involving drivers with high BACs to single-vehicle crashes late at night, in each of the five states (for a total of 30 measures) and found statistically significant decreases in 9 of the 30 measures. The study also had several important limitations, which the authors acknowledged. For example, as with the Boston University study, the staff study made no effort to separately account for the relative contributions of .08 BAC laws and license revocation laws in the three states that enacted them within a short period. The staff study cautioned that the results were preliminary and that they pointed to the need for further research. NHTSA's public

study found statistically significant reductions after .08 BAC laws became effective.

Table 2: Results of the 11-State Study of .08 BAC Laws

		Statistically significant reduction occurred in		
State	**Year .08 BAC law became effective**	**Alcohol-related fatalities**	**Fatalities involving "high BAC" drivers**	**Proportion of fatalities involving "high BAC" drivers to those involving sober drivers**
Utah	1983	No	No	No
Oregon	1983	No	No	No
Maine	1988	No	No	No
California	1990	No	No	No
Vermont	1991	**Yes**	**Yes**	**Yes**
Kansas	1993	No	No	**Yes**
North Carolina	1993	No	No	**Yes**
Florida	1994	**Yes**	**Yes**	**Yes**
New Hampshire	1994	No	No	No
New Mexico	1994	No	No	**Yes**
Virginia	1994	No	No	No
Total		**2 of 11**	**2 of 11**	**5 of 11**

Note: "Yes" indicates a statistically significant reduction after the .08 BAC law became effective. "No" indicates no statistically significant reduction

Reductions in all three measures of fatalities involving alcohol occurred in Florida and Vermont. Although alcohol involvement in fatal crashes began to decline in Florida before the .08 BAC law was enacted, it continued to do so after the law went into effect on January 1, 1994. According to FARS, the number of alcohol-related traffic deaths in Florida declined in 1994 by nearly 10 percent, while the proportion of fatalities involving alcohol fell from 44 to 39 percent—in 1997 it stood at around 34 percent. While the study noted that Vermont has experienced fluctuations in its fatal crash rates, it found that after Vermont's .08 BAC law took effect, it also experienced statistically significant reductions in both the number of fatalities involving alcohol and the proportion of fatalities involving drivers with high BACs to those involving sober drivers. In this study, Vermont was the only state of the first five states to enact .08 BAC laws that showed any reductions in alcohol-related fatalities associated with .08 BAC laws.

it concluded that .08 BAC laws added to the impact that enforcement; public information; and legislative activities, particularly license revocation laws, were having. In addition to the two states where .08 BAC and license revocation laws were found to be effective in combination, the study noted that the five states with .08 BAC laws that showed reductions already had license revocation laws in place. One of the authors told us that this suggested that the .08 BAC laws had the effect of expanding the scope of the license revocation laws to a new portion of the driving public.

University of North Carolina Study

A NHTSA-sponsored study by the University of North Carolina concluded, in contrast to the 11-state study, that the .08 BAC law in North Carolina had little clear effect. The study examined alcohol-related crashes and crashes involving drivers with BACs greater than .10 from 1991 through 1995; compared fatalities among drivers with BACs greater than .10 in North Carolina with such fatalities in 11 other states; and compared six measures of alcohol involvement in North Carolina and 37 states that did not have .08 BAC laws at that time. The study controlled for and commented on external factors that could confound the results, such as the state's sobriety checkpoints, enforcement, and media coverage. The study found the following:

- No statistically significant decrease in alcohol-related crashes after passage of North Carolina's .08 BAC law in three direct and two "proxy" measures.[9]
- A continual decline in the proportion of fatally injured drivers with BACs equal to or greater than .10 but no abrupt change in fatalities that could be attributed to the .08 BAC law.
- Decreases in alcohol-related crashes in North Carolina and in the 11 other states studied. While North Carolina's decreases were greater, the study concluded that no specific effects could be attributed to the .08 BAC law.
- No statistically significant difference between North Carolina and 37 states without .08 BAC laws in four of the six measures. While reductions in police-reported and estimated instances of alcohol involvement were found to be statistically significant, these reductions happened 18 months before North Carolina lowered its BAC limit. The authors attributed these decreases, in part, to increased enforcement.

[9]Direct measures are actual observations, such as police reports of alcohol involvement in crashes, whereas proxy measures are not actual observations, but categories in which the involvement of alcohol is considered probable, such as nighttime crashes between 2 and 3 a.m.

fatalities or drivers as a percentage of all fatalities or drivers. The 50-state study's 8-percent estimate is the change in the ratio of alcohol-involved drivers to sober drivers who are in fatal crashes. While this is not an inappropriate way to measure differences in crashes and fatalities, this method can increase the size of the effect because, rather than comparing fatalities or drivers involving alcohol to all fatalities or drivers, it compares the number of alcohol-involved drivers to just the number of sober drivers. This method produced a larger effect in this study because, since 1982, of the drivers involved in fatal crashes, the number reported to have been using alcohol has dramatically declined (by around 39 percent), while the number reported to have been sober has substantially increased (by around 25 percent). While the 11-state study also measured this ratio, that study did not report a numerical effect.

Table 3 illustrates the difference between these methods of portraying traffic statistics using NHTSA's FARS data on drivers involved in fatal crashes between 1995 and 1997. As the table shows, while the number of alcohol-involved drivers declined by about 6 percent, the ratio of such drivers to sober drivers declined by 9 percent.

Table 3: Drivers Involved in Fatal Crashes, 1995-97

	1995	1997	Difference
Alcohol-involved drivers	14,269	13,393	(6.1%)
Sober drivers	41,895	43,209	3.1%
All drivers	56,164	56,602	0.8%
Ratio of alcohol-involved drivers to sober drivers	34%	31%	(9%)

Source: GAO's analysis of FARS data

Another reason why this study's results cannot be directly compared to other studies' is because it did not include data for drivers under 21. In 1997, drivers under 21 accounted for around 14 percent of the drivers in fatal crashes and about 12 percent of the drivers in fatal crashes involving alcohol. According to the authors, drivers under 21 were excluded from the analysis because other laws affect these drivers, such as minimum drinking age and "zero tolerance" BAC laws, and thus the primary effect of .08 BAC legislation would be expected to be on the population over 21 years old. While this argument may have merit, other arguments exist for including this population. First, NHTSA has stated that .08 BAC laws have a general deterrent effect on drinking and driving among all drivers. Also, young drivers violating .08 BAC laws have been prosecuted under those

conclusively establish that .08 BAC laws by themselves result in reductions in the number and severity of crashes involving alcohol. Until recently, limited published evidence existed on the effectiveness of .08 BAC laws, and NHTSA's position—that this evidence was conclusive—was overstated. In 1999, more comprehensive studies have been published that show many positive results, and NHTSA's characterization of the results has been more balanced. Nevertheless, these studies fall short of providing conclusive evidence that .08 BAC laws by themselves have been responsible for reductions in fatal crashes.

Because a state enacting a .08 BAC law may or may not see a decline in alcohol-related fatalities, it is difficult to accurately predict how many lives would be saved if all states passed .08 BAC laws. The effect of a .08 BAC law depends on a number of factors, including the degree to which the law is publicized; how well it is enforced; other drunk driving laws in effect; and the unique culture of each state, particularly public attitudes concerning alcohol.

As drunk driving continues to claim the lives of thousands of Americans each year, governments at all levels seek solutions. Many states are considering enacting .08 BAC laws, and the Congress is considering requiring all states to enact these laws. Although a strong causal link between .08 BAC laws by themselves and reductions in traffic fatalities is absent, other evidence, including medical evidence on impairment, should be considered when evaluating the effectiveness of .08 BAC laws. A .08 BAC law can be an important component of a state's overall highway safety program, but a .08 BAC law alone is not a "silver bullet." Highway safety research shows that the best countermeasure against drunk driving is a combination of laws, sustained public education, and vigorous enforcement.

Agency Comments and Our Evaluation

DOT provided comments on a draft of this report (see app. I). The Department generally agreed with the information presented in the report. DOT reiterated its long-standing commitment to a systems approach for combating drunk driving and stated that while no individual component, including .08 BAC laws, is effective in isolation, the overall evidence supports the effectiveness of .08 BAC laws. DOT stated that the four original studies provided positive, if not conclusive, results and formed a reasonable basis for supporting .08 BAC laws. The three recent studies added to this body of evidence, including the North Carolina study, which, while finding little clear effect of the state's .08 BAC law, did find

The scope of our study was limited to the effect of .08 BAC laws on the number and severity of alcohol-related crashes. We did not review several other arguments raised by both proponents and opponents of .08 BAC laws; for example, while we describe the medical evidence on impairment, we did not evaluate that evidence. In addition, our ability to review the severity of alcohol-related crashes was limited by the fact that the FARS database—used entirely by five of the seven studies and in part by a sixth—includes only fatal crashes. The .08 BAC laws reviewed may have had a greater or lesser effect on nonfatal crashes than it did on fatal crashes. Finally, section 2008 of the Transportation Equity Act for the 21st Century required us to review the effect of .02 BAC laws for drivers under 21 in reducing the number and severity of alcohol-related crashes. As agreed with your staff, we will not address those laws as all 50 states and the District of Columbia now have laws establishing BAC levels of .02 or less for drivers under 21 years of age.

We performed our work from August 1998 through April 1999 in accordance with generally accepted government auditing standards.

We will send copies of this report to cognizant congressional committees; the Secretary of Transportation; and the Administrator, National Highway Traffic Safety Administration. We will make copies available to others upon request. If you have any questions regarding this report, please contact me at (202) 512-3650 or Ronald Stouffer at (202) 512-4416. Key contributors are listed in appendix II.

Sincerely yours,

Phyllis F. Scheinberg

Phyllis F. Scheinberg
Associate Director,
Transportation Issues

Department of Transportation
Comments on the General Accounting Office (GAO) Draft Report
"Highway Safety: Effectiveness of State .08 Blood Alcohol Laws,"
RCED-99-179

The Department commends GAO for reaching the sound and accurate conclusion that a .08 blood alcohol concentration (.08 BAC) law can be an important component of a state's overall highway safety program. We agree that highway safety research shows that the best countermeasure against drunk driving is a combination of laws, including .08 BAC, sustained public education, and vigorous enforcement. The Department has consistently supported such a systems approach to reduce alcohol related driving fatalities. The .08 BAC laws are an important component of this system, as research has shown substantial evidence that performance in driving-related skills such as reaction time, tracking and steering, and emergency response is substantially impaired for all persons at .08 BAC. It is not the Department's position that .08 BAC laws, by themselves, are sufficient to address the issue of alcohol-impaired driving.

Systems Approach Most Effective for Reducing Alcohol Related Highway Deaths

GAO aptly recognizes in the draft report that the National Highway Traffic Safety Administration (NHTSA) has, since 1970, espoused a systems approach for reducing alcohol-impaired driving. This systems approach must include legislative, enforcement, judicial, licensing and public information components. In 1998, NHTSA further refined this concept with the publication of an action plan to further reduce alcohol related driving fatalities. This plan recommends that all states initiate a wide range of laws and programs including .08 BAC limits, administrative license revocation (ALR) laws, comprehensive screening and treatment programs for alcohol offenders, vehicle impoundment and zero tolerance BAC laws for youth.

While studies conducted for NHTSA have attempted to measure the effectiveness of individual components of such a systems approach to reducing alcohol related deaths, it is recognized that no component operates in a vacuum. All of the efforts to reduce alcohol-impaired driving over the past two decades have built upon and operated in the environment created by the totality of actions which have preceded it. Thus, new laws will be most effective when they complement other laws and activities. Consistent with this position, the Agency has often pointed out that .08 BAC laws are likely to be most effective when combined with ALR laws, and vice versa. The studies conducted to date convincingly support this position.

Three Recent Studies Strengthen Analytical Basis for Supporting .08 BAC Laws

NHTSA recently released the results of these three high quality studies of .08 BAC law effects, which provided additional evidence to support the effectiveness of these laws. When combined with the previously conducted studies, the three new studies provide additional confidence in the expectation that .08 BAC laws, when added to existing laws or programs, reduce alcohol-related traffic fatalities. A substantial body of directionally consistent evidence is now available to support the Department's position that .08 BAC laws are effective in reducing alcohol-related fatalities. The 50-state study, for example, controlled for more extraneous variables than any previous study and showed a significant reduction in the involvement of both low BAC and high BAC drivers in fatal crashes. The 11-state study found that .08 BAC laws were associated with reductions in alcohol-related fatalities in 7 of the 11 states studied, either alone or in conjunction with ALR laws. In the North Carolina study, which found no clear effect of its .08 BAC law, the majority of outcomes were directionally consistent with such an effect, over and above the sharp decline in alcohol-related fatalities that began before the law was enacted.

The methodologies used in these studies provide tools to make responsible estimates of how many lives would be saved if all states enacted .08 BAC laws. It is common and appropriate for such estimates to be made, based on average, pooled, or aggregated study results. Researchers that make such estimates are fully aware that there will be a range of results experienced by individual states. However, if such estimates are based on sound research and appropriate algorithms, it is reasonable to predict average effects which can be expected in states yet to adopt a particular program.

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In Depth Rebuttal of Points Made in GAO Report

"Results of Recent .08 Studies are Mixed."

By far the majority of the outcomes contained in the eight studies that have been conducted to date support the contention that .08 BAC laws are associated with reductions in alcohol-related fatalities. For example, in the recent NHTSA-sponsored 11-state study, a total of 39 outcomes were reported in the results section (33 relating to .08 BAC laws alone). Of these, 32 (26 relating to .08 BAC laws alone) were directionally in support of reduction in alcohol-related fatalities associated with .08 BAC laws, alone or in conjunction with Administrative License Revocation (ALR) laws. Eleven of these outcomes (involving 7 of the 11 states) were statistically significant. Of the remaining four states, one (UT) had non-significant outcomes which supported a decrease in alcohol related fatalities; one (ME) had mixed results; and two (OR and NH) had non-significant outcomes in the opposite direction.

In summary, significant reductions associated with .08 BAC laws were found in 5 of 11 states and significant reductions associated with the combination of .08 BAC and ALR laws were found in an additional two states.

It should be added that, in the previously published multi-state study conducted by Boston University (Hingson et. al., 1996), 8 of 10 outcomes were directionally in support of reductions in alcohol related fatal motor vehicle crashes. Six of these outcomes (covering 4 of the 5 states studied) were statistically significant. Two outcomes were neither directionally in support of an impact nor statistically significant.

"Some studies find different results for the same state"

One other aspect of variation in .08 study outcomes involves the fact that different studies have sometimes found different results in the same individual states. The most resent example of this involves the two recent studies which included North Carolina. This statement is somewhat misleading, however, since the majority of the outcomes reported in the NHTSA 11-state study and in the NHTSA North Carolina study are directionally consistent. Outcomes differ primarily in magnitude and statistical significance. Both studies reported evidence of an additional effect of the .08 BAC laws, above and beyond the sharp decline in alcohol-related fatalities that had begun prior to the implementation of the .08 BAC law.

Different studies have reported different results for other states as well, most notably for OR, UT, NH, and ME. However, these kinds of inconsistencies in outcomes have been found in other areas of traffic safety research where the body of research is considered to be consistent and convincing.
Among the studies of the age-21 minimum drinking age (MDA), for example, different results were reported by different studies for several states (most notably GA, IA, ME, and MT). As the 1987 GAO report that reviewed these studies points out, these

include the combined effect of .08 and ALR laws in CA and VA). Thirty two of 39 outcomes directionally support evidence of an impact of .08 laws alone.

The 50-state study controlled for multiple extraneous factors known to be related to fatal crashes (more than any other .08 study conducted to date) and, *in addition*, introduced a time-trend factor to account for variation which *might have been* attributable to unknown or unmeasurable factors. It still found an impact for both low and high BAC drivers.

The North Carolina study conducted approximately 17 analyses where the authors provided information regarding the directionality of the results. In 11 of these 17 analyses, the results suggested the presence of a reduction in alcohol related crashes or fatalities associated with the .08 BAC law, over and above the pre-existing trend.

We consider these results to be directionally unambiguous and consistent with the findings of previous studies.

"The North Carolina researchers found no clear evidence of effect of the .08 BAC law."

Again, most of the outcomes of the North Carolina study were directionally consistent with an impact over and above the sharp decline in alcohol-related fatalities already being experienced in the state. It was this pre-existing sharp decline that prevented the observed effect of the law from being even greater than it was. The North Carolina researchers recognized this possibility when the stated that ...

"... given the dramatic decline in alcohol-related crashes that was occurring in North Carolina during the early 1990s, it may be that any possible effects of reducing the BAC limit were simply obscured by a broad change in drinking-driving behavior that was already occurring."

"The NHTSA 50-state study was well controlled but its results must be interpreted differently from other studies because it used a different outcome measure."

The 50-state study represents one of the most sophisticated, well conceived, comprehensive and controlled studies conducted to date. It directly controlled for many factors which could have affected alcohol-related crashes over the 16 years of the study. It covered the experiences of fifteen .08 BAC law states; it was based on a clear theoretical model of potential variables which affect drinking and driving; data were gathered and entered into the analysis to control for vehicle miles traveled, urban/rural distribution, seasonality, unemployment rates, alcohol consumption; and safety belt usage laws.

In addition, a sophisticated outcome measure was used (just as in the 11-state study) which helped control for any extraneous factors which might affect both alcohol-related

A Comparison of Studies of the Effectiveness of Minimum Drinking Age Laws and .08 BAC Laws

Background to the MDA 21 Literature

A review of the literature on the effectiveness of Minimum Drinking Age (MDA) laws is informative with regard to the current discussion surrounding the studies of the effectiveness of .08 BAC laws. The research literature regarding MDA law effectiveness is considered by many researchers to be among the most consistent and robust of any area. This perception is conveyed in a March 1987 report by the General Accounting Office (GAO) which reviewed these studies.

On page 27, the GAO reviewers stated: *"We identified far more studies that met our minimum threshold criteria for the traffic-accident outcome than for other reported research areas. In addition, almost as many studies met our minimum criteria as did not."*

In its conclusion, the GAO report stated: *"In total, the evidence is persuasive that raising the minimum drinking age has had significant effects on reducing alcohol-related traffic accidents for the age group affected by the law. We conclude that states can generally expect reductions in their traffic accidents, but the magnitude will depend on the outcome measure evaluated and the characteristics of the state. This finding is supported through multiple observations of similar direction and, often, similar magnitude, obtained by alternative approaches to analyzing various measures of traffic accidents. Further support for our conclusion comes from the knowledge that such consistent findings rarely occur in reviews of this sort."*

What the Current .08 Studies Have Found

Before looking at the MDA law literature, it would be useful to review the results of studies of .08 laws conducted to date. There have been eight studies of the effectiveness of .08 BAC laws in the U.S:

NHTSA **(1991)**; covered California; single outcome measure
- *found 12 percent effect of 08 and ALR together*

Johnson and Fell (1995); covered five states, 6 outcome measures
- 26 of 30 outcomes suggested reductions; 10 were statistically significant
- consistent reductions found in four states (CA, OR, UT, VT)
- mixed results found in one state (ME)
- estimated effect varied between *4 and 40 percent reductions* (no pooling)

Rogers (1995) California DMV study; used a variety of outcome measures
- mixed results, most non-significant
- *7.2% reduction in nighttime fatal* and severe injury crashes
- *10% reduction in fatal and total injury crashes between 2-3 a.m.*

Hingson et al (1996); covered five (early .08) states; single outcome measure

from 5 percent (Hoskin et al, 1986) to 28 percent reductions (Williams et al 1983).

Studies that pooled results from several states always reported overall decreases in (measures of) alcohol-related crashes, but **within these pools, the results for individual states varied considerably**, with the majority of them not reaching statistical significance.

The Characteristics of the MDA 21 Literature Relative to the .08 BAC Literature

With this summary information in mind, it is instructive to compare the characteristics of the highly regarded body of MDA 21 law studies with those of the .08 BAC law studies.

Clearly, the MDA 21 studies have involved a competent group of researchers, sound research methods, and results that have been directionally consistent.

On the other hand, these studies have also reported a *wide range of effect sizes*, used a variety of outcome measures, and *have sometimes reported inconsistent results* -- even among some studies conducted in exactly the same manner. With some states, there were actually findings of increased crash involvement for the age group(s) affected.

The level of consistency (or inconsistency) of outcomes in the .08 BAC law literature is similar to that of the MDA 21 area. Reported inconsistencies have nearly always involved significant versus non-significant findings, not directionally different findings. *In both areas, the level of consistency in the directionality of outcomes is very similar*

With regard to quality of studies, the overall quality and sophistication of studies of .08 BAC laws is just as high, if not higher, than the studies reported in the 1987 GAO report.

Several specific issues of concern have been raised with regard to .08 BAC law studies. They include: *inconsistent or equivocal results*, *use single comparison states*, and *suggested inappropriateness of pooling or aggregating results* across states.

Variation in Reported Outcomes

It has been suggested (by GAO reviewers and others) that there is a degree of inconsistency (and equivocality of results) among the studies of .08 BAC laws.

All research findings are equivocal!

Within both the MDA-21 and the .08 BAC literature, *between-state differences in effect have been common* and *different studies have often reported different results for a particular state.* Usually these differences involve outcomes that are directionally consistent but which vary in magnitude and/or statistical significance. With regard to the .08 BAC law literature, there is no greater inconsistency with regard to either magnitude or directionality of outcomes than in the

However, pooling is a common practice, particularly when dealing with small states. Nearly all of the MDA 21 multi-state studies included some form of pooling, averaging, or aggregating across states (e.g., Arnold (1985); DuMouchell (1985); Hoskin (1985); and Williams et al. (1983)).

Another form of (GAO) criticism that relates to pooling is the suggestion that it is inappropriate to include states in the pool if they have had results that were either not statistically significant or directionally inconsistent.

This is not uncommon and it is not inappropriate. In fact, the 1987 GAO report acknowledges the fact that between-state outcomes varied considerably within the "pools" of states included in the studies they cited as meeting their criteria and showing impact. The report stated that: *"most individual states making up the pool of states evaluated in each study observed statistically significant reductions in this category; however, there were some exceptions. For example, in the Arnold (1985) study, Georgia, Iowa, and Maine exhibited a net percentage increase in "driver fatal" crashes for the age groups affected by the law during the study period."*

Use and Selection of Single Comparison States

Perhaps the most frequently voiced criticism of the Hingson et al. (1996) study o. .08 BAC law effectiveness has been that these researchers (arbitrarily) selected single states to serve as a control or comparison for each .08 BAC law state.

Hingson and his associates selected their comparison states on the basis of geographical proximity and similar (high) levels of BAC testing as the .08 law states. Critics (including GAO) have focused on the fact that selection of different states would have produced different results.

Most researchers agree that multi-state comparison groups (such as those used by Foss et. al., and by Apsler et. al.) are more robust than single state comparison groups. As a result, it is preferable to use a combination of states (or even all remaining) states for comparison purposes.

However, it should also be pointed out that the use of single comparison states is common in public health research. *Nearly all of the MDA law studies included single states for comparison with individual law states.* In fact, one of the better multi-state MDA studies included in the GAO review (Williams et al., 1983) used an approach similar to that used by Hingson et al. (1986).

Summary

In summary, many of the current criticisms of the .08 BAC effectiveness literature are inconsistent with the views held regarding similar research conducted with regard to MDA laws. As with the MDA laws, the studies of .08 BAC law impact have been conducted by reputable researchers who have employed sound analytical methods.