
Andrés Villaveces1,2, Peter Cummings1,2, Thomas D. Koepsell1,2,3, Frederick P. Rivara1,2,4, Thomas Lumley5, and John Moffat6

1 Department of Epidemiology, School of Public Health and Community Medicine, University of Washington, Seattle, WA.
2 Harborview Injury Prevention and Research Center, University of Washington, Seattle, WA.
3 Department of Health Services, School of Public Health and Community Medicine, University of Washington, Seattle, WA.
4 Department of Pediatrics, School of Medicine, University of Washington, Seattle, WA.
5 Department of Biostatistics, School of Public Health and Community Medicine, University of Washington, Seattle, WA.
6 Washington Traffic Safety Commission, Olympia, WA.

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The authors compared US motor vehicle and motorcycle mortality rates during periods when each of several alcohol-related laws were in effect with mortality rates during other periods. During the period 1980–1997, there were 792,184 deaths due to motor vehicle crashes and 63,052 deaths due to motorcycle crashes. An estimated 26% and 49% of these fatalities, respectively, were attributable to alcohol use. The incidence of alcohol-related mortality in motor vehicle crashes was lower when laws specifying a blood alcohol concentration of 0.08 g/dl per se (laws stating that it is a criminal offense to drive with a blood alcohol concentration above the state’s legal limit) were in effect (adjusted rate ratio (RR) = 0.86, 95% confidence interval (CI): 0.83, 0.88). For motorcycle deaths, the adjusted rate ratio was 0.87 (95% CI: 0.79, 0.95). The incidence of alcohol-related mortality in motor vehicle crashes was also lower during periods when two other types of laws were in effect: zero tolerance laws (adjusted RR = 0.88, 95% CI: 0.86, 0.90) and administrative license revocation laws (adjusted RR = 0.95, 95% CI: 0.93, 0.98). Overall motorcycle mortality was lower when administrative license revocation laws were in effect (adjusted RR = 0.95, 95% CI: 0.92, 0.98).

accidents, traffic; alcoholic intoxication; automobile driving; automobiles; legislation; motorcycles

Abbreviations: BAC, blood alcohol concentration; CI, confidence interval; RR, rate ratio.

In 1998, 15,935 motor vehicle fatalities in the United States were attributed by the National Highway Traffic Safety Administration to alcohol use (1). Approximately 43 percent of all fatal motorcycle crashes in the United States involve alcohol (2), and motorcycle drivers have the highest frequency of alcohol use among all motor vehicle drivers (3). Motorcycle riders who have been consuming alcohol wear helmets half as often as sober riders (4). Unhelmeted riders are twice as likely to incur a head injury of any type and are at least three times more likely to incur a fatal head injury (5).

In the United States, many states have passed laws aimed at drinking and driving. Several studies have examined these laws individually, usually in a single state or a few states (6–13). In some studies, other laws concurrently in effect have not been included in the analysis as potential confounders (6–11, 14). With regard to motorcycle riders, while several studies have found an association between helmet laws and motorcycle deaths (15–21), few have studied alcohol legislation (22, 23). To our knowledge, no study has evaluated potential interactions between different legal measures.

We estimated the association between several laws pertaining to driving under the influence of alcohol and crash mortality. We studied the following policies simultaneously: 1) the effect of laws making a blood alcohol concentration (BAC) of 0.08 g/dl per se illegal (laws which state that it is a criminal offense to drive with a BAC above the state’s legal limit), as compared with any higher legal limits or no legal
limit; 2) the effect of having a BAC illegal limit of 0.02 g/dl or less for persons younger than age 21 years (zero tolerance laws); 3) the effect of having administrative license revocation laws; 4) the effect of explicitly allowing police to set up sobriety checkpoints; and 5) the effect of imposing mandatory jail terms after a first conviction for driving under the influence of alcohol. We also considered, as potentially confounding factors, primary and secondary seat-belt laws (the former allow police to stop and ticket an occupant solely because he or she is unrestrained; the latter allow police to issue a citation for lack of restraint use only if the motorist has been stopped for some other reason), universal helmet laws (which mandate that all motorcycle riders wear a helmet), and selective helmet laws (which mandate helmet use for younger persons, defined as motorcycle riders younger than age 20, 18, or 16 years, depending on the state).

MATERIALS AND METHODS

Mortality data

We used crash mortality data for the United States for the period 1980–1997. We obtained counts of motor vehicle and motorcycle crash deaths by year, state, type of vehicle, sex, and age from the Fatality Analysis Reporting System (24). This database provides information on driver and occupant/ rider characteristics, vehicle characteristics, and the circumstances surrounding all crashes that involve a death within 30 days of the incident.

Denominator data

Population estimates by year, state, age, and sex were downloaded from the US Census Bureau website (25). We also obtained data on total vehicle miles of travel by year and number of registered motorcycles by state and year from the Federal Highway Administration (26).

Legal data

Information on the date on which each law went into effect was obtained by reviewing the statutes of each state for the period 1980–1997. This was compared with the dates on law lists provided by the National Highway Traffic Safety Administration (27–32). Any disagreement between these sources was resolved by reviewing multiple versions of the Digest of State Alcohol-Related Legislation (33).

Analysis

Separate analyses were conducted using both person-time and annual miles driven as the denominators for rate ratios. We assessed the effects of the laws using three outcome measures: 1) counts of all deaths due to motor vehicle crashes, including pedestrian and bicycle deaths; 2) counts of deaths due to automobile crashes only, excluding pedestrians and bicyclists and crashes of heavy trucks, buses, and motorcycles; and 3) counts of all motorcycle deaths. We assessed zero tolerance laws by restricting the population denominator and counts of deaths to persons younger than age 21 years, because these laws apply specifically to this population. Using the same rationale for selective helmet laws, we assessed the effect of these measures among persons younger than age 16 years. We assessed both sex and age (categorized as 0–11, 12–20, 21–29, 30–39, 40–49, 50–59, and ≥60 years) as potential confounders but ultimately did not adjust for these variables, since the slight changes in the age and sex distribution of the population over time did not change any rate ratio estimates by more than 0.02. We studied the potential multiplicative effects of every combination of the five alcohol-related laws.

The study period of 18 years, multiplied by the 51 states (including the District of Columbia), can be thought of as 918 state-years. The number of state-years when relevant laws were in effect ranged from 81.9 for BAC laws to 412.4 for selective helmet laws. For each law, we estimated the mortality rate ratio for periods with a law compared with other periods, adjusted for the presence of the other alcohol-related laws, seat-belt laws, and any trends in crash mortality over time.

We used random-effects Poisson regression models for longitudinal data and estimated mortality rate ratios conditional on state (34) for each law, using Stata 6.0 software (35). For each law, the resulting rate ratio was a pooled estimate of the within-state ratio of mortality rates while the law was in effect, compared with what would have been expected in those same states had the law not been implemented. Because mortality counts over time can be correlated within a state, we used a variance estimator that accounted for possible within-state correlation. We used a random-effects model, which accounts, in a statistical sense, for the possibility that the effects of a law may differ between states. To control for any trend in traffic mortality rates, we divided time into 18 consecutive 1-year segments and included these variables in the models by using linear spline terms.

Alcohol-related deaths

We estimated the number of deaths that could be attributed to alcohol use by a driver, since it is these deaths that alcohol-related laws were designed to prevent. We calculated attributable fractions (36) ((relative risk – 1)/relative risk) on the basis of the BAC of the intoxicated driver and applied them to all individuals who died in that event. These calculations were based on reported tables of the relative risk of driver involvement in fatal crashes due to alcohol in relation to age and sex (37). For example, suppose that 10 38-year-old male drivers with a BAC of 0.09 g/dl were each involved in a single-vehicle crash, where one person died in each crash. According to the tables by Zador et al. (37), they each had a relative risk of involvement of 8.58 compared with not being intoxicated. The number of deaths attributable to alcohol for those specific events would be 8.83 ([(8.58 – 1)/8.58] × 10 deaths = 8.83).

For those few crashes in which two or more drivers had positive BACs, we computed a pooled attributable fraction; the attributable fraction for driver 1 (AF1) was pooled with not being intoxicated; the latter allow police to issue a citation for lack of restraint use only if the motorist has been stopped for some other reason), universal helmet laws (which mandate that all motorcycle riders wear a helmet), and selective helmet laws (which mandate helmet use for younger persons, defined as motorcycle riders younger than age 20, 18, or 16 years, depending on the state).
to all fatalities in that crash. Zador et al. (37) estimated a few relative risks below 1.0 for some age groups; for these few crashes, we assigned an attributable fraction of 0.1 to all fatalities. We thought it implausible that subjects with a positive BAC would be less likely to be involved in a crash or fatal event than sober persons (38).

BACs were missing for 60 percent of drivers. We therefore used multiple imputation methods (39–42), described in detail by Rubin et al. (43), for the imputation of BACs in the Fatality Analysis Reporting System data. The models used police-reported drinking, age, sex, use of a restraint system, driver’s license status, injury severity, previous infractions, day of the week, time of day, vehicle’s role in the crash, vehicle class, and vehicle’s position on the roadway as predictors of BAC values (44). The first imputation step assigned each driver to either no alcohol use or any alcohol use. The second step imputed the BACs among drivers who were predicted to have any level of alcohol in their bloodstream. Both steps used an expectation-maximization algorithm and a Markov-chain Monte Carlo method for simulating the draws from the cell probabilities (41). We used software written for S-Plus by Schafer (45, 46). We generated 10 complete data sets which differed, one from another, on the imputed BAC values and consequently on the estimated count of deaths attributable to alcohol.

For example, a 25-year-old automobile driver with a missing BAC value could be assigned three times to no alcohol value and seven times to some positive value. In the three data sets with a BAC assigned to 0.0, this driver’s crash would contribute no deaths related to alcohol use. In the data sets with the BAC assigned to some value greater than 0, this driver’s crash would contribute to the count of alcohol-related deaths. The final count of deaths attributable to alcohol is an average of the alcohol-related counts in each of the 10 imputed data sets.

We then carried out Poisson regression as described above, producing 10 estimates for the effects of each law. We combined these estimates for each variable by averaging them on a logarithmic scale. Confidence limits were computed using methods that account for both the variance within each imputed data set and the variance between the 10 imputed data sets (41).

RESULTS

During the period 1980–1997, there were 792,184 deaths due to traffic crashes in the United States (table 1). For all crashes, 68 percent of the dead were male, the median age of the dead was 28 years, and 26 percent of the deaths were attributable to alcohol use. Seventy-one percent of the deaths (n = 560,944) occurred to occupants in automobiles, and 31 percent of these were due to alcohol (table 2).

There were 63,052 deaths due to motorcycle crashes (table 3). Ninety percent of the dead were male, and 61 percent were between ages of 21 and 39 years. An estimated 31,005 motorcycle deaths (49 percent) were attributable to alcohol use (table 3).

In the discussion below, the denominator was person-years unless otherwise stated, and all mortality rate ratios were adjusted as described in Materials and Methods.

BAC 0.08 g/dl laws

During time periods when a state had a BAC standard of 0.08 g/dl as an indication that the driver was legally intoxicated, compared with periods with a higher BAC standard or no standard, the incidence of all crash fatalities was lower (rate ratio (RR) = 0.97, 95 percent confidence interval (CI): 0.96, 0.98). The association between the law and mortality was stronger among all alcohol-related deaths (table 4). Results were essentially the same when the number of miles driven was used as the denominator and when the analysis was limited to deaths occurring in automobiles. When time periods with a BAC standard of 0.08 g/dl were compared with time periods with a standard of 1.0 g/dl, the rate ratio was 0.97 (95 percent CI: 0.95, 0.98) for all deaths and 0.85 (95 percent CI: 0.83, 0.86) for alcohol-related deaths.

For motorcycles, the adjusted rate ratio was 0.95 (95 percent CI: 0.91, 1.00). The association between these laws and mortality was stronger for alcohol-related deaths (table 5). The rate ratio was 0.92 (95 percent CI: 0.88, 0.97) for all motorcycle crash fatalities and 0.85 (95 percent CI: 0.77, 0.94) for alcohol-related motorcycle deaths using number of registered motorcycles as the denominator (table 5).

Zero tolerance laws

During periods with a law that forbade drivers younger than 21 years to have any alcohol in their blood or limited the BAC to less than 0.02 g/dl, compared with periods with a higher BAC standard or no standard for drivers under age 21 years, crash mortality was lower (RR = 0.96, 95 percent CI: 0.95, 0.97). We found a stronger association between these laws and alcohol-related deaths (table 4). This association was stronger among persons under age 21 years: The rate ratio was 0.94 (95 percent CI: 0.92, 0.96) for all deaths and 0.83 (95 percent CI: 0.76, 0.90) for deaths attributed to alcohol.

These laws were not associated with rates of motorcycle death (table 5). The results were similar when we used registered motorcycles as the denominator or examined alcohol-related crashes. For the analysis restricted to persons under age 21 years, there were 732 deaths during periods when the law was in effect (rate = 0.11 per 100,000 person-years) and 13,983 deaths when the law was not in effect (rate = 0.37 per 100,000 person-years) (RR = 0.91, 95 percent CI: 0.82, 1.01). For the same subpopulation, there were 124 alcohol-related deaths during periods when the law was in effect (rate = 0.02 per 100,000 person-years) and 3,567 alcohol-related deaths during other periods (rate = 0.01 per 100,000 person-years) (RR = 0.91, 95 percent CI: 0.66, 1.27).

Administrative license revocation laws

When a state had a law that quickly revoked a driver’s license if the BAC was higher than legally allowed, the incidence of all crash fatalities was lower (RR = 0.95, 95 percent CI: 0.94, 0.96). We found similar associations between these laws and mortality when we examined all alcohol-related deaths, when we limited the analysis to deaths occurring in
automobiles, and when we used vehicle miles as the denominator.

The incidence of motorcycle crash fatalities was also lower with this type of law (RR = 0.95, 95 percent CI: 0.92, 0.98). We found no association when we used number of registered motorcycles as the denominator. We found weak associations between these laws and alcohol-related motorcycle deaths (table 5).

**Sobriety checkpoint laws**

When a law that allowed the use of sobriety checkpoints was in force, the incidence of all crash fatalities was slightly greater (RR = 1.02, 95 percent CI: 1.01, 1.03). Similar results were obtained for deaths occurring in automobiles and using vehicle miles as the denominator. However, among alcohol-related deaths, the direction of association was reversed (RR = 0.99, 95 percent CI: 0.97, 1.01) (table 4). Similar weak negative associations were found for alcohol-related deaths in automobiles and using vehicle miles as the denominator.

The incidence of motorcycle fatalities was somewhat greater (RR = 1.08, 95 percent CI: 1.05, 1.11). The direction of association was reversed when we used number of registered motorcycles as the denominator (table 5). Among alcohol-related deaths, the rate ratio was 1.05 (95 percent CI: 1.00, 1.09) (table 5).

**Mandatory jail terms for first conviction**

When a state mandated a jail term for a first conviction for driving under the influence of alcohol, the incidence of all crash fatalities was slightly greater (RR = 1.02, 95 percent CI: 1.01, 1.03) (table 4). Similar results were obtained for deaths occurring in automobiles and using vehicle miles as the denominator. For all alcohol-related deaths, the association was negative (table 4). A similar association was found for alcohol-related deaths in automobiles and using vehicle miles as the denominator.

The incidence of motorcycle crash fatalities was greater (RR = 1.05, 95 percent CI: 1.01, 1.09) (table 5). The association was reversed when number of registered motorcycles

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**TABLE 1. Mortality rates for all motor vehicle fatalities, by period of law enactment, United States, 1980–1997**

<table>
<thead>
<tr>
<th>Law type</th>
<th>All motor vehicle fatalities</th>
<th>Alcohol-related motor vehicle fatalities*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Count</td>
<td>Mortality rate per 100,000 person-years</td>
</tr>
<tr>
<td>Overall period</td>
<td>792,184</td>
<td>17.4</td>
</tr>
<tr>
<td>Blood alcohol concentration ≤0.08 g/dl per se</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>69,225</td>
<td>15.9</td>
</tr>
<tr>
<td>No</td>
<td>722,959</td>
<td>18.1</td>
</tr>
<tr>
<td>Zero tolerance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>100,126</td>
<td>15.0</td>
</tr>
<tr>
<td>No</td>
<td>692,058</td>
<td>18.3</td>
</tr>
<tr>
<td>Administrative license revocation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>280,408</td>
<td>17.2</td>
</tr>
<tr>
<td>No</td>
<td>511,776</td>
<td>18.2</td>
</tr>
<tr>
<td>Sobriety checkpoints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>294,488</td>
<td>16.1</td>
</tr>
<tr>
<td>No</td>
<td>497,696</td>
<td>19.1</td>
</tr>
<tr>
<td>Mandatory jail term upon first DUI† offense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>171,666</td>
<td>17.9</td>
</tr>
<tr>
<td>No</td>
<td>620,518</td>
<td>17.7</td>
</tr>
<tr>
<td>Primary seat-belt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>205,059</td>
<td>16.2</td>
</tr>
<tr>
<td>No</td>
<td>587,125</td>
<td>18.3</td>
</tr>
<tr>
<td>Secondary seat-belt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>241,259</td>
<td>16.8</td>
</tr>
<tr>
<td>No</td>
<td>550,925</td>
<td>18.3</td>
</tr>
</tbody>
</table>

* Alcohol-related fatalities were based on 10 imputations of blood alcohol concentration values in Fatality Analysis Reporting System data using the imputation method described by Rubin et al. (43).

† DUI, driving under the influence of alcohol.
was used as the denominator. For alcohol-related deaths, there was no association between these laws and death (table 5).

**Seat-belt laws**

Mortality was lower when primary seat-belt laws were in effect, compared with no seat-belt law. For deaths in automobiles only, the rate ratio was 0.90 (95 percent CI: 0.89, 0.92) (table 4). The association with all alcohol-related deaths was 0.94 (95 percent CI: 0.92, 0.97). We found essentially no association with mortality among all vehicle crashes during periods when secondary seat-belt laws were in effect compared with periods without a seat-belt law.

**Helmet laws**

Mortality was lower when universal helmet laws were in effect, compared with no helmet law (RR = 0.67, 95 percent CI: 0.63, 0.71). We found a weaker association using number of registered motorcycles as the denominator (table 5). The association with alcohol-related deaths was 0.61 (95 percent CI: 0.56, 0.66). Similar results were obtained using number of registered motorcycles as the denominator (table 5).

We found little change in motorcycle mortality during periods in which selective helmet laws were in effect. The association of these laws with mortality in the population younger than 21 years was 1.05 (95 percent CI: 0.91, 1.02).

**Interactions between laws**

Interactions between laws were examined. No two-way or higher-order interactions were statistically significant ($p > 0.05$ for all tests).

**DISCUSSION**

From 1980 through 1997, laws mandating a BAC of 0.08 g/dl per se and zero tolerance laws had modest associations with a reduction in overall traffic mortality: approximately 3 percent and 4 percent, respectively. Both had stronger asso-
ciations with reductions in crash fatalities attributable to alcohol: approximately 14 percent and 12 percent, respectively. Administrative license revocation laws were associated with a 5 percent reduction in overall mortality and alcohol-related mortality. Implementation of mandatory jail terms for persons first convicted for driving under the influence of alcohol was associated with an overall 2 percent increase in traffic mortality, while there was a 5 percent reduction in alcohol-related traffic mortality. Implementation of laws that explicitly allowed police to set up sobriety checkpoints for controlling drinking and driving did not appear to be related to a reduction in overall traffic mortality or alcohol-related traffic mortality.

Our study had several limitations. With the methods used, we were unable to measure any police effort to enforce a law. Substantial variations might occur within a state and between states. We did not account for any policy, law, or program applied at a county or city level. This is especially important for the evaluation of sobriety checkpoints, which have been mostly applied at local levels and at specific times (47). Another potential limitation, one that is common to most studies that deal with this subject, is the high proportion of missing information on BACs. We used multiple imputation methods in an attempt to reduce the bias that may result from only considering data without missing values. We dealt with missing BAC values by employing the multiple imputation methods suggested by Rubin et al. (43); we think the method of Rubin et al. is an improvement over the method of Klein (44), because continuous rather than categorical values of BAC are imputed and because multiple imputation allowed us to account for the uncertainty regarding the missing BAC values. Finally, defining denominators to evaluate the association of laws with deaths is difficult for motorcycle crashes. Data on total vehicle miles driven for motorcycles is not available by state and year, because not all states report this information. Data on registered motorcycles are available but serve only as a rough estimate of motorcycle use.

Our study had several strengths. We used models appropriate for longitudinal count data, took into account changes in mortality over time, and evaluated possible interactions between the laws. We calculated alcohol-related deaths

### Table 3. Mortality rates for motorcycle fatalities, by period of law enactment, United States, 1980–1997

<table>
<thead>
<tr>
<th>Law type</th>
<th>Motorcycle deaths</th>
<th>Alcohol-related motorcycle deaths*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Counts</td>
<td>Mortality rate per 100,000 person-years</td>
</tr>
<tr>
<td>Overall period</td>
<td>63,052</td>
<td>1.42</td>
</tr>
<tr>
<td>Blood alcohol concentration ≤ 0.08 g/dl per se</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>4,493</td>
<td>1.03</td>
</tr>
<tr>
<td>No</td>
<td>58,559</td>
<td>1.46</td>
</tr>
<tr>
<td>Zero tolerance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>5,619</td>
<td>0.84</td>
</tr>
<tr>
<td>No</td>
<td>57,433</td>
<td>1.52</td>
</tr>
<tr>
<td>Administrative license revocation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>18,891</td>
<td>1.17</td>
</tr>
<tr>
<td>No</td>
<td>44,161</td>
<td>1.57</td>
</tr>
<tr>
<td>Sobriety checkpoints</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>20,424</td>
<td>1.12</td>
</tr>
<tr>
<td>No</td>
<td>42,628</td>
<td>1.63</td>
</tr>
<tr>
<td>Mandatory jail term upon first DUI† offense</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>12,858</td>
<td>1.33</td>
</tr>
<tr>
<td>No</td>
<td>50,194</td>
<td>1.45</td>
</tr>
<tr>
<td>Universal helmet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>25,584</td>
<td>1.09</td>
</tr>
<tr>
<td>No</td>
<td>37,468</td>
<td>1.79</td>
</tr>
<tr>
<td>Selective helmet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yes</td>
<td>21,433</td>
<td>1.79</td>
</tr>
<tr>
<td>No</td>
<td>41,619</td>
<td>1.28</td>
</tr>
</tbody>
</table>

* Alcohol-related fatalities were based on 10 imputations of blood alcohol concentration values in Fatality Analysis Reporting System data using the imputation method described by Rubin et al. (43).
† DUI, driving under the influence of alcohol.
based on the relative risk of being in a fatal crash due to a specific driver BAC, as described by other investigators (38, 48), because this is a more accurate assessment of alcohol-relatedness than proxy measures such as single nighttime crashes (11, 49) or police-reported alcohol consumption (49, 50). This explained the smaller percentage of alcohol-related deaths that we estimated in comparison with some other studies (1, 6, 30, 49, 51, 52).

**BAC 0.08 g/dl per se laws**

Our finding of a 14 percent reduction in alcohol-related deaths due to implementation of BAC 0.08 g/dl per se laws is similar to that of several recent studies (9, 10, 53). Another study (6) found only five of 11 states to have a significant reduction in mortality. Our findings differ from the findings of a North Carolina study (14) that reported no overall association of these laws with a reduction in alcohol-related deaths.

Two studies (6, 54) used the ratio of the number of fatalities for drinking drivers to the number of fatalities with no drinking drivers as their dependent variable. Another study (9) used a proportion of fatalities rather than the actual count. This use of ratios could bias estimates as described by Kronmal (55) and others (56–59). A recent systematic review of studies reported an estimate similar to ours (60).

**Zero tolerance laws**

Our estimate of a 12 percent reduction in alcohol-related mortality due to the implementation of zero tolerance laws is consistent with findings from other studies as reported in a systematic review (12). Previous studies estimated reductions in mortality between 11 percent and 33 percent after implementation of zero tolerance laws in the United States and Australia. Our finding that the association of these laws was greater among alcohol-related crashes supports the view that these laws affected their target population.

**Administrative license revocation laws**

Administrative license revocation laws were associated with a 5 percent reduction in overall motorcycle mortality and a 2 percent reduction in alcohol-related motorcycle mortality. This is consistent with findings by Whetten-Goldstein et al. (49), who reported a statistically significant fatality rate difference of –0.04 per 1,000 persons, and Zador
et al. (61), who reported a 9 percent reduction in nighttime fatal crashes.

**Sobriety checkpoints**

Enacting laws that allowed police to set up sobriety checkpoints did not appear to be related to a reduction in overall mortality, and it had a minimal, statistically nonsignificant association with lower alcohol-related mortality. Other studies (47, 62–64) have reported a benefit from sobriety checkpoints. Those studies used information about the degree of enforcement, whereas we could not account for actual enforcement.

**Mandatory jail terms upon first conviction**

For all alcohol-related deaths, mandatory jail terms imposed upon the first conviction for driving under the influence of alcohol were associated with a 5 percent reduction in mortality. Previous studies have differed in their conclusions regarding these measures (49, 65–67), ranging from no effect (49, 67) to a 40 percent decrease in reoffending (65).

**Other laws**

Primary seat-belt laws were associated with reductions in traffic mortality in all crashes and in alcohol-related crashes. This association was slightly weaker for alcohol-related crashes—a finding consistent with evidence that intoxicated drivers are less likely to comply with seat-belt laws (68–70). Secondary seat-belt laws appeared to have no association with reductions in traffic mortality among any of the groups studied. This is consistent with other evidence that primary seat-belt laws are more strongly related to mortality reductions than are secondary seat-belt laws (68, 71).

Universal helmet laws appeared to be strongly related to reductions in traffic mortality in all motorcycle crashes, as well as in alcohol-related crashes. Several studies have evaluated the relation of universal helmet laws with mortality (15, 16, 18, 72–74), estimating changes that range from 12 percent to 73 percent. Our results are generally consistent with those findings. Selective helmet laws were not associated with significant reductions in motorcycle fatalities.

This study provided information on the effect of alcohol-related laws in the 50 states and the District of Columbia during a period of 18 years. Our results support recent policy measures that set a national level of 0.08 mg/dl for BAC

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**TABLE 5. Adjusted mortality rate ratios* for motorcycle fatalities, United States, 1980–1997**

<table>
<thead>
<tr>
<th>Alcohol-related law</th>
<th>Mortality per 100,000 person-years</th>
<th>Mortality per 100,000 licensed motorcycle-years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted rate ratio</td>
<td>95% confidence interval</td>
</tr>
<tr>
<td>Blood alcohol concentration ≤0.08 g/dl per se</td>
<td>0.95 (0.91, 1.00)</td>
<td>0.92 (0.88, 0.97)</td>
</tr>
<tr>
<td>Zero tolerance</td>
<td>1.00 (0.96, 1.05)</td>
<td>0.99 (0.95, 1.04)</td>
</tr>
<tr>
<td>Administrative license revocation</td>
<td>0.95 (0.92, 0.98)</td>
<td>1.00 (0.97, 1.03)</td>
</tr>
<tr>
<td>Sobriety checkpoints</td>
<td>1.08 (1.05, 1.11)</td>
<td>0.96 (0.95, 1.01)</td>
</tr>
<tr>
<td>Mandatory jail term upon first DUI† offense</td>
<td>1.05 (1.01, 1.09)</td>
<td>0.93 (0.89, 0.96)</td>
</tr>
<tr>
<td>Universal helmet</td>
<td>0.67 (0.63, 0.71)</td>
<td>0.72 (0.68, 0.76)</td>
</tr>
<tr>
<td>Selective helmet</td>
<td>1.03 (0.99, 1.07)</td>
<td>0.98 (0.94, 1.02)</td>
</tr>
<tr>
<td>Blood alcohol concentration ≤0.08 g/dl per se</td>
<td>0.87 (0.79, 0.95)</td>
<td>0.85 (0.77, 0.94)</td>
</tr>
<tr>
<td>Zero tolerance</td>
<td>0.98 (0.89, 1.07)</td>
<td>0.97 (0.89, 1.06)</td>
</tr>
<tr>
<td>Administrative license revocation</td>
<td>0.98 (0.91, 1.05)</td>
<td>0.97 (0.90, 1.05)</td>
</tr>
<tr>
<td>Sobriety checkpoints</td>
<td>1.05 (1.00, 1.09)</td>
<td>1.03 (0.98, 1.09)</td>
</tr>
<tr>
<td>Mandatory jail term upon first DUI† offense</td>
<td>1.01 (0.95, 1.08)</td>
<td>1.00 (0.92, 1.09)</td>
</tr>
<tr>
<td>Universal helmet</td>
<td>0.61 (0.56, 0.66)</td>
<td>0.62 (0.56, 0.68)</td>
</tr>
<tr>
<td>Selective helmet</td>
<td>0.93 (0.86, 1.00)</td>
<td>0.91 (0.85, 0.98)</td>
</tr>
</tbody>
</table>

* Adjusted for all other laws examined in the study and time trend.  
† DUI, driving under the influence of alcohol.  
‡ Alcohol-related fatalities were based on 10 imputations of blood alcohol concentration values in Fatality Analysis Reporting System data using the imputation method described by Rubin et al. (43).
Additional measures such as zero tolerance laws and administrative license revocation laws may also have reduced mortality due to drunk driving.

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REFERENCES