Alcohol Policies and Alcohol-Related Motor Vehicle Crash Fatalities Among Young People in the US

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abstract

BACKGROUND: Motor vehicle crashes (MVCs) are a leading cause of death among young people in the United States. We examined the relationship between states' alcohol policy environments and alcohol-related MVC fatalities among children, adolescents, and young adults under the minimum legal drinking age of 21 years.

METHODS: We used the Alcohol Policy Scale (APS), an assessment of 29 alcohol policies across 50 states and Washington, DC, developed with the assistance of an interdisciplinary Delphi panel. Using the Fatality Analysis Reporting System, we examined APS scores in relation to fatalities of people ≤20 years old from 2000 to 2013 occurring in crashes in which ≥1 involved driver had a blood alcohol content ≥0.08%. Logistic regression was used with a 1-year lag between policies and MVC fatalities and adjusted for potential confounders.

RESULTS: Of 84 756 MVC fatalities of those ≤20 years old during the study period, 23 757 (28.0%) were alcohol related, including deaths of 11 006 (46.3%) drivers, 10 212 (43.0%) passengers, and 2539 (10.7%) pedestrians, cyclists, and others. People killed in alcohol-related MVCs were predominantly male (72.7%) and older (65.5% were 18–20 years old), and 51.2% were non-Hispanic white. Restrictive policy environments were associated with fewer fatalities (adjusted odds ratio, 0.91 per 10-percentage-point increase in APS score; 95% confidence interval, 0.89–0.94). The association was observed for drivers and passengers, male and female decendents, and children, adolescents, and young adults.

CONCLUSIONS: More restrictive alcohol policies are associated with reduced alcohol-related MVC mortality among young people. Studies should scrutinize the relationship between policies and fatalities to highlight mechanisms.

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WHAT'S KNOWN ON THIS SUBJECT: Motor vehicle crashes are a leading cause of death among young people in the United States. Stronger alcohol policies prevent motor vehicle crash deaths, but studies to date have examined only single policies rather than the overall alcohol policy environment.

WHAT THIS STUDY ADDS: We found that >1 in 4 motor vehicle crash fatalities among children, adolescents, and young adults <21 years old were alcohol related and that stronger alcohol policy environments appeared protective for both drivers and passengers regardless of age and sex.

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Unintentional injury is the leading cause of mortality for children, adolescents, and young adults in the United States.[1] Motor vehicle crash (MVC) fatalities are the most common cause of unintentional injury deaths among young people, and 1 in 4 male and 1 in 5 female MVC fatalities involve alcohol.[2,3] More restrictive state-level alcohol policy environments, that is, a strong collection of alcohol control policies acting in concert in a state, have been linked to decreased alcohol consumption.[4–6] Because adolescents and young adults who drink may drive while impaired or ride with an impaired driver,[7] and children may be driven by adults who drink,[8] more restrictive alcohol policies may be an effective intervention to reduce MVC deaths among young people.

However, studies to date have generally examined only the effect of single alcohol policies.[9,10] Additionally, most studies examining MVCs have examined the entire driving population rather than specifically considering young people. This is a critically important omission in the literature because adolescents and young adults under the minimum legal drinking age access alcohol through different means from adults ≥21 years old and are subject to different driving rules, such as graduated licensing requirements.[6,11] Furthermore, deaths of young people who are passengers of alcohol-impaired adult drivers have not been systematically examined in relation to alcohol policies.[8]

A number of individual alcohol policies may lower risk of MVC death, such as provisions that reduce alcohol availability,[12] raise the price of alcohol through taxes,[13,14] lower legal blood alcohol limits for underage drivers,[15,16] raise the minimum legal drinking age to 21 years,[16,17] limit nighttime driving and transportation of passengers for underage drivers,[11,15] and institute sobriety checkpoints.[18,19] Alcohol-related MVC mortality is complex and likely to be influenced by multiple policies acting simultaneously to influence both drinking and driving behaviors. Therefore, it is critical to examine states' comprehensive alcohol policy environments.

To identify associations between alcohol policy environments and MVC deaths among young people in US states, we used the Alcohol Policy Scale (APS) score,[4] a novel rating system that takes into account the efficacy of alcohol policies and their level of implementation in a given state. We hypothesized that stronger (ie, more restrictive) alcohol policy environments would be associated with reduced alcohol-related MVC mortality.

METHODS

Alcohol Policy Environment

To quantify the alcohol policy environment, we used the APS, a previously validated assessment of policies across all 50 states and Washington, DC from 1999 to 2012.[4–6,10] Ratings were developed with the guidance of a modified Delphi panel of policy experts from academia, government, and the private sector who represented multiple disciplines, including law, sociology, economics, epidemiology, and psychology.

Policies for potential inclusion in the score were obtained from the Alcohol Policy Information System from the National Institute on Alcohol Abuse and Alcoholism and other data sources.[4,20] A full list of policies is available in Supplemental Table 4, and the coding system has been described previously.[4]

Once study investigators generated the list of alcohol policies for potential inclusion, the Delphi panelists independently assessed each policy with regard to its efficacy for reducing excessive drinking or alcohol-related harm. Panelists drew on their expertise and the available scientific literature to generate a 5-point Likert score (1 = *low efficacy,* 5 = *high efficacy*) for each policy for each state and year. Next, the panel met as a group to review ratings and discuss the evidence supporting each policy before independently rerating each policy after the discussion. These final ratings were compiled.

Panelists then provided ratings on the degree of legislative implementation for each policy for each state and year. To guide panelists in doing so, study investigators designed an implementation rating scale for each policy, specifically examining each law's provisions that made the policy broadly applicable, effective, or enforceable at reducing excessive drinking or alcohol-related harm. For example, laws restricting hours of alcohol sales received higher implementation ratings the earlier they required stores to close (eg, states requiring closure by 12:00 midnight received higher scores than states requiring closure by 2:00 AM). Panelists then provided study investigators with feedback on the implementation rating scales for each policy, and investigators revised the scales based on this feedback, generating a possible range from 0 (*no policy in a given state that year*) to 1.0 (*policy present in a given state that year with the strongest possible provisions*).[4]

Ultimately, 29 policies were included in the APS. To calculate an overall APS score for each state and year, each of the 5-point Likert efficacy scores was multiplied by its implementation score, and they were summed with the other policies for that state and year.[4,6,10] We then standardized scores on a scale from 0 to 100, with high APS scores representing more restrictive alcohol policy environments.

MVC Fatalities

Data on fatal MVCs from 2000 to 2013 were extracted from the Fatality Analysis Reporting System (FARS) database of the National Highway Traffic Safety Administration (NHTSA).[21] To have been recorded in FARS, an MVC death had to have occurred in a crash that involved ≥1 motor vehicle, directly resulted in any involved person's death within 30 days of the incident, and occurred on a US public roadway.

For each state and year, we extracted data on all people ≤20 years of age who died as a result of a MVC. Decedents included people who were drivers, passengers, cyclists, pedestrians, or occupants of a motor vehicle not in transit. We also extracted data on age, sex, and race and ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, or other) of all decedents. We then defined "alcohol-related" MVC fatalities as those resulting from a crash in which ≥1 driver of any involved motor vehicle had a blood alcohol content (BAC) greater than or equal to the legal limit of 0.08%. If several vehicles with both drivers and passengers were involved in a crash and only 1 driver had a BAC ≥0.08%, *all* people who died in that crash were considered an alcohol-related MVC death. All people who died as cyclists, pedestrians, or occupants of a motor vehicle not in transit were killed by a driver with positive BAC in a moving vehicle.

BAC in FARS is ascertained by combining information from multiple sources, including police reports, coroner or medical examiner reports, and emergency medical service reports. Of all drivers involved in crashes in the present analyses, 67.3% had a BAC that had been directly measured and recorded in FARS. To address missing data in FARS, NHTSA has developed an algorithm that uses multiple imputation that has been previously validated.[22] In this approach, NHTSA provides 10 probability-based imputed values per missing BAC that are combined into an unbiased estimate and SE of the BAC by using multiple imputation. We applied this technique to the remaining 32.7% of drivers for whom BAC was missing in our sample.

Statistical Analyses

Alcohol-related MVC deaths were first stratified according to whether the decedent was a driver or a passenger, and we also examined overall alcohol-related MVC deaths (including drivers and passengers, as well as pedestrians, cyclists, and occupants of a motor vehicle not in transit who were killed as a result of a driver with BAC ≥0.08%). We also explored time trends in alcohol involvement in MVC deaths over the study period by using BAC cutoffs of >0% (ie, any amount of alcohol in the blood) and ≥0.05%. To describe the epidemiology of alcohol-related MVC deaths, we also examined the day of the week and time of day that such deaths occurred during the study period.

Odds ratios (ORs) were computed for alcohol-related MVC deaths across states in relation to their APS score. Recognizing that there is often a delay between enactment of a policy and its actual implementation, we introduced a 1-year lag between exposure and outcome such that, for example, MVC fatalities from 2006 were examined in relation to APS scores from 2005. We used the alternating logistic regression algorithm to account for clustering of multiple MVC deaths within a single crash and of multiple crashes occurring within a single state.[23] Associations were examined for overall MVC deaths, as well as for driver and passenger deaths separately. We generated a map of state-by-state comparisons of the proportion of MVCs that were alcohol-related and APS scores pooling the 2 most recent years of data available to generate information about the current public health and policy context across the United States.

After identifying bivariate associations between APS score and odds of alcohol-related MVC fatality, we evaluated sequential multivariable models incorporating sex, age, race or ethnicity, year (treated as an indicator variable), and state-level covariates (proportion male, proportion ≥21 years old, race and ethnicity proportions, college education, median household income, level of urbanization, policing rates, and vehicle miles traveled). All state-level covariates were extracted from the US Census Bureau's American Community Survey and Current Population Survey with the exception of vehicle miles traveled, which were obtained from the National Institute on Alcohol Abuse and Alcoholism.[14,24,25] We also examined final multivariable models with respect to odds of a fatal alcohol-involved MVCs involving BAC ≥0.05% and >0%. After fitting multivariable models, we repeated models stratifying by sex, age, and race and ethnicity to examine associations between APS score and alcohol-related MVC fatalities according to sociodemographic characteristics and identified associations according to day of the week and time of day.

Analyses were performed in SAS version 9.3 (SAS Institute Inc, Cary, NC). All P values were 2-sided and considered significant at $P < .05$.

RESULTS

Across states from 1999 to 2012, the mean APS score by state-year was 42 (SD, 8; range 24 [Iowa in 1999] to 75 [Utah in 2011]). The APS increased during the study period (mean APS in 1999, 38; mean APS in 2012, 45; $P < .001$ for trend).

From 2000 to 2013, there were 84 756 MVC fatalities observed among people ≤20 years of age, of which 23 757 (28.0%) were alcohol-related (as defined by ≥1 involved driver in the MVC having a BAC ≥0.08%). Among these 23 757 alcohol-related MVC deaths, 11 006 (46.3%) were drivers, 10 212 (43.0%) were passengers, and 2539 (10.7%) were pedestrians, cyclists, or occupants of a motor vehicle not in transit; nearly four-fifths (79.5%) of passenger deaths occurred in a vehicle operated by a driver ≥21 years of age. Fig 1 shows trends in the proportion of MVC deaths that were alcohol involved according to different BAC thresholds. The proportion of MVC deaths that were alcohol involved remained nearly constant during the study period at all BAC levels.

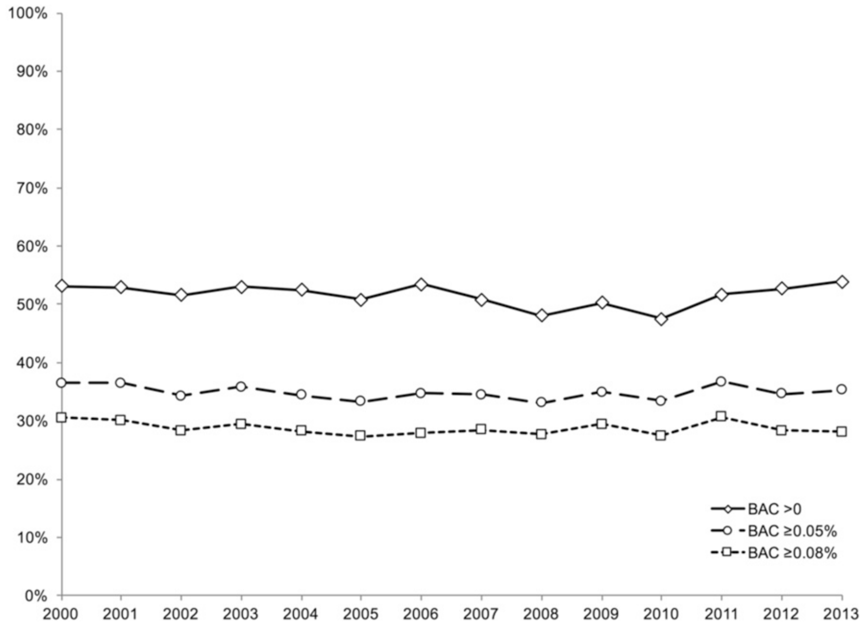

FIGURE 1
Proportion of all MVC fatalities among people ≤20 years old that are alcohol related according to different BAC cutoffs.

Table 1 lists the characteristics of decedents of alcohol-related MVCs. As noted, underage driver decedents were more likely to be male, older (18–20 years), and non-Hispanic white compared with passengers, who had a higher proportion of female decedents, younger decedents (16–17 years), and those with race or ethnicity other than non-Hispanic white. Fig 2 shows the proportion of alcohol-related MVC fatalities by day of week and time of day. Nearly one-half (47.6%) of all deaths occurred in the evening or after midnight on a weekend night (ie, between 6:00 PM Friday evening and 5:59 AM on Saturday morning and between 6:00 PM on Saturday evening and 5:59 AM on Sunday morning).

Fig 3 displays the proportion of MVC fatalities that were alcohol related and the associated APS scores across states for the 2 most recent years of data available (2012–2013). Table 2 shows unadjusted and adjusted odds ratios (aORs) of alcohol-related

TABLE 1 Characteristics of People <21 y Old Who Died in Alcohol-Related MVCs, US States, FARS, 2000–2013

	Fatalities, *n* (%)		
Characteristic	Overall[a] (*n* = 23 757)	Drivers (*n* = 11 006)	Passengers (*n* = 10 212)
Sex			
Male	17 266 (72.7)	8994 (81.7)	6357 (62.5)
Female	6486 (27.3)	2011 (18.3)	3833 (37.5)
Age			
0–15 y	4056 (17.1)	192 (1.7)	3099 (30.3)
16–17 y	4149 (17.4)	1754 (16.0)	1960 (19.2)
18–20 y	15 552 (65.5)	9060 (82.3)	5153 (50.5)
Race or ethnicity			
Non-Hispanic white	12 168 (51.2)	6387 (58.1)	4765 (46.7)
Non-Hispanic black	2298 (9.7)	724 (6.7)	1212 (11.9)
Hispanic	4209 (17.7)	1707 (15.5)	1977 (19.3)
Other	5082 (21.4)	2188 (19.9)	2258 (22.1)
Census region			
Region 1 (Northeast)	2724 (11.5)	1290 (11.7)	1108 (10.9)
Region 2 (Midwest)	4999 (21.0)	2523 (22.9)	2054 (20.1)
Region 3 (South)	10 823 (45.6)	5082 (46.2)	4648 (45.5)
Region 4 (West)	5211 (21.9)	2111 (19.2)	2402 (23.5)

Alcohol-related MVC fatalities were those occurring in crashes in which the BAC of ≥1 involved driver was ≥0.08%.
[a] "Overall" category includes not only drivers and passengers but also pedestrians, cyclists, and occupants of motor vehicles not in transit; therefore, this category contains a larger sample than the sum of the "Drivers" and "Passengers" columns.

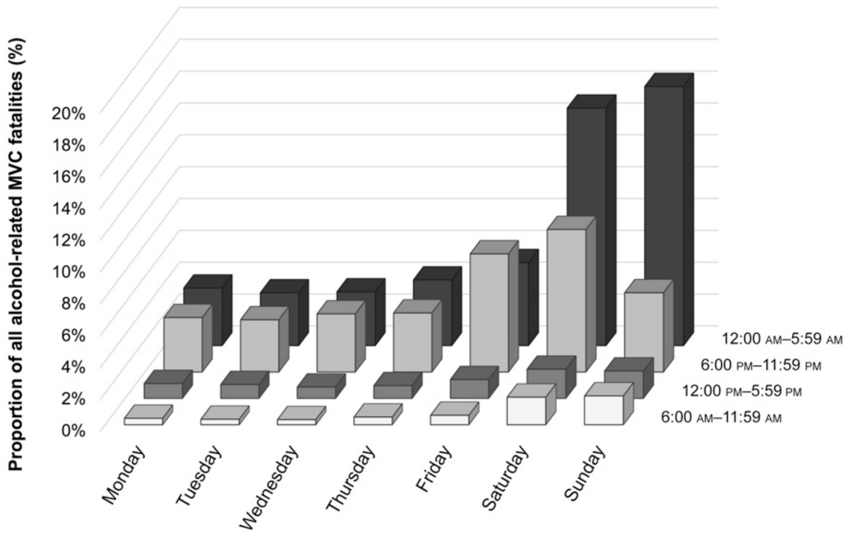

FIGURE 2
Proportion of alcohol-related MVC fatalities among people ≤20 years old according to day of week and time of day. (Alcohol-related MVCs are defined as those in which any involved driver had a BAC ≥0.08%.)

MVC death associated with a 10-percentage-point increase in states' APS scores. Higher APS scores were associated with reduced odds of alcohol-related MVC mortality both before and after adjustment for individual-level covariates (sex, age, and race or ethnicity) and year, as well as state-level covariates, both overall and when drivers and passengers were examined separately. Final multivariable models showed a consistent association with odds of alcohol-involved MVC fatality at BAC cutoffs of ≥0.05% (overall: aOR, 0.92; 95% confidence interval [CI], 0.89–0.94; drivers: aOR, 0.92; 95% CI, 0.89–0.96; passengers: aOR, 0.91; 95% CI, 0.87–0.95) and >0% (overall: aOR, 0.92; 95% CI, 0.89–0.94; drivers: aOR,

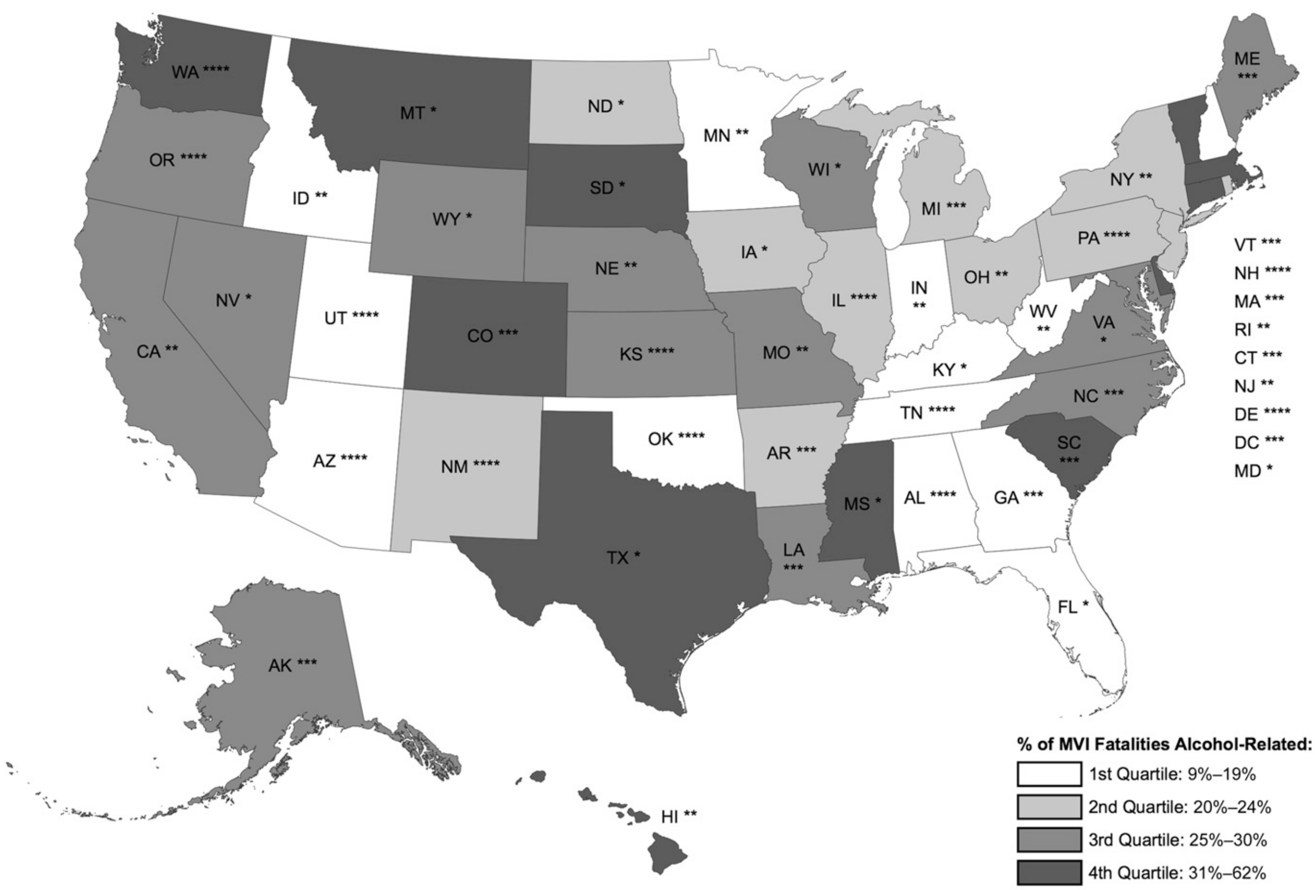

FIGURE 3
Proportion of MVC fatalities among people ≤20 years old that were alcohol-related and quartile of APS scores by state, 2012 to 2013. Number of asterisks denotes the quartile of APS scores (ie, states with the strongest policy environment are marked by 4 asterisks).

0.92; 95% CI, 0.88–0.95; passengers: aOR, 0.91; 95% CI, 0.87–0.95).

Table 3 displays aORs for alcohol-related MVC mortality associated with a 10-percentage-point increase in states' APS scores in analyses stratified by decedent and crash-related characteristics. Stronger alcohol policy environments were associated with lower odds of alcohol-related MVC fatalities for both sexes and for all age categories. However, the association was significant only for people from non-Hispanic white and other backgrounds and for passengers who were Hispanic. The associations were similar and significant regardless of day of week and were significant at various times of day except for drivers killed in a daytime MVC and passengers killed in an evening MVC.

DISCUSSION

This study offers a comprehensive examination of alcohol-related MVC fatalities among children, adolescents, and young adults in the United States in relation to states' alcohol policy environments. From 2000 to 2013, >1 in 4 deaths from MVCs were alcohol related (ie, attributable to a driver with a BAC above the legal limit of 0.08%), and more than half involved a driver with any level of alcohol >0. Nearly half of all deaths occurred at nighttime on weekends. More importantly, we found that a 10-percentage-point increase in the strength of states' alcohol policy environments was associated with a 9% decrease in the odds of alcohol-related MVC fatalities.

These findings are consistent with previous studies in which we found that states with restrictive alcohol policy environments have lower levels of binge drinking and self-reported impaired driving.[4,6,26] Our results suggest that reducing driving after any amount of drinking may be an important policy goal, because one-quarter of young people died in MVCs in which the BAC of the driver was positive but below the 0.08% legal limit. Previous research shows that a higher BAC clearly places young people at increased risk of alcohol-related MVC death (either as drivers or passengers) in a dose-dependent fashion; the relative risk

TABLE 2 ORs of Alcohol-Related MVC Deaths Among People ≤20 y Old Associated With a 10-Percentage-Point Increase in States' APS Scores, US States, FARS, 2000–2013

	OR (95% CI)		
Subcategory	Overall[a] (n = 19 701)	Drivers (n = 10 814)	Passengers (n = 7113)
Unadjusted model	0.93 (0.91–0.95)	0.92 (0.89–0.95)	0.92 (0.89–0.95)
Adjusted model (sex, age, race or ethnicity)	0.92 (0.90–0.94)	0.91 (0.88–0.94)	0.91 (0.88–0.94)
Adjusted model (sex, age, race or ethnicity, year[b])	0.92 (0.90–0.94)	0.91 (0.88–0.94)	0.91 (0.87–0.94)
Adjusted model (sex, age, race or ethnicity, year,[b] state-level covariates[c])	0.91 (0.89–0.94)	0.92 (0.88–0.95)	0.89 (0.85–0.93)

Alcohol-related MVCs were defined as those in which the BAC of ≥1 driver involved was ≥0.08%. A 1-y lag was introduced between APS score and MVC fatalities (eg, states' mortality rates from 2013 were associated with APS scores from 2012).

[a] "Overall" category includes not only drivers and passengers but also pedestrians, cyclists, and occupants of motor vehicles not in transit.

[b] Year is modeled as a categorical variable.

[c] State-level covariates included proportion male, proportion ≥21 y old, race and ethnicity proportions, college education, median household income, level of urbanization, policing rates, and vehicle miles traveled.

TABLE 3 aORs of Alcohol-Related MVC Deaths Among People <21 y Old Associated With a 10-Percentage-Point Increase in States' APS Scores According to Sociodemographic Factors, US States, FARS, 2000–2013

	aOR[a] (95% CI)		
Subcategory	Overall[b]	Drivers	Passengers
Sex			
Male	0.91 (0.89–0.94)	0.92 (0.88–0.96)	0.90 (0.85–0.94)
Female	0.89 (0.85–0.94)	0.90 (0.84–0.98)	0.87 (0.82–0.92)
Age			
0–15 y[c]	0.93 (0.87–0.98)	–	0.93 (0.87–0.98)
16–17 y	0.85 (0.81–0.91)	0.85 (0.78–0.92)	0.85 (0.78–0.93)
18–20 y	0.91 (0.88–0.95)	0.92 (0.87–0.97)	0.87 (0.81–0.94)
Race or ethnicity			
Non-Hispanic white	0.93 (0.90–0.97)	0.93 (0.89–0.97)	0.93 (0.88–0.99)
Non-Hispanic black	0.95 (0.87–1.05)	0.92 (0.77–1.04)	0.95 (0.83–1.08)
Hispanic	0.93 (0.85–1.02)	0.99 (0.86–1.14)	0.87 (0.77–0.98)
Other	0.81 (0.76–0.87)	0.78 (0.71–0.87)	0.79 (0.72–0.87)

A 1-y lag was introduced between APS score and MVC fatalities (eg, states' mortality rates from 2013 were associated with APS scores from 2012).

[a] All models adjusted for age, sex, race and ethnicity, year (as a categorical variable), and state-level covariates (proportion male, proportion ≥21 y old, race and ethnicity proportions, college education, median household income, level of urbanization, policing rates, and vehicle miles traveled). Alcohol-related MVCs were defined as those in which the BAC of ≥1 driver involved was ≥0.08%.

[b] "Overall" category includes not only drivers and passengers but also pedestrians, cyclists, and occupants of motor vehicles not in transit.

[c] Driver deaths were not examined for 0- to 15-y-old drivers because of small sample size.

of MVC fatality is increased by 55% among young male drivers and by 35% among young female drivers at a measured BAC of only 0.01% to 0.02%.[27] Recognizing the elevated risk of MCV death even after only low levels of alcohol consumption, approximately half of countries worldwide have imposed lower legal BAC limits, most commonly 0.05%.[28,29] Notably, whereas other industrialized countries have experienced a decrease in alcohol-involved crashes in recent decades, the United States has continued to demonstrate little decline in alcohol-related MVC mortality.[30]

We found that the potential impact of alcohol policies was consistent across sex and age and generally held for drivers as well as passengers. This relationship did not hold for young people who were Hispanic or non-Hispanic black. Although previous data show that black and Hispanic people are less likely than white people to have an alcohol-related MVC,[31] other studies have shown that seat belt and child restraint laws may have lower penetration to black and Hispanic populations in the United States.[32] Thus, poor safety restraint usage might dampen the potential impact of alcohol policies on MVC deaths among minority populations. It is important that future research disentangle the extent to which policies may not have an equal effect on all sectors of the population and thus exacerbate health disparities.

Although younger children in the study were driven by adults who had been drinking, many adolescents and young adults were killed in MVCs in which the driver was also <21 years old. Previous studies highlight that legal BAC limits <0.08% are appropriate for underage youth drivers, because they are less experienced and may be disproportionately at risk for MVCs even after drinking only small amounts.[27,33] Zero tolerance laws, which prohibit driving after any amount of drinking for people ≤20 years of age, have been associated with a decrease in MVC mortality of ∼20%.[16] Our results showed that most alcohol-related MVC fatalities among young people occur at nighttime and support graduated licensing laws that place restrictions on driving after dark.[34–37] Limiting passengers of underage drivers (also a component of many graduated licensing laws) may be appropriate because a large number of youth who died in alcohol-related MVCs were passengers rather than drivers.[35,37–39] Notably, most states in the United States have already implemented graduated licensing laws that include these and other provisions,[39,40] thus highlighting the importance of enforcing such laws.[41–43] Opportunities for enforcement include sobriety checkpoints, which not only offer opportunities to stop drivers who operate vehicles while intoxicated but also raise awareness of possible apprehension and serve as a deterrent for impaired driving.[18,19]

There are several limitations to this study. There are no cross-state data on enforcement of alcohol policies; thus, it is possible that some policies may have been efficacious but lacked enforcement in some settings. Nonetheless, in developing the implementation rating for policies, study investigators and panelists carefully considered whether policies included provisions that made policies more likely to be enforceable.[4,10] Additionally, reverse causality is possible, in that states with lower rates of underage drinking and lower mortality from alcohol-related MVCs might have been the same states to establish stronger alcohol policies. To address this concern, we lagged MVC fatalities by 1 year after the measured APS score to establish temporality in the relationship between exposure and outcome. Finally, APS scores incorporated only state policies and do not account for interactions with federal or local policies.

CONCLUSIONS

Our study supports the importance of comprehensive alcohol policies to reduce alcohol-related MVC fatalities among young people. More restrictive alcohol policy environments are clearly associated with lower odds of alcohol-related MVCs, an effect that holds for drivers and passengers alike and across age and sex. Future research should examine whether demographic subgroups such as non-Hispanic black and Hispanic people benefit equally from current state policies and should distinguish which policies within the overall policy environment are most effective. Our findings lay the groundwork for studying the relationship between the alcohol policy environment and crash fatalities in the United States and internationally.

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ABBREVIATIONS

aOR: adjusted odds ratio
APS: Alcohol Policy Scale
BAC: blood alcohol content
CI: confidence interval
FARS: Fatality Analysis Reporting System
MVC: motor vehicle crash
NHTSA: National Highway Traffic Safety Administration
OR: odds ratio

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