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The Utility of Including the Strengths of Underage Drinking Laws in Determining Their Effect on Outcomes

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Abstract

Background—To control underage drinking in the United States, which has been associated with an estimated 5,000 deaths and 2.6 million injuries or other harm annually, each state has developed a unique set of laws. Previous research examining these laws' effectiveness has frequently focused on the laws' existence without considering variance in sanctions, enforcement, or exemptions.

Methods—We scored 20 minimum legal drinking age 21 (MLDA-21) laws for their strengths and weaknesses based on (1) sanctions for violating the law, (2) exceptions or exemptions affecting application, and (3) provisions affecting the law or enforcement. We then replicated a 2009 study of the effects of six MLDA-21 laws in three different ways (using identical structural equation modeling): Study 1—eight additional years of data, no law strengths; Study 2—years from the original study, added law strengths; Study 3—additional years, law strengths, serving as an update of the six laws' effects.

Results—In all three studies—and the original study—keg registration laws were associated with both an unexpected significant increase (+11%, $p < .001$) in underage drinking-driver ratios and a notable 25% reduction in per capita beer consumption—opposing results that are difficult to explain. In Study 3, possession and purchase laws were associated with a significant decrease in underage drinking-driver fatal crash ratios (−4.9%, $p < .001$; −3.6%, $p < .001$, respectively). Similarly, zero tolerance and use and lose laws were associated with reductions in underage drinking-driver ratios (−2.8%, $p < .001$; −5.3%, $p < .001$, respectively).

Conclusions—Including strengths and weaknesses of underage drinking laws is important when examining their effects on various outcomes as the model fit statistics indicated. We suggest that this will result in more accurate and more reliable estimates of the impact of the laws on various outcome measures.

Keywords

Minimum legal drinking age 21 (MLDA-21) laws; drinking drivers in fatal crashes; beer consumption; Alcohol Policy Information System (APIS)

Introduction

Underage drinking is prevalent in the United States. It has been associated with ~5,000 deaths (U.S. Department of Health and Human Services, 2007) and 2.6 million injuries or other harm annually (Miller et al., 2006), for a societal cost of ~\$62 billion each year (Miller et al., 2006). To strengthen MLDA-21 laws and reduce injuries and deaths, states have also enacted legislation to prevent, reduce, and delay the onset age of drinking; however, such legislation varies substantially among states. For example, although it is illegal in all states and DC for underage youth to *possess* alcohol in public, it is not illegal in 15 states for youth to *consume* alcohol in public. The intent of the possession law is to prevent underage alcohol consumption; however, without an illegal-to-consume law, enforcement can be difficult. For example, before law enforcement officers enter the premises of an underage-drinking party, many youth dispose of their alcohol containers. To cite for possession, officers must witness youth in possession of alcohol. If the state does not have a consumption law, the officer cannot administer a breath alcohol test (even if the officer smells it) or cite for consumption—nor can they cite for possession. If there is a consumption law, the officer can administer the breath test and cite for consumption. This enforcement limitation is common. Some states also have zero tolerance (ZT) laws (no alcohol for drivers under age 21) that are unenforceable because police officers cannot take a youth into custody or transport them to the police station for a breath test unless they can demonstrate that the youth has a BAC higher than the adult illegal limit of .08 (Ferguson et al., 2000).

In our legal research, we uncovered 20 laws—described in Table 1—designed to prevent or reduce the prevalence of underage drinking adopted by various states. Of the 20 MLDA-21 laws we researched, we found that Utah has all 20 laws while Kentucky has only 9. Two thirds of states have fewer than 15 of these 20 laws (Fell et al., 2015).

Numerous studies have demonstrated the importance of enforcing underage drinking laws (Wagenaar et al., 2000, Wagenaar et al., 2005, Erickson et al., 2014, Yörük, 2014); however, few studies have examined the strengths of these laws. The objective of this study was to examine the utility of scoring the strengths and weaknesses of various underage drinking laws. The current U.S. legal effort to control underage drinking involves a variable package of legislative policies—different in each state—and the level and intensity of enforcement of these policies is relatively unknown at the state level. Further, the laws themselves have strengths and weaknesses. To determine if these strengths and weaknesses make a difference, we scored the 20 MLDA-21 laws based on (1) sanctions enacted for violating the law, (2) exceptions or exemptions affecting the law's application and enforcement, and (3) provisions that could negatively or positively affect the law or its enforcement (Fell et al., 2015).

The two core MLDA-21 laws—possession and purchase—have been associated with significant reductions in underage drinking consequences. In Fell et al. (2009), six MLDA-21 laws—two core laws plus ZT, use and lose, keg registration, and graduated driver licensing (GDL) nighttime restriction—were evaluated for their effect on the ratio of underage drinking drivers to underage nondrinking drivers involved in fatal crashes using a pre-post design and structural equation modeling (SEM). The results indicated that four of

the underage drinking and underage impaired-driving laws were associated with significant decreases in the ratio of drinking to nondrinking drivers under age 21 in fatal crashes. Specifically, significant decreases in the underage fatal crash incidence ratio were associated with the implementation of possession and purchase (-16% , $p < .001$), ZT (-5% , $p = .015$), and use and lose (-5% , $p = .026$) laws. Results displayed in Figure 1 are adapted from Fell et al. (2009).

Three laws targeting the overall driving public were also associated with reductions in the drinking-driver fatal crash incidence ratio for underage youth—the secondary enforcement seat belt law or adding a primary enforcement law (-3% , $p = .041$), the administrative license revocation (ALR) law (-5% , $p = .024$), and the .08 BAC illegal per se law (-8% , $p = .002$). Results displayed in Figure 2 are adapted from Fell et al. (2009).

In our current study, we hypothesize that the inclusion of law strengths results in a superior fitting SEM and states with stronger MLDA-21 laws will demonstrate reduced per capita beer consumption and reduced underage drinking-driver fatal crash ratios. Many of the six laws in our study have not changed in recent years, and we theorize that laws have the greatest impact immediately following their implementation when enforcement and media exposure are likely at the highest levels. Similarly, we also hypothesize that the model with limited years and strengths incorporated will have the highest fit statistics when compared with the other models, which incorporate additional years, and when compared to the original study, which did not use law strengths.

Materials and Methods

To examine the effectiveness of including law strengths when determining the impact of MLDA-21 laws, we replicated—in three different ways—our previous work in which we determined the impact of six MLDA-21 laws (see Table 1) in addition to several control variables (Fell et al., 2009). The first replication—Study 1—repeated the original study (1982–2004) with eight additional years of data (1982–2012) and no law strengths. This allowed us to gauge the impact of including additional years of data into the original model and determine if the laws were still effective. The second replication—Study 2—included the same years as the original study (1982–2004) with the addition of the MLDA-21 law strengths adapted from Fell et al. (2015). This allowed us to examine how the outcomes of the original study would have changed had the law strengths been incorporated into the original model. The third replication—Study 3—included both the additional years and the strengths of the six MLDA-21 laws. Study 3 allowed us to update the findings of our 2009 study with a better model.

We updated Fell et al.'s (2008, 2009) previous legal research to determine the effective dates of the six MLDA-21 laws in various states. Of the six laws, only the GDL nighttime restriction was newly enacted by three states, and no states that previously had the laws discontinued them. As such, we only updated GDL nighttime restriction laws, crash rates, beer consumption, and the control variables described below for use in Studies 1 and 3. Study 2 required no update of data as we used the same timespan as the original study.

Data Sources

Law and Law Strengths—The Alcohol Policy Information System (APIS) is a valuable resource funded by the National Institute on Alcohol Abuse and Alcoholism (NIAAA) that provides detailed information on alcohol-related state and federal policies. The current studies use implementation dates for six MLDA-21 laws: (1) possession, (2) purchase, (3) ZT, (4) use and lose, (5) keg registration, and (6) GDL nighttime restriction (see Table 1). The effective dates were drawn from data sets gathered from the previous research (Fell et al., 2009). Legal research conducted via APIS determined there had been no changes in five of these six laws in the interim period (2005–2012). However, GDL nighttime restriction laws were adopted in some states (Insurance Institute for Highway Safety [IIHS], 2014). Law strength data were drawn from Fell et al. (2015) and based on the number of exemptions, allowances, and sanctions possible under each law. Table 2 provides an example of how we scored the possession law. Only 20 states achieved the maximum score for a possession law: 11. The average score was 8 (range: 1–11).

Depending in part on APIS data, we developed a considerable store of information on the status of various underage drinking law components. Providing data on the laws' effective dates in each of the 50 states and DC opens the way for investigators to conduct time-series analyses of data from individual states and pre-post panel studies of all 50 states and DC. Additionally, the Substance Abuse and Mental Health Services Administration (2011) provides data on social host civil liability statutes and common law for the 50 states and DC. The IIHS website provides current data on states' GDL nighttime restriction laws.

Traffic Fatalities—Data for annual state-level traffic fatalities (1982–2012) was derived from the National Highway Traffic Safety Administration's (NHTSA) Fatality Analysis Reporting System (FARS). FARS is a continuous census of motor vehicle crashes that (1) resulted in a death within 30 days of the crash, (2) occurred on U.S. public roadways, and (3) had been investigated and reported by police. Since 1982, every driver in FARS has a BAC either from testing by police/medical examiners or imputed based on other crash data, such as time of the crash, police assessment that the driver had been drinking, driver's age and gender, and number of vehicles in the crash (Subramanian, 2002). Crashes were considered alcohol-related if the driver had a measured or imputed BAC > .00.

The numbers of drinking drivers involved in fatal crashes were divided by numbers of nondrinking drivers in fatal crashes to produce a ratio of drinking to nondrinking drivers in fatal crashes (crash incidence ratio) (Voas et al., 2007). This approach controls for numerous unknown or unmeasurable factors that may impact crash ratios as both the alcohol and nonalcohol crashes would likely be impacted. Two outcome measures were used: fatal crash ratios for drivers aged 20 years and younger, and fatal crash ratios for drivers aged 26 years and older. The use of two outcome measures—or more accurately, the exclusion of drivers aged 21 to 25 years—allowed us to control for carryover effects of any of the underage drinking laws. By age 26 any carryover effects of the six laws would be diminished.

Beer Consumption—From the annual publication of NIAAA's Alcohol Epidemiologic Data System (LaVallee et al., 2014), per capita beer consumption rates were obtained for

individuals aged 15 years and older by year and state. Although it would have been ideal to have beer consumption rates by age to allow for a more accurate representation of the role of beer consumption, these data were only available as general numbers by state and year.

Impaired-Driving Laws—As in the 2009 study, we selected three laws with strong evidence for regulating drinking-and-driving behaviors, including lowering the BAC limit for driving to .10 (followed later by its lowering to .08) and ALR laws. These three laws have been shown to be effective in reducing impaired-driving fatal crashes (Klein, 1989, Voas et al., 2000, Shults et al., 2001, Wagenaar and Maldonado-Molina, 2007, Wagenaar et al., 2007) and subsequently were deemed necessary to include as control variables in the current research. The effective dates of these laws were drawn from NHTSA's Digests of State Alcohol Highway Safety Legislation (1983–2005) and from the Digests of Impaired Driving and Selected Beverage Control Laws (2006–2013). All three of these laws were coded as “0” if the law was absent, and “1” if present, while years in which the law was implemented were coded as a fraction to indicate what percentage of the year the law covered. For example, if a law went into effect in September, it would be present for only a third of that year and was coded as “0.33.” To control for unique variance within the latent construct, ALR law variable loading was fixed at 1.0.

Driving Safety Laws—We also selected laws intended to promote general driving safety, which have been shown to impact impaired-driving fatal crashes, including sobriety checkpoints designed to deter impaired driving in the first place (Lacey et al., 1999, Peek-Asa, 1999, Fell et al., 2003) and mandatory seat belt laws (primary and secondary enforcement) (Voas et al., 2007). Given the potential impact of these laws on drinking and driving, we again deemed it necessary to control for these laws in the current research. Driving safety laws were composed of the frequency of sobriety checkpoints and a composite score of primary enforcement (can be stopped by police for not wearing a safety belt) and secondary enforcement (must be stopped by police for another violation before cited for not wearing a safety belt) seat belt laws. Primary enforcement seat belt laws have been shown to affect impaired-driving fatalities more so than non-impaired-driving fatalities (Voas et al., 2007). Data concerning the frequency of sobriety checkpoints were derived from previous research by Fell et al. who interviewed state representatives in 2000 to determine the number and frequency of checkpoints conducted in the previous year (Fell et al., 2003). Based on this research, sobriety checkpoints were coded as “0” if checkpoints were illegal or otherwise not conducted, “1” if conducted infrequently, and “2” if conducted frequently (e.g., monthly or weekly). Similarly, states' seat belt laws were coded as follows: states without a seat belt law were coded as “0”; states with secondary seat belt laws were coded as “1”; and states with secondary seat belt laws upgraded to primary seat belt laws were coded as “2.” To control for unique variance within the latent construct, seat belt safety variable loading was fixed at 1.0.

Economic Strength—Finally, we replicated a design used in the original research, which found that additional variables assessing state economic strength may contribute to the ratio of drinking drivers to nondrinking drivers involved in fatal crashes. Economic strength and exposure to crashes were measured by state unemployment rates and vehicle miles traveled

(VMT). VMT were derived from the Federal Highway Administration (Office of Highway Policy Information, 2012), which produces an annual estimate of total VMT by state and year. Unemployment statistics were derived from the U.S. Bureau of Labor Statistics online area statistics public database (U.S. Bureau of Labor Statistics, 2014), which publishes monthly unemployment statistics by state. To control for unique variance within the latent construct, VMT variable loading was fixed at 1.0.

Research Design

For all three studies, we used an identical SEM in our analysis of the data. The differences between the models pertain to the number of years of data and the inclusion of MLDA-21 law strengths. The hypothesized SEM for all three studies is illustrated in the path diagram (Figure 3). The model consists of—

- The six MLDA-21 laws originally evaluated;
- Three impaired-driving laws (.08 illegal limit, .10 illegal limit, and ALR);
- Two driving safety laws (sobriety checkpoints and seat belt laws);
- Two variables determining economic strength (unemployment and VMT);
- One alcohol consumption measure in the state (per capita beer consumption); and
- Two outcome measures:
 - The ratio of underage drinking drivers to underage nondrinking drivers in fatal crashes and
 - The ratio of drinking drivers to nondrinking drivers in fatal crashes among drivers aged 26 years and older.

The inclusion of the aged 26 years and older cohort was deemed appropriate to prevent overstating the effects of the law changes on the underage population. By using the adult cohort as a simultaneous outcome, differential effects of the laws can be measured on both age groups (Fell et al., 2009). Data for all variables were available by state for each year from 1982 to 2012. However, Study 2 only utilized data from 1982 to 2004.

Data Analysis

Structural Equation Modeling—The data were analyzed using SEM with Analysis of Moment-Based Structures (AMOS v.21), an SPSS-based package (IBM SPSS Inc., Chicago, IL). SEM generally requires a large number of data points (>200) (Kline, 2005). As Study 2 allowed for the fewest data points but still had 1,173 ((50 states + DC) x 23 years), SEM was deemed appropriate. Further, SEM was used in the current analysis to more accurately account for simultaneous effects of laws on multiple outcomes (i.e., FARS ratios and beer consumption) and because beer consumption was modeled as an intervening variable rather than only a predictor of FARS ratios.

Ideally, fit statistics for SEM would yield a nonsignificant χ^2 statistic, a comparative fit index (CFI) and normed fit index (NFI) of 0.95 or greater, and a root mean square error of approximation (RMSEA) between 0.05 and 0.10 (Barrett, 2007, Hu and Bentler, 1999,

MacCallum et al., 1996). Generally speaking, the closer a CFI and NFI score is to 1.0, the better the model fit. Similarly, the lower the RMSEA, the better the model fit. Given these standards of fit, all models exhibited a relatively low level of fit to the data (Table 3). Despite this, fit statistics are merely guidelines and should be deemed acceptable if they meet or exceed previous models in the field (Bollen, 1989). As is the case in the current studies, the fit data to the model display similar fit statistics as previous research into the effect of laws on FARS data, indicating that the current model is comparable to previous models proposed in this field and as such should be retained (Fell et al., 2009). Model fit statistics are found in Table 3.

Univariate Analysis of Variance—Finally, we examined the difference between states with strong laws and those with weak laws on measures of underage FARS ratios and per capita beer consumption. To do this, we first dichotomized states into strong law and weak law states. States were categorized by comparing their average law strength against the national average law strength. Those with average law strengths above the national average were categorized as strong law states, while those with averages below the national average were categorized as weak law states. This was accomplished by running a series of univariate ANOVA in SPSS (IBM SPSS Inc., Chicago, IL).

Results

Studies 1 and 2

The purpose of Study 1 was to repeat the original study by Fell et al. (2009) but with the inclusion of additional years of data. The original study used data from 1982 to 2004; Study 1 of the current effort added data from eight additional years (1982–2012). This allowed us to examine the impact of the original six laws on underage drinking-driver crash ratios and on per capita beer consumption including more current years. Study 2 used the same years as the original study, but incorporated the law strengths as described in Fell et al. (2015). This allowed us to examine what impact incorporating the law strengths might have had on the original findings. In Study 1, possession and purchase laws were evaluated together as their implementation dates were often identical. Without the inclusion of law strengths, individual assessment of these laws was impossible. As was the case in the original study, the two laws were combined into a single “possession and purchase” law. Regression weights and significance levels for all variables in the original study (Fell et al., 2009) are provided in Table 4. Regression weights and significance levels for all variables in Studies 1, 2, and 3 are provided in Tables 4 and 5 for comparison.

Possession and Purchase—In Study 1, the combined possession and purchase laws demonstrated a 12.6% decrease in underage drinking-driver FARS ratios. However, when they were separated and their strength scores considered in Study 2, they demonstrated a 4.5% and 4.7% decrease in the underage FARS ratios, respectively. Compared to a 16% decrease reported by Fell et al. (2009) for possession and purchase law composites, Study 1 demonstrated a decrease in law effectiveness over time and Study 2 demonstrated that both laws contributed about equally to the variance explained by the composite score.

Zero Tolerance—In Study 1, ZT laws demonstrated only a 2.5% decrease in the underage drinking-driver FARS ratios. However, when law strength was incorporated in Study 2, the variance explained by this law decreased underage drinking-driver FARS ratios by 8%. Compared to the 5% decrease reported by Fell et al. (2009) in the original study, Study 1 demonstrated a decrease in law effectiveness over time, and Study 2 demonstrated that stronger ZT laws explained more variance than when law strength was omitted.

Use and Lose—In Study 1, use and lose laws demonstrated a 3.7% reduction in underage drinking-driver FARS ratios. When law strengths were incorporated in Study 2, use and lose laws demonstrated a 6% decrease in underage drinking-driver FARS ratios. Compared to the 5% decrease reported by Fell et al. (2009) in the original study, we saw a similar pattern as with previous laws concerning a decreased effectiveness of the law over time in Study 1 and a general increase in the variance explained by the law when the strength was taken into consideration.

Keg Registration—Keg registration was the only one of the six laws examined that was originally hypothesized to impact FARS ratios for both those younger than 21 years and those 26 years and older, as well as per capita beer consumption. In Study 1, keg registration demonstrated an increase in FARS ratios for both the younger than 21 years and 26 years and older groups (8.7% and 2.4%, respectively). Conversely, in Study 1 keg registration demonstrated a 10.7% decrease in per capita beer consumption. When law strengths were incorporated in Study 2, keg registration demonstrated a 12% *increase* in the underage FARS ratios, yet demonstrated a 27.7% *decrease* in beer consumption. In the original study, keg registration also showed a 12% increase in the FARS ratio for drivers younger than 21 years and a 4% increase in the FARS ratio for drivers 26 years or older.

GDL Nighttime Restriction—No significant relationship was found between underage drinking-driver FARS ratios and the GDL nighttime restriction laws in Study 1, Study 2, or the original study. However, in a separate study using different methods and focusing on drivers aged 16 to 17 years who were affected by GDL nighttime restrictions, it was found that GDL laws with nighttime restrictions were associated with reductions in involvement of drivers aged 16 to 17 years in fatal crashes at night by 10% and drinking drivers aged 16 to 17 years in fatal crashes at night by 13% (Fell et al., 2011).

Study 3

In Studies 1 and 2, we examined separately the impact of adding additional years to our original research and incorporating the strengths of the six MLDA-21 laws. In Study 3, we again replicated our original research but incorporated both the additional years of data available and the law strength data gathered from Fell et al. (2015).

MDLA-21 Laws—In Study 3, we found that both possession and purchase laws were associated with a significant decrease in the underage FARS ratios (−4.9%, $p < .001$ and −3.6%, $p < .001$, respectively). Similarly, use and lose laws and ZT laws also demonstrated an association with reductions in underage drinking-driver FARS ratios (−5.3%, $p < .001$ and −2.8%, $p < .001$, respectively). As was the case in Studies 1 and 2, keg registration was

again associated with a significant increase in the underage FARS ratios (+11%, $p < .001$) and a 2.4% ($p = .039$) increase in 26 years and older FARS ratios. Keg registration laws, however, were associated with a notable 25% reduction in per capita beer consumption. See Table 4 for regression weights and significance level of the entire model, and Figure 4 for a summary of the findings.

Latent Factors—Impaired-driving laws—constituted when states adopted .10 BAC and .08 BAC limit laws—and ALR laws served as covariates in our analyses. ALR was set to “1” and both .08 and .10 legal limit laws were found to be significant predictors of the impaired-driving latent construct (85.8%, $p < .001$ and 41.1%, $p < .001$, respectively). Driving safety laws (seat belt and sobriety checkpoint frequency) and economic strength (unemployment rates and VMT) were both set to “1” while also serving as covariates in our models. Sobriety checkpoints were found to be a significant indicator of driving safety laws (9.7%, $p < .001$) and unemployment rates were found to be a significant indicator of economic strength (31.2%, $p < .001$).

A significant relationship was found between underage drinking-driver FARS ratios and impaired-driving laws (−20.9%, $p < .001$), driving safety laws (−11.6%, $p < .001$), and economic strength (−0.6%, $p = .045$). However, when examining factors impacting per capita beer consumption, only economic strength (−1.5%, $p < .001$), not impaired-driving laws (−3.8%, $p = ns$), was found to be significant. Conversely, when examining 26 years and older FARS ratios, driving safety laws (−6.8%, $p < .001$) and impaired-driving laws (−11.9%, $p < .001$) were found to be significant, but economic strength was not (−1.5%, $p = ns$).

We then examined how underage drinking-driver FARS ratios were impacted by strong versus weak MLDA-21 laws. We conducted an ANOVA with a dichotomized law strength variable, where states with law strengths above the national average were considered strong, while those below the national average were considered weak. There was a significant relationship between law strength and underage drinking-driver FARS ratios ($F(4, 1525) = 8.55$, $p = .004$, partial $\eta^2 = .006$) with states with strong laws ($M = 0.302$) averaging lower drinking-driver fatal crash ratios among drivers younger than 21 years than states with weak laws ($M = 0.313$).

Next, we examined how strong versus weak MLDA-21 laws impacted per capita beer consumption. We again conducted an ANOVA with the dichotomized law strength variable. There was a significant relationship between law strength and beer consumption ($F(4, 1525) = 15.96$, $p < .001$, partial $\eta^2 = .088$) in which states with strong laws ($M = 1.275$) averaged lower per capita beer consumption rates than states with weak laws ($M = 1.298$).

Discussion

Clearly, when we replicated the original study (Fell et al., 2009) by extending the years from 1982–2004 (original) to 1982–2012 (Study 1), the effect sizes were smaller, as expected. The possession/purchase effect decreased from −16.1% to −12.6%, use and lose from −5.4% to −3.7%, and ZT from −5.2% to −2.5%. The keg registration law still resulted in an

increase in the FARS ratio, but a smaller one (from +12.3% to +8.7%). We hypothesize that this occurred due to (a) the lack of any significant national progress in reducing impaired-driving rates in fatal crashes between 1998 and 2012 (Voas and Fell, 2013); (b) a decrease in enforcement levels and novelty of the six laws; and/or (c) youth finding better ways to circumvent the six laws.

When we replicated Fell et al. (2009) with the law strengths, a number of effects changed. The possession and purchase laws were separated and had a -4.5% and -4.7% effect, respectively, compared to a -16.1% effect together. With the inclusion of the strengths of each law, the use and lose law had a larger effect (-6.0% v -5.4%) as did the ZT law (-8.0% v -5.3%). We believe these changes were due to better fit statistics for the model with the strengths included (Table 3).

However, the most important changes came when we included the strengths and weaknesses of the MLDA-21 laws and examined the FARS ratios with eight additional years of data (1982–2012). The possession (-4.9%) and purchase (-3.6%) laws still had significant effects ($p < .001$), the use and lose (-5.3%) and ZT (-2.8%) laws were also highly significant. The driving safety laws (seat belt and sobriety checkpoint frequency) had a substantial effect (-11.6%) on the underage drinking-driver ratio, as did the impaired-driving laws (-20.9%). Per capita beer consumption was associated with a 16.1% increase and keg registration law an 11.0% increase in the underage FARS ratio. It is clear that a higher per capita beer consumption rate is associated with significantly higher underage drinking-driver rates in fatal crashes. However, it is still not clear why beer keg registration laws are associated with significant increases in the underage drinking-driver rates in fatal crashes. We speculate that drink replacement may be occurring. In states that adopt keg registration laws, underage drinkers may be replacing their draft beer with beverages that have a higher alcohol content and reaching higher BACs with the same amount of consumption. This explanation would also account for the observed reduction in beer consumption associated with the adoption of keg registration laws. It is also clear that certain MLDA-21 laws still have an effect while facing stagnated drinking-and-driving rates in recent years, especially the stronger MLDA-21 laws (possession, purchase, use and lose, and ZT).

Using lives saved estimations similar to our previous research (Fell et al., 2009, Fell et al., 2014), we determined the relative risk of drivers based on BAC levels. Specifically, derived from previous research by Terhune et al. (1992), we determined that drivers with a BAC between .05 and .079 and those with a BAC $\geq .08$ were 2 and 7.3 times, respectively, more as likely to be involved in a crash as those with a BAC $< .05$. We then examined BAC values in the FARS crash data set to determine the annual fatalities attributable to drivers younger than 21 years with a BAC $\geq .05$. Using the effect sizes listed in Table 5, we then determined that the possession (-4.9% effect size) and ZT (-2.8% effect size) laws—present in every state and DC—annually save 153 and 115 lives, respectively. The purchase law (-3.6% effect size) currently saves 104 lives each year but could save an additional 7 lives if all states adopted the law. Technically, all states are supposed to have purchase laws, but our legal research revealed that three states do not. The use and lose law (-5.3% effect size)

currently saves 131 lives annually, but an additional 36 lives could be saved if all states adopted the law.

This means that the four effective MLDA-21 laws currently save an estimated 503 lives annually in the states that have these laws. However, if all states adopted all four laws, an additional 40 lives could be saved each year across the United States. Notably, however, the current research only examines 6 of the 20 MLDA-21 laws. Future research is needed to examine the impact of all 20. Doing so would likely result in slight alterations to the effect sizes described in the current study.

This effort is not free of limitations. The primary outcome measure in the current study involved alcohol-related fatal crash ratios, which are relatively uncommon and perhaps an extreme outcome of consuming alcohol. To this end, nonfatal alcohol-related crash data would have been preferable both to highlight nuances between laws and to demonstrate more realistic outcomes from alcohol-related crashes. However, alcohol reporting in nonfatal crashes is incomplete and highly variable in quality and availability from state to state; hence, fatal crashes were deemed suitable. Further, the use of crashes as an outcome might also downplay the effectiveness of some laws. That is, a law may not have a significant impact on crash ratios, but may indeed impact other alcohol-related outcomes (e.g., binge drinking, assaults, unintentional injuries, suicides). Additionally, the current study does not consider important demographic differences in population. Previous research has established the differences in alcohol-related outcomes in both sex and age of drivers, but due to the complexity of the analyses involved, it was not feasible to include this level of detail in this study.

We conclude that it is important to include the strengths and weaknesses of underage drinking laws when examining their effects on various outcomes. This will give a more accurate and a more current estimate of the impact of the laws on various outcome measures. We used underage drinking-driver rates in fatal crashes and per capita beer consumption as outcome measures, but these laws (including their strengths and weaknesses) could also affect underage alcohol consumption, binge drinking, alcohol-related violence, and unintended injuries, as well as other negative consequences. Future research is needed on the effects of these MLDA-21 laws (with their strengths) on other outcome measures, but reliable data on many of these measures may be difficult to obtain.

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Figure 1.
MLDA-21 Law Effects on the Ratio of Drinking Drivers Younger Than 21 Years to
Nondrinking Drivers Younger Than 21 Years in Fatal Crashes (1982–2004)

Figure 2.
Traffic Safety Law Effects on the Ratio of Drinking Drivers Younger Than 21 Years to 1
Nondrinking Drivers Younger Than 21 Years in Fatal Crashes (1982–2004)

Figure 3.
Hypothesized Structural Pathways Predicting Beer Consumption and FARS Ratios

Figure 4.
Underage Drinking Law Effects on the Ratio of Drinking Drivers Younger Than 21 Years to Nondrinking Drivers Younger Than 21 Years in Fatal Crashes (1982–2012)

Table 1**Minimum Legal Drinking Age 21 (MLDA-21) Law Components and Descriptions**

MLDA-21 Law Components	Description
Core Laws That Apply to Youth	
1. Possession *	<i>Illegal for youth younger than 21 years to possess alcohol.</i>
2. Purchase *	<i>Illegal for youth younger than 21 years to purchase or attempt to purchase alcohol.</i>
Possession and purchase were treated together as the laws that met federal standards by 1988.	
Expanded Laws That Apply to Youth	
3. Consumption	Illegal for youth younger than 21 years to consume alcohol.
4. Internal Possession	Evidence of possession and consumption via a BAC test.
5. Use and Lose *	<i>Alcohol citation for youth younger than 21 years results in drivers' license suspension.</i>
6. Use of Fake Identification	FID minor—Illegal for youth younger than 21 years to use fake identification to purchase alcohol.
Apply to Youth Driving	
7. Zero Tolerance *	<i>ZT—Illegal for a driver younger than 21 years to have any alcohol in their system when driving.</i>
8. Graduated Driver Licensing with Nighttime Restrictions *	<i>GDL—Youth with intermediate or provisional license prohibited from driving after a certain hour at night without an adult in the vehicle.</i>
Apply to Providers	
9. Furnishing or Selling	Illegal to furnish or sell alcohol to a youth younger than 21 years.
10. Age of On-Premise Servers	Minimum age set for selling/serving alcohol.
11. Age of On-Premise Bartenders	Minimum age set for bartenders.
12. Age of Off-Premise Sellers	Minimum age set for selling/serving alcohol.
13. Keg Registration *	<i>Identification number for beer keg and purchaser required.</i>
14. Responsible Beverage Service Training	RBS—Responsible beverage training mandatory or voluntary.
15. Retailer Support Provisions for Fake Identification	FID Retailer—Provisions to assist retailers in avoiding sales to youth younger than 21 years.
16. Social Host Prohibition	SHP—Prohibits social hosting of drinking parties for underage youth.
17. Dram Shop Liability	Action against commercial provider of alcohol.
18. Social Host Civil Liability	Action against noncommercial (private) provider of alcohol.
Apply to Manufacturers or Suppliers of Fake Identification	
19. Transfer/Production of Fake Identification	FID Supplier—Prohibits manufacturing and/or supplying fake identification to youth for the purposes of buying alcohol.
Apply to States Concerning Control of Alcohol Distribution	
20. State Control of Alcohol Sales	State Control—A state-run retail distribution system of one or more alcohol beverage types

* The six laws examined in this study.

Table 2

Scoring Example—Possession Law

Scoring Criteria	Weight Point Values
Law present	+ 11.0 points
Any private location exception	– 6.0 points for unconditional – 3.0 points for conditional
Any private residence exception	– 4.0 points for unconditional – 2.0 points for conditional
Parent/guardian home only exception	– 2.0 points for unconditional – 1.0 point for conditional
Parent and/or spousal exception not conditional on location exception	– 4.0 points

Table 3

Comparison of Fit Statistics for Models With and Without Strength of Laws

Model	χ^2	CFI ¹	NFI ²	RMSEA ³
For Comparison: Fell et al. 2009 (without strengths 1982–2004)	4041.26***	0.443	0.439	0.18
Study 1: Model without strengths (1982–2012)	5967.34***	0.409	0.403	0.19
Study 2: Model with strengths (1982–2004)	4059.38***	0.552	0.548	0.17
Study 3: Model with strengths (1982–2012)	5856.81***	0.453	0.448	0.17

¹Comparative fit index²Normed fit index³Root mean square error of approximation***
 $p < .001$

Table 4

Regression Weights and Significance for Models Examining 1982 through 2004 Both Without Strengths (Fell et al., 2009) and With Strengths (Study 2)

Fell et al. (2009) Study Without Law Strengths (1982–2004)		Study 2: Model Including Strengths (1982–2004)				
Predictor	Estimate	S.E.	p-value	Estimate	S.E.	p-value
Outcome = Younger Than 21 Years FARS Ratio						
Economic strength	−.030	.011	.007	.009	.003	.002
GDL nighttime law	.10		.983	−.004	.016	.821
Use and lose law	−.054	.024	.026	−.060	.011	<.001
Keg registration law	.116	.026	<.001	.120	.024	<.001
Possession law	−.176	.036	<.001	−.045	.012	<.001
Purchase law				−.047	.012	<.001
ZT law	−.052	.021	.015	−.080	.011	<.001
Driving safety laws				−.140	.007	<.001
Seat belt laws	−.032	.016	.041			
Checkpoint enforcement	−.90		.387	−.147	.019	<.001
Impaired-driving laws						
ALR	−.051	.023	.024			
.08 BAC	−.079	.026	.002			
.10 BAC	−.068	.037	.065			
Beer consumption	.367	.051	<.001	.191	.024	<.001
Outcome = Aged 26 Years and Older FARS Ratio						
Economic strength	−.031	.006	<.001	.006	.002	.005
Keg registration law	.042	.013	.001	.029	.015	.059
Driving safety laws				−.076	.005	<.001
Seat belt laws	−.019	.008	.016			
Checkpoint enforcement	−.014	.005	.004			
Impaired-driving laws				−.079		<.001
ALR	−.037	.011	<.001			
.08 BAC	−.065	.013	<.001			
.10 BAC	−.037	.018	.042			

Fell et al. (2009) Study Without Law Strengths (1982–2004)						Study 2: Model Including Strengths (1982–2004)					
Predictor	Estimate	S.E.	p-value	Estimate	S.E.	p-value					
Intermediate Outcome = Beer Consumption											
Beer consumption	.250	.025	<.001	.158	.015	<.001					
Economic strength											
Keg registration law	–.070		.257	.001	.004	.875					
Impaired-driving laws	–.077	.015	<.001	–.277	.028	<.001					
ALR	.061	.013	<.001	.022	.018	.221					
.08 BAC	–.109	.015	<.001								
.10 BAC	2.70		.218								
Latent Factor = Impaired-Driving Laws ^l											
0.08 legal limit law				.465	.052	<.001					
0.10 legal limit law				.326	.038	<.001					
ALR law				Set to 1							
Latent Factor = Driving Safety Laws ^l											
Sobriety checkpoints				.083	.030	.005					
Seat belt safety				Set to 1							
Latent Factor = Economic Strength											
Unemployment rates	.909	.215	<.001	.091	.008	<.001					
VMT	Set to 1			Set to 1							

^lThe original Fell et al. (2009) study did not use these Impaired Driving and Driving Safety laws as latent factors. Instead, the original study directly linked the predictors directly to outcome variables.

Regression Weights and Significance for Models Examining 1982 through 2012 Both Without Strengths (Study 1) and With Strengths (Study 3)

Table 5

Study 1: Model Without Strengths (1982–2012)						Study 3: Model Including Strengths (1982–2012)					
Predictor	Estimate	S.E.	p-value	Estimate	S.E.	p-value	Predictor	Estimate	S.E.	p-value	Predictor
Outcome = Younger Than 21 Years FARS Ratio											
Economic strength	-.007	.003	.009	-.006	.003	.045	Economic strength	.003	.002	.179	Economic strength
GDL nighttime law	-.010	.008	.183	-.018	.011	.095	GDL nighttime law	.006	.012	.039	GDL nighttime law
Use and lose law	-.037	.007	<.001	-.053	.010	<.001	Use and lose law	.004	.004	<.001	Use and lose law
Keg registration law	.087	.010	<.001	.110	.019	<.001	Keg registration law	.013	.012	<.001	Keg registration law
Possession law	-.126	.012	<.001	-.049	.011	<.001	Possession law	.013	.013	<.001	Possession law
Purchase law				-.047	.012	-.036	Purchase law				Purchase law
ZT law	-.025	.007	<.001	-.028	.010	.006	ZT law				ZT law
Driving safety laws	-.092	.006	<.001	-.116	.006	<.001	Driving safety laws				Driving safety laws
Impaired-driving laws	-.192	.020	<.001	-.209	.20	<.001	Impaired-driving laws				Impaired-driving laws
Beer consumption	.170	.021	<.001	.161	.021	<.001	Beer consumption				Beer consumption
Outcome = Aged 26 Years and Older FARS Ratio											
Economic strength	.003	.002	.105	.002	.002	.179	Economic strength	.003	.002	.179	Economic strength
Keg registration law	.024	.006	<.001	.024	.012	.039	Keg registration law	.006	.012	.039	Keg registration law
Driving safety laws	-.068	.004	<.001	-.068	.004	<.001	Driving safety laws	.004	.004	<.001	Driving safety laws
Impaired-driving laws	-.131	.013	<.001	-.119	.012	<.001	Impaired-driving laws	.013	.012	<.001	Impaired-driving laws
Beer consumption	.150	.013	<.001	.150	.013	<.001	Beer consumption	.013	.013	<.001	Beer consumption
Intermediate Outcome = Beer Consumption											
Economic strength	-.016	.003	<.001	-.015	.003	<.001	Economic strength	.003	.003	<.001	Economic strength
Keg registration law	-.107	.012	<.001	-.252	.022	<.001	Keg registration law	.012	.022	<.001	Keg registration law
Impaired-driving laws	-.063	.022	.004	-.038	.021	.070	Impaired-driving laws	.022	.021	.070	Impaired-driving laws
Latent Factor = Impaired-Driving Laws											
0.08 legal limit law	.915	.070	<.001	.858	.067	<.001	0.08 legal limit law	.070	.067	<.001	0.08 legal limit law
0.10 legal limit law	.419	.035	<.001	.411	.034	<.001	0.10 legal limit law	.035	.034	<.001	0.10 legal limit law

Study 1: Model Without Strengths (1982–2012)					Study 3: Model Including Strengths (1982–2012)				
Predictor	Estimate	S.E.	p-value	Estimate	S.E.	p-value	Estimate	S.E.	p-value
ALR law	Set to 1			Set to 1			Set to 1		
Latent Factor = Driving Safety Laws									
Sobriety checkpoints	.097	.027	<.001	.097	.026	<.001			
Seat belt safety	Set to 1			Set to 1					
Latent Factor = Economic Strength									
Unemployment rates	.095	.022	<.001	.312	.26	<.001			
VMT	Set to 1			Set to 1					