Published in final edited form as:
Traffic Inj Prev. 2011 October ; 12(5): 423–431. doi:10.1080/15389588.2011.588296.

An Evaluation of Graduated Driver Licensing Effects on Fatal Crash Involvements of Young Drivers in the United States

James C. Fell, **Kristina Jones**, **Eduardo Romano**, and **Robert Voas**
Pacific Institute for Research and Evaluation, 11720 Beltsville Drive, Suite 900, Calverton, MD 20705

James C. Fell: fell@pire.org; Kristina Jones: kjones@pire.org; Eduardo Romano: romano@pire.org; Robert Voas: voas@pire.org

Abstract

Objective—Graduated driver licensing (GDL) systems are designed to reduce the high crash risk of young novice drivers. Almost all states in the United States have some form of a three-phased GDL system with various restrictions in the intermediate phase. Studies of the effects of GDL in various states show significant reductions in fatal crash involvements of 16- and 17-year-old drivers; however, only a few national studies of GDL effects have been published. The objective of this national panel study was to evaluate the effect of GDL laws on the fatal crash involvements of novice drivers while controlling for possible confounding factors not accounted for in prior studies.

Methods—The Fatality Analysis Reporting System (FARS) was used to examine 16- and 17-year-old driver involvement in fatal crashes (where GDL laws are applied) relative to two young driver age groups (19-20, 21-25) where GDL would not be expected to have an effect. Dates when various GDL laws were adopted in the states between 1990 and 2007 were coded from a variety of sources. Covariates in the longitudinal panel regression analyses conducted included four laws that could have an effect on 16- and 17-year-old drivers: primary enforcement seat belt laws, zero-tolerance (ZT) alcohol laws for drivers younger than age 21, lowering the blood alcohol concentration limit for driving to .08, and so-called "use and lose" laws where drivers aged 20 and younger lose their licenses for underage drinking violations.

Results—The adoption of a GDL law of average strength was associated with a significant decrease in fatal crash involvements of 16- and 17-year-old drivers relative to fatal crash involvements of one of the two comparison groups. GDL laws rated as "good" showed stronger relationships to fatal crash reductions, and laws rated as "less than good" showed no reductions in crash involvements relative to the older driver comparison groups.

Conclusions—States that adopt a basic GDL law can expect a decrease of 8 to 14% in the proportion of 16- and 17-year-old drivers involved in fatal crashes (relative to 21- to 25-year-old drivers), depending upon their other existing laws that affect novice drivers, such as those used in these analyses. This finding is consistent with recent national studies that used different outcome measures and covariates. The results of this study provide additional support for states to adopt, maintain, and upgrade GDL systems to reduce youthful traffic crash fatalities.

Keywords

Graduated Driver Licensing (GDL); Fatality Analysis Reporting System (FARS); drivers aged 16-17; national panel study; regression analyses

---

Corresponding author: James C. Fell, Pacific Institute for Research and Evaluation, 11720 Beltsville Drive, Suite 900, Calverton, MD 20705, Phone: 301-755-2746, Fax: 301-755-2799, fell@pire.org.

INTRODUCTION

The Problem

Motor-vehicle crashes are the leading cause of death for young people aged 15 to 20 in the United States, accounting for approximately 35% of their deaths (National Center for Statistics and Analysis [NCSA] 2008). Young drivers aged 15 to 20 make up 8 to 9% of the U.S. population (U.S. Census Bureau 2009) but only about 6 to 7% of the licensed drivers (Federal Highway Administration 2008); however, they are involved in 13 to 14% of the fatal traffic crashes each year (NCSA 2009a). In recent years, between 6,000 and 7,000 young drivers and passengers aged 15 to 20 have been fatally injured in motor-vehicle crashes (NCSA 2009a). In 2000, crashes involving young drivers aged 15 to 20 cost the U.S. economy an estimated $42.3 billion (Blincoe et al. 2002). About 23 to 24% of young drivers (aged 15 to 20) involved in fatal crashes are estimated to have been drinking before their crash (NCSA 2009a). Sixteen-year-old drivers have crash rates that are three times greater than 17-year-olds, five times greater than 18-year-olds, and twice those of drivers aged 85 (McCartt et al. 2003).

Research has indicated that at least four factors play a prominent role in crashes involving young drivers (Masten 2004;Senserrick & Haworth 2004): (1) inexperience, (2) immaturity, (3) risk taking, and (4) greater exposure to risk. Young drivers start out with very little knowledge or understanding of the complexities of driving a motor vehicle. Many young drivers act impulsively, use poor judgment, and participate in high-risk behaviors (Beirness et al. 2004). Teens often drive at night with other teens in the vehicle that substantially increases their risk of a crash (Chen et al. 2000). When these factors are combined with inadequate driving skills, excessive speeds, drinking and driving, distractions from teenaged passengers and electronic devices, and a low rate of safety belt use, crash injury rates accelerate rapidly (Masten 2004; Masten & Chapman 2004; NCSA 2009b).

Efforts to Reduce the Problem

The high crash rate of youthful novice drivers has been recognized for some time. Initially, the official response to that problem was to require a driver education program for high school sophomores as a prerequisite for obtaining a driver's license. Experience demonstrated, however, that universal driver education in the public schools, though providing some driving skills and knowledge, was not effective in reducing crashes (Williams & Ferguson 2004) because it resulted in earlier licensing and increased exposure to crashes for many novice drivers. Without the incentive that the high school driver education program provided, many of these teens would not have obtained a license until it was necessary for employment or college. Thus, many safety officials viewed driver education as counterproductive, and support for it as a mandatory requirement for licensing has declined (Mayhew et al. 1998, 2002; Williams 1996; Williams & Ferguson 2004).

To address the young driver problem, traffic safety officials from several organizations in the United States developed a licensing system that prolongs the learning process for beginning drivers and restricts their driving to less risky conditions. The National Highway Traffic Safety Administration (NHTSA) and the American Association for Motor Vehicle Administrators (AAMVA), with assistance from the Insurance Institute for Highway Safety (IIHS), the National Safety Council (NSC), and the National Transportation Safety Board (NTSB), developed an entry-level licensing program in the United States that gives young beginning drivers more time to learn the complex skills required to drive a motor vehicle (NHTSA 2008).

Over the last two decades, the alternative of extending the period of supervised driving and limiting the novice's exposure to higher-risk conditions, such as nighttime driving, has effectively reduced crash involvements (Williams & Ferguson 2002). Research around the world has shown that the first few months of licensure for young novice drivers entail the highest crash risk (McCartt et al. 2003; Mayhew et al. 2003; Sagberg 1998). This high crash rate of novice drivers in the first few months suggests that restricting driving in situations known to be risky during this initial licensure period is one option for dealing with this vulnerability.

Typically, the graduated driver licensing (GDL) concept requires a supervised learning stage of 6 months or more, followed by an intermediate or provisional license stage of at least several months with restrictions on high-risk driving before a driver "graduates" to full license privileges with no restrictions (third stage). This three-staged national model for GDL has been established to introduce driving privileges gradually to beginning drivers. Under these systems, novice drivers are required to demonstrate responsible driving behavior (no traffic offenses) in each stage before advancing to the next stage. After novice drivers have graduated from supervised driving to independent driving, most GDL systems restrict nighttime driving and the number of teen passengers, among other provisions, until the novice driver is fully licensed (NHTSA 2008).

According to the United States Government Accountability Office (U.S. GAO 2010) and IIHS (2010a), 49 states and the District of Columbia currently have three-staged GDL systems. The IIHS has rated the various GDL systems in the states (IIHS, 2010a). Only 16 states were rated as having "good" GDL systems in 2004, but currently, 35 states are rated as having "good" GDL systems (IIHS, 2010a). Chen, Baker, and Li (2006) found the "good" systems to be most effective, and they noted the gaps and weaknesses of the existing legislation that needed to be addressed. Despite such a general concept and specific guidelines, GDL systems in the United States vary widely, with different states enacting different components aimed to strengthen the GDL program.

Evaluations of GDL Systems

Reviews of the research on GDL systems have been published in various journals (Hedlund & Compton 2004; Hedlund et al. 2006) and in entire special issues of the *Journal of Safety Research* (2003, 2007). Williams and Shults (2010) recently provided a review of and commentary on the latest GDL research. All the reviews indicated that analyses of GDL laws showed they effectively reduced crashes involving some defined group of novice drivers (15-, 16-, 17-, or 18-year-olds, or combinations thereof).

The four national evaluations of GDL programs conducted to date have all reported significant benefits from the implementation of GDL laws. However, the age groups evaluated, the measures used, and the comparison groups of drivers employed have varied substantially between the studies.

Dee, Grabowski, and Morrisey (2005) conducted an econometric panel study of the effect of GDL laws on fatal crash involvements of 15- to 17-year-olds. The study covered the contiguous 48 states over 11 years from 1992 to 2002. They evaluated three levels of GDL laws (good, fair, and marginal). A special feature of their study was the inclusion in the analysis as covariates some eight laws that might be expected to affect young driver fatalities. These covariates included laws such as the .08 blood alcohol concentration (BAC) illegal per se law, the primary enforcement safety belt law, and the zero-tolerance (ZT) law for drivers younger than age 21.

Chen, Baker, and Li (2006), in their national evaluation of GDL programs, found that the presence of a GDL program in a state was associated with a significant decrease in the fatal crash rate of 16-year-old drivers. In their study, they calculated an incidence rate ratio (IRR) for fatal crashes involving 16-year-old drivers in relation to the presence of a GDL program. They found that the presence of GDL was associated with an 11% lower fatal crash involvement rate for 16-year-old drivers. The comparison groups were drivers aged 20 to 24 and 25 to 29. They found reductions of 16 to 21% in the 16-year-old IRR associated with the GDL programs that had five or more of the seven key components to GDL laws. The seven key components are (1) minimum age for a learner's permit; (2) mandatory waiting period before applying for an intermediate license; (3) minimum hours of supervised driving; (4) minimum age for an intermediate license; (5) nighttime restrictions; (6) passenger limitations; and (7) minimum age for full licensing.

In a recent meta-analysis of GDL programs in North America, Vanlaar et al. (2009) found that GDL programs had a significant effect on 16-year-old drivers but not on 17-, 18-, or 19-year-old drivers. Passenger restrictions in the intermediate phase of licensing were also significantly associated with reductions in 16-year-old driver fatality rates.

McCartt and colleagues (2009) from IIHS conducted another national study of GDL laws in the states using methods similar to Chen et al.'s (2006). They found that, compared to GDL systems IIHS had rated as "poor," the states with GDL laws rated as "good" had a 30% lower fatal crash rate among 15- to 17-year-old drivers, and states with GDL systems rated as "fair" had 15- to 17-year-old driver fatal crash rates that were 11% lower.

The four national studies described herein have indicated that GDL reduced fatalities among at least one group of novice drivers and supported the movement in the United States and other countries to enact GDL laws. It is clear, however, that not all versions of the GDL laws were found to be equally effective. Measuring the effectiveness of a new safety program such as GDL is complicated because it must be implemented within preexisting legislation and in an enforcement environment that can moderate the effect on crash injuries and deaths. This issue was particularly salient in the development of support in the 1990s for lowering the per se illegal limit from .10 to .08 BAC. Opponents of that movement focused on research indicating that lowering the BAC to .08 was only effective in the presence of administrative license revocation (ALR) laws (see the General Accounting Office, June 1999, report for a discussion of the issue). This issue of the possible potentiating effect of other laws on novice drivers has not received much attention in the research program supporting the enactment of GDL laws. Three of the four national studies described herein have depended on using a variable representing each of the states or state years as a method of accounting for the legal and enforcement environment within which the GDL law was implemented. These three studies were conducted without examining the effect of any specific laws, such as the zero-tolerance legislation that essentially made it illegal for drivers younger than age 21 to have any alcohol in their systems.

Only the study by Dee, Grabowski, and Morrisey (2005) attempted to measure how the existing traffic safety laws affected the GDL laws. They evaluated the effects of five laws: speed limits, seat belt laws, illegal per se laws, ALR laws, and ZT laws. Dee and colleagues (2005) found a very modest 4.4% reduction in their estimate of the reduction in 15- to 17-year-old driver deaths attributable to GDL when traffic laws, such as speed limits and safety belt laws, were added to their analysis. A substantially larger 17.6% reduction in the deaths attributable to GDL was found when the alcohol-related laws (illegal per se, ALR, and ZT) were added to the analysis. The inclusion of these impaired-driving laws in their fixed effects model reduced their estimate of the percentage of teen lives saved by GDL laws from 6.8 to 5.6%, which was still statistically significant.

NIH-PA Author Manuscript

NIH-PA Author Manuscript

We used a more direct measurement of the effects of GDL laws in the form of a ratio of 16- to 17-year-old drivers relative to older drivers in fatal crashes. Our objective was to investigate the findings of Dee and his colleagues (2005) that other traffic laws affecting the fatal crash rates of novice drivers were not responsible for the reductions in novice driver deaths being attributed to GDL programs. Our study also allowed us to update the 11 years (1992 to 2002) of data evaluated by Dee et al. (2005) that covered only the early years of the application of GDL laws. Our study covered the adoption of GDL laws for 18 years from 1990 to 2007. Finally, we added as a covariate to our study the so-called "use and lose" laws that provide for persons aged 20 and younger apprehended in possession or consumption of alcohol a suspension of their driver's licenses—a key and effective component of the minimum legal drinking age (MLDA) laws (Fell et al. 2009) that Dee and associates did not include in their study.

METHODS

Data Sources

Crash data—As was the case with the four previous national studies, we used data from the Fatality Analysis Reporting System (FARS) with our study covering the years from 1990 to 2007 (NHTSA, 2007). Data on driver crash involvements for three age groups—16- and 17-, 19- and 20-, and 21- to 25-year-olds—were drawn from the FARS for each of the 18 years. The first group (16- and 17-year-olds) was chosen to represent the drivers affected by the GDL law. The second group (19- and 20-year-olds) was selected as a comparison or control for young drivers subject to all of the under age 21 laws related to drinking and drinking-and-driving—but not to GDL. We omitted 18-year-olds to minimize the spillover that any GDL effect might have on that adjacent age group. Finally, we selected the 21- to 25-age group as the youngest set of adults not subject to any of the underage laws but still at an elevated risk of crash involvement.

State GDL laws—Baker, Chen, and Li (2006) graciously provided us with the data on state GDL laws that they used in their study. These data files were modified to incorporate changes in (or modifications to) any of the laws up to the time of our analyses in 2010. We used the IIHS Web site (www.iihs.org), NHTSA's *Digest of State Alcohol-Highway Safety Related Legislation (2004)*, Lexis-Nexis, and other appropriate sources to identify states that passed or upgraded GDL laws and to record the dates when the laws were adopted. NHTSA (2008) reported that 17 states adopted a three-stage GDL system with nighttime restrictions between 1996 and 1999 (California, Delaware, Florida, Georgia, Illinois, Indiana, Iowa, Louisiana, Maryland, Massachusetts, Michigan, New Hampshire, North Carolina, Ohio, Rhode Island, South Carolina, and South Dakota). The periods for the restrictions and the duration of the restrictions varied by state. The remaining 33 states and the District of Columbia did not have a three-stage GDL during that timeframe. These sources provided at least 9 years of post-GDL data (2000 to 2008) for analyses for the states implementing GDL laws by 1999.

Beginning in 2000, 32 states plus the District of Columbia had adopted a three-stage GDL with a nighttime restriction (Alabama, Alaska, Arizona, Arkansas, Colorado, Connecticut, District of Columbia, Hawaii, Idaho, Kansas, Kentucky, Maine, Minnesota, Mississippi, Missouri, Montana, Nebraska, Nevada, New Jersey, New Mexico, New York, Oklahoma, Oregon, Pennsylvania, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, Wisconsin, and Wyoming). Currently, only one state has a three-stage GDL with no nighttime restrictions (Vermont). Finally, the remaining state without a three-stage GDL (as of January 2011) is North Dakota.

Legal and Enforcement Environment Measures

The development and adoption of GDL laws occurred in a legislative environment in which at least four traffic safety laws have been shown to have significant effects on fatal crashes involving underage drivers: (1) upgrading the seat belt law to include primary enforcement (National Highway Traffic Safety Administration 1995; Voas et al. 2000, 2007a) which also served as a surrogate for increased enforcement of all traffic laws; (2) ZT laws that make it illegal for drivers younger than 21 to have any alcohol in their blood system while driving (Voas et al. 2003; McCartt et al. 2007; Fell et al. 2009); (3) lowering the illegal BAC limit for adult drivers to .08 g/dL (Wagenaar et al. 2007); and (4) use and lose laws where persons younger than 21 temporarily lose their driver's licenses for any alcohol violation (possession, purchase, etc.) (Fell et al. 2009). Dee and his colleagues (2005) analyzed the effect of the first three laws, as well as the speed limits and ALR. We chose not to use speed limits since Dee et al. (2005) found that speed limits had only minimally affected the estimated effectiveness of GDL laws. We retained safety belt laws as a covariate, even though Dee et al. (2005) found that they were not significantly related to GDL effectiveness. Since their study (covering 1992 to 2002), a national movement of annual safety belt enforcement and publicity campaigns has played a role in the increased number of states with primary seat belt laws. We believe those laws now have more of a safety effect. We added to Dee's list of policies the use and lose laws to reflect the level of enforcement and deterrent effect of the MDLA laws (Fell et al. 2009).

Data Analyses

A longitudinal panel approach (sometimes called a cross-sectional time-series approach) was used in this study. We initially examined annual FARS data for all 50 states and the District of Columbia from 1990 to 2008. For each state-by-year, the incidence of crashes in each of the three age groups was recorded. The year 2008 was excluded due to unexpected anomalies in the trend data, mainly associated with the U.S. economic recession that caused an abnormal reduction in miles driven and traffic fatalities (Sivak & Schoettle 2010). We combined the state-by-year crash incidences of 16- and 17-year-olds because many state-by-year cells had an incidence rate of zero when these ages were observed separately. The District of Columbia was excluded due to reporting zero crashes among 16- and 17-year-old drivers in more than half of the years observed after the ages were combined. After excluding the District of Columbia, there were no other states-by-year with zero incidences of crashes. We applied a Box and Jenkins (1976) ARIMA (Autoregressive Integrated Moving Average) intervention regression method to evaluate the enactment of a GDL law (the intervention) on the fatal crash incidence among 16-and 17-year-old drivers relative to the two older driver age groups.

Because FARS contains only the population numerator (persons involved in a fatal crash) and no population denominator (number of persons at risk for a fatal crash), a direct comparison of the crash risk before and after the adoption of GDL laws was not possible. The typical approach to this problem is to use population figures to create crash rates for each age group and then compare rates between groups within state years, counting on the state or the year variable to account for factors other than the GDL effect. Dee et al. (2005) used population in their models. In previous studies, we have argued that because of the wide differences in alcohol use between urban and rural and upper and lower socioeconomic groups, the use of population data is not the best approach to the problem. We have taken a different approach using ratios of affected and unaffected cases as in our previous work (Fell et al. 2009). To account for crash exposure, we computed and compared ratios of the 16- and 17-year-old drivers involved in fatal crashes with two older age groups: 19 and 20 and 21 to 25. By using the crash population of 19- and 20-year-olds and 21- to 25-year-olds as proxy denominators for the 16- and 17-year-olds, we believe we controlled for most of the driving exposure elements common to both groups. The ratios were log-transformed to normalize the distribution. All state-by-year cells with less than ten 16-and 17-year-old drivers in fatal crashes were excluded from the analyses to reduce bias introduced by using ratios with small Ns.

Measures of GDL Quality

Three categories of GDL laws were tested: (1) when all the GDL laws present during our study period from 1990 to 2007 were included, we labeled the category as “average”; (2) when only GDL laws rated “good” by the IIHS (2010a) were included, we labeled the category “good”; (3) when only the GDL laws rated “less than good” (i.e., fair, marginal, or poor) by the IIHS (2010) were included, we labeled that category “less than good.” Recall that the IIHS rated a GDL law as good if it had five or more of the following seven components: (1) minimum age for a learner’s permit; (2) mandatory waiting period before applying for intermediate license; (3) minimum hours of supervised driving; (4) minimum age for intermediate license; (5) nighttime restriction; (6) passenger limitation; and (7) minimum age for full licensing. For this categorization, we used the rating given to each state’s GDL law in 2007 by the IIHS. Thus, a GDL law adopted, for example, in 1996 by a state with a rating of good in 2007 was evaluated as a good GDL law in 1996 and thereafter.

Regression models for each age-group ratio were separately performed for the three categories of GDL laws (average, good, and less than good). The ratios of interest (drivers aged 16- and 17-years-old involved in fatal crashes relative to the two other age groups) were then regressed on the GDL laws alone and with each of the four potentially confounding laws individually and finally with all four covariates included in the analysis.

Based on the regression analysis, we calculated the expected reduction in crash involvements based on the GDL law alone and in the presence of one or of all four covariate laws. Using the coefficients resulting from the regression models, we estimated the percentage of reduction in 16- and 17-year-old drivers in fatal crashes following the implementation of the GDL laws. Because the dependent variable was a ratio (16- and 17-year-old drivers in fatal crashes over 19- and 20-year-old drivers and over 21- to 25-year-old drivers in fatal crashes), estimation of the effect of GDL only on 16- and 17-year-old drivers in fatal crashes (the ratio’s numerator) required the ratio’s denominator (19- and 20-year-old drivers and 21- to 25-year-old drivers) to be fixed at some point in time. We used two different approaches to fixing the denominator: (1) the mean annual 19- and 20-year-old drivers and the 21- to 25-year-old drivers over the pre-GDL state/years and (2) the corresponding mean for the post-GDL state/years. The pre-GDL criterion underestimates the percentage of reduction in 16- and 17-year-old driver fatal crash involvements, for it fails to account for the reduction in the 19- to 20-year-old and 21- to 25-year-old driver involvements that have taken place over time. On the other hand, the post-GDL criterion overestimates the percentage of reduction in 16- and 17-year-old drivers in fatal crashes, as it implicitly assumes that the passing of the GDL law is also responsible for the observed reduction in the 19- to 20-year-old driver involvements and the 21- to 25-year-old driver involvements. We present both extremes here.

RESULTS

Table 1 shows the total number of fatal crash involvements for each driver age group used in the analyses. Although these numbers are very large, they quickly diminish when state-by-year analyses are performed. These diminishing numbers are why we combined 16- and 17-year-old drivers into one group in our analyses. Table 2 presents the regression results for the three classifications of GDL laws we studied (states with average laws, states with good laws, and states with less-than-good laws). Table 2 shows the following results:

1. The adoption of an average GDL law considered alone was associated with a reduction in both the 16–17/19–20 age and the 16–17/21–25 age fatal crash ratios.
2. This was also true when an average GDL law was considered in the presence of each of the four legal environment laws individually or in the presence of all four laws together.
3. The strength of the relationship of good GDL laws to reductions in the ratios (reflecting reductions in fatal crash incidence) is slightly greater than for average GDL laws.
4. The evidence for the effectiveness of less-than-good GDL laws is mixed. Such laws were not significant in the contrast between the two underage groups. For the 16–17/21–25 age comparison GDL laws significantly reduced the ratio only when considered alone. In the presence of the covariates, this effect disappeared.
5. When analyzed in the presence of one or in the presence of all four covariates, the relationship of the reduction in the ratios was smaller than when GDL was considered alone, but was still significant.
6. The one exception to item 5 was the presence of a ZT law that appeared to enhance the extent to which the GDL law reduced the 16- and 17-year-old fatal crash involvements.

Table 3 shows the estimated percentage of reduction in mean proportion of 16- and 17-year-olds involved in fatal crashes for GDL laws alone, in the presence of each of the four legal environment laws individually, and in the presence of all four laws combined. All reflect reductions in 16- and 17-year-old driver crash involvements. For Table 3, as in Table 2, the reductions attributable to GDL laws are slightly reduced in the presence of the legal environment covariates that absorb some of the reductions that would otherwise be attributed to GDL. Again, the presence of the ZT law appears to be associated with an enhanced effect of the GDL law.

GDL laws produce modest but significant reductions in the fatal crash rates of 16- and 17-year-old drivers. States that adopt a basic GDL law can expect a decrease of 8 to 14 percent in the proportion of 16- and 17-year-old drivers involved in fatal crashes (relative to 21- to 25-year-old drivers), depending upon the other existing laws that affect novice drivers, such as those used in these analyses. These reductions are not dependent on the presence of other traffic safety or underage drinking laws. The more GDL components included, however, the more effective these seven key components will be in reducing novice driver fatal crashes. Incomplete applications of the 7 key components in the GDL laws may have limited or no effect.

DISCUSSION

This national panel study indicates that the adoption of an average GDL law was associated with a significant decrease in fatal crash involvements of 16- and 17-year-old drivers (under GDL restrictions) relative to involvements of their closest peer group, 19- and 20-year-old drivers (who were not subject to GDL restrictions), but were subject to the same underage drinking and underage drinking-and-driving laws. GDL laws were even more effective in reducing 16- and 17-year-old driver involvements in fatal crashes relative to adults aged 21 to 25 who were not subject to GDL, underage drinking, or underage drinking-and-driving laws. Our results appear to confirm those of Dee, Grabowski, and Morrisey (2005): that the benefits of GDL, though varying somewhat within the legal environment in which the laws are implemented, are not dependent on the existence of other traffic or underage drinking laws.

Our analysis does suggest, however, that the strength of the effect of GDL laws varies with their comprehensiveness or quality. The data from Table 2 indicate that good GDL laws based on the IIHS rating system (IIHS 2010b) produced greater reductions in the fatal crash ratios than did the average GDL laws. Conversely, our analysis of the effectiveness of the less-than-good laws found that (with one small exception) they did not appear to be effective in reducing 16- and 17-year-old driver fatal crashes. This finding of limited effectiveness of less-than-good GDL laws agrees with the results of Chen et al. (2006) and McCartt et al. (2010). It should be noted, however, that the effectiveness of GDL laws varies with the extent to which its key components are implemented. Thus, the strength of the GDL laws provides additional evidence for their effectiveness. Nevertheless, the limited effectiveness of the less-than-complete GDL laws should not discourage enacting such limited provisions. Limited GDL laws may act as a stepping stone to the development of stronger legislation. In any case, the demonstrated benefit of GDL laws with most of the seven major components should encourage legislation (e.g., the STANDUP Act 2011) and amendments to current legislation to create more comprehensive GDL laws in the states.

Three of the legal environment laws (primary seat belt, .08 BAC illegal per se, and use and lose) were somewhat collinear, and when analyzed concurrently with GDL laws, the combination of these laws reduced GDL’s measured effect on 16- and 17-year-old fatal crash involvements. However, the analysis of GDL in combination with the ZT law strengthened GDL’s measured relationship with crash involvements. Although we could not determine the reason for this relationship, this result likely occurred because states that produced early and strong ZT laws (before the federal legislation essentially mandating them) were also more likely to enact strong GDL laws. Another possible reason for the ZT law effect is that it may represent a surrogate measure of enforcement of youthful drivers, especially novice drivers. Whatever the reason, Dee et al. (2005) found an effect of ZT similar to ours.

A significant problem in evaluating GDL laws that primarily affect crash involvements of 16- and 17-year-olds is accounting for the influence of general changes in the legal, roadway, and vehicle environment in which the GDL laws have been implemented. Aside from using population rates, most studies have attempted to compare the rates for the 16- and 17-year-old cohorts to which GDL regulations apply to the rates of older drivers not affected by GDL laws. A limitation in this approach is illustrated in Figure 1, which presents the trends in fatal crash involvements for the three age groups included in this study. As displayed in Figure 1, crash frequency declined for the 16–17 and 21–25 age groups but not for the 19 to 20 age group. In this study, we compensated for changes in crash frequency of the two comparison groups by using the crash ratio measure and by including a time (year) variable in our regression analysis. To ensure a conservative estimate of the public health benefits of GDL, we based our crash reduction benefits (Table 4) on the pre-GDL period to avoid incorporating the lower denominator produced by the reduction in 20 to 25 age group crash rates. The effect of the downward trend in the crash rates of the 21- to 25-year-old drivers is illustrated in Table 4, which shows the estimated percentage of reductions in 16- and 17-year-old fatal crashes assuming no change versus the actual observed change in the 16–17/21–25 ratio. The no-change estimate for the average GDL law (6.9%) is similar to the value (6.8%) reported by Dee et al. (2005) for the analysis of GDL laws alone. However, when Dee and colleagues introduced alcohol safety laws into their study, the reduction was decreased to 5.8%.

Limitations

Some of the limitations in this study include:

- A number of the sample sizes for 16- and 17-year-old driver involvements in fatal crashes in the state-by-year analyses were small, increasing the year-to-year variance in the ratios of fatal crashes for age groups. This may have accounted for some statistically insignificant findings. It would have been advantageous to have state crash files for 1990 to 2007 for all states and the District of Columbia because these files include crashes of all severities (fatal and nonfatal). Consequently, these files would have a larger number of cases that would have increased the power of this study. Although we used covariates accounting for the existence in the states of primary seat belt laws, ZT laws, .08 BAC per se laws, and use and lose laws (Fell et al. 2009) that could have had an effect on 16- and 17-year-old driver involvements in fatal crashes, there certainly may have been other factors in specific states that could also have had an effect on these young drivers. These effects include (a) traffic enforcement intensity of GDL restrictions by police, (b) publicity surrounding GDL laws, and (c) parental influence on driving restrictions, to mention a few. Measures for these factors were not readily available at the state level.
- Use of fatality ratios is a well-known technique to control for changes in crash exposure over time (i.e., Voas et al. 2007b; Romano et al. 2008). This approach, however, only adjusts for changes that similarly affect both the numerator and denominator (i.e., the 16- and 17-year-olds as well as older age groups). Changes in crash exposure that occur differently across age groups may not have been fully accounted for by this approach. Our adult (aged 21 to 25) comparison group exhibited a large reduction in crash involvements over the period of our study. The use of a crash ratio and a time trend in the analysis may not have fully compensated for the adult trend.
- Because we relied on fatal crash ratios to account for changes in crash exposure, we could not use the driver as the unit of analysis. By aggregating data (i.e., by using state/year as the unit of analysis), we were forced to leave some potentially relevant explanatory variables out of our models. The role of variables, such as gender or race/ethnicity, were not considered in this study.
- We used the IIHS GDL grades from September 2007, the last year included in our time-series analysis, to categorize the GDL law for each year an individual state had a GDL law on the books. Thus, our results specific to these grades are the most conservative we could have provided. This is because states improve their GDL laws over time, if they change at all. We did not see any weakening of the GDL laws. For example, from 2007 to 2008, the IIHS GDL grade changed for one state (Minnesota), improving from “M” (marginal) to “G” (good). Given this trend, the effect of G laws compared to non-G laws may be underestimated in our results, but this was the most conservative way to handle these particular data.

Despite the limitations inherent to the use of crash ratios computed over an aggregated unit of analyses, we believe that the control in crash exposure provided by those ratios (and the consequent reduction in bias) more than compensates for the limitations described herein.

CONCLUSIONS

GDL laws produce modest but significant reductions in the fatal crash rates of 16- and 17-year-old drivers. States that adopt a basic GDL law can expect a decrease of 8 to 14% in the proportion of 16- and 17-year-old drivers involved in fatal crashes (relative to 21- to 25-year-old drivers), depending upon their other existing laws that affect novice drivers, such as those used in these analyses. These reductions are not dependent on the presence of other traffic safety or underage drinking laws. The more GDL components included, however, the more effective these seven key components will be in reducing novice driver fatal crashes. Incomplete applications of the seven key components in the GDL laws may have limited or no effect.

Although 49 states in the United States have adopted a three-phased GDL program, the elements or components within each phase adopted by states vary considerably (IIHS 2010b). State GDL laws vary in the age drivers are allowed to enter a GDL program, the provisions included in the GDL program, and the way GDL laws are enforced. For instance, some states allow individuals aged 15 to enter the GDL program, and in other states, individuals must wait until they are aged 16. Many states include restrictions on unsupervised nighttime driving and on unsupervised driving with other teen passengers in the second GDL phase when the novice begins to drive alone, but these restrictions vary considerably. States have also enacted GDL laws under a primary or secondary enforcement (i.e., secondary enforcement means that police must stop drivers for other violations before enforcing GDL laws). Many states require a minimum of 50 hours of on-the-road practice with an adult driver in the beginning stage before the driver graduates to the second stage, whereas other states vary substantially in the hours required (e.g., 0, 20, 30, 40, 60). Such a myriad of components has not been fully examined nor has their effect on motor-vehicle crashes been fully evaluated. After a thorough review of GDL systems in the states, the GAO in the United States concluded: "… officials identified several challenges to improving state teen driver safety programs, such as difficulty in enacting and enforcing teen driver safety laws, limited resources to implement a teen driver safety program, limited access to standardized driver education, and difficulties involving parents as their teens learn to drive, among others" (U.S. GAO 2010). Thus, while it appears that GDL systems work to reduce fatal crash involvements of young novice drivers, more research is needed on the effects of the various components of GDL systems in the United States and other countries around the world not covered in this study."

Acknowledgments

This study was funded under grant number 1R21HD056344 from the National Institute of Child Health and Human Development (NICHD). Dr. Michael Spittel was the Federal Project Officer.

The authors extend their appreciation to Dr. Susan Baker, Dr. Li-Hui Chen, and Dr. Guohua Li for their gracious cooperation in providing their GDL data base to use for updating and data analyses. We also thank Pedro Torres for his initial data-processing services. Finally, a special thanks to Alma Lopez and Stephanie Stevens for their editing and formatting services.

References

Special Issue: Graduated Driver Licensing. J Safety Res. 2003; 34:125.

Special Issue: Novice Teen Driving: GDL and Beyond – Research Foundation for Policy and Practice Symposium. J Safety Res. 2007; 38:266.

Baker, SP.; Chen, LH.; Li, G. National Evaluation of Graduated Driver Licensing Programs (DOT HS 810 614). U.S. Department of Transportation, National Highway Traffic Safety Administration; Washington, DC: 2006.

Beirness, DJ.; Mayhew, DR.; Simpson, HM.; Desmond, K. The Road Safety Monitor 2004: Young Drivers. Traffic Injury Research Foundation; Ottawa, Ontario, Canada: 2004.

Blincoe, LJ.; Seay, A.; Zaloshnja, E., et al. The Economic Impact of Motor Vehicle Crashes, 2000 (DOT HS 809 446). U.S. Department of Transportation, National Highway Traffic Safety Administration; Washington, DC: 2002.

Box, GEP.; Jenkins, GM. Time Series Analysis: Forecasting and Control. Holden-Day, Inc; San Francisco, CA: 1976. Revised

Chen LH, Baker SP, Braver ER, Li G. Carrying Passengers as a Risk Factor for Crashes Fatal to 16- and 17-Year-Old Drivers. J Am Med Assoc. 2000; 283:1578–1582.

Chen LH, Baker SP, Li G. Graduated Driver Licensing Programs and Fatal Crashes of 16-Year-Old Drivers: A National Evaluation. Pediatr. 2006; 118:56–62.

Dee TS, Grabowski DC, Morrisey MA. Graduated Driver Licensing and Teen Traffic Fatalities. J Health Econ. 2005; 24:571–589. [PubMed: 15811544]

Federal Highway Administration. By Sex and Percentage in Each Age Group and Relation to Population. U.S. Department of Transportation, Federal Highway Administration; Washington, DC: 2008. Distribution of Licensed Drivers—2008. Last, 2010. Available at: http://www.fhwa.dot.gov/policyinformation/statistics/2008/pdf/dl20.pdf

Fell JC, Fisher DA, Voas RB, Blackman K, Tippetts AS. The Impact of Underage Drinking Laws on Alcohol-Related Fatal Crashes of Young Drivers. Alcohol Clin Exp Res. 2009; 33:1208–1219. [PubMed: 19389192]

General Accounting Office. Report to Congressional Committees on Highway Safety: Effectiveness of State .08 Blood Alcohol Laws. (GAO/RCED-99-179). U.S. General Accounting Office; Washington, DC: 1999 Jun.

Hedlund J, Compton R. Graduated Driver Licensing Research in 2003 and Beyond. J Safety Res. 2004; 35:5–11. [PubMed: 14992841]

Hedlund JH, Shults RA, Compton R. Graduated Driver Licensing and Teenage Driving Research in 2006. J Safety Res. 2006; 37:107–121. [PubMed: 16564541]

Insurance Institute for Highway Safety. Licensing Ages and Graduated Licensing Systems. IIHS; Arlington, VA: 2010a. Available at: http://www.iihs.org/laws/graduatedlicenseintro.aspx

Insurance Institute for Highway Safety. Licensing Systems for Young Drivers. IIHS; Arlington, VA: 2010b. Available at: http://www.iihs.org/laws/graduatedlicenseintro.aspx

Masten, SV. Teenage Driver Risks and Interventions. Research Report No. 207. California Department of Motor Vehicles; Sacramento, CA: 2004.

Masten SV, Chapman EA. The Effectiveness of Home-Study Driver Education Compared to Classroom Instruction: The Impact on Student Knowledge and Attitudes. Traffic Inj Prev. 2004; 5:117–121. [PubMed: 15203946]

Mayhew DR, Simpson HM, Pak A. Changes in Collision Rates among Novice Drivers During the First Months of Driving. Accid Anal Prev. 2003; 35:683–691. [PubMed: 12850069]

Mayhew DR, Simpson HM, Robinson A. The Safety Value of Driver Education and Training. Inj Prev. 2002; 8:ii3–8. [PubMed: 12221024]

Mayhew DR, Simpson HM, Williams AF, Ferguson SA. Effectiveness and Role of Driver Education and Training in a Graduated Licensing System. J Public Health Policy. 1998; 19:51–67. [PubMed: 9581430]

McCartt AT, Blackman K, Voas RB. Implementation of Washington State's Zero Tolerance Law: Patterns of Arrests, Dispositions, and Recidivism. Traffic Inj Prev. 2007; 8:339–345. [PubMed: 17994486]

McCartt AT, Shabanova VI, Leaf WA. Driving Experience, Crashes and Traffic Citations of Teenage Beginning Drivers. Accid Anal Prev. 2003; 35:311–320. [PubMed: 12643948]

McCartt, AT.; Teoh, ER.; Fields, M.; Braitman, KA.; Hellinga, LA. Graduated Licensing Laws and Fatal Crashes of Teenage Drivers: A National Study. Insurance Institute for Highway Safety; Arlington, VA: 2009.

McCartt AT, Teoh ER, Fields M, Braitman KA, Hellinga LA. Graduated Licensing Laws and Fatal Crashes of Teenage Drivers: A National Study. Traffic Inj Prev. 2010; 11:240–248. [PubMed: 20544567]

National Center for Statistics and Analysis. Traffic Safety Facts: 2008 Data - Young Drivers (DOT HS 811 169). National Highway Traffic Safety Administration; Washington, DC: 2009a.

National Center for Statistics and Analysis. Traffic Safety Facts: Fatal Crashes Involving Young Drivers. (DOT HS 811 218). National Highway Traffic Safety Administration; Washington, DC: 2009b.

National Center for Statistics and Analysis. Traffic Safety Facts: Motor Vehicle Traffic Crashes as a Leading Cause of Death in the United States, 2005. Washington, DC: National Highway Traffic Safety Administration; 2008. Report No.: DOT HS 810 936

National Highway Traffic Safety Administration. National Safety Belt Usage Rates: A Population-Weighted Aggregate of State Reported Usage Traffic Safety Programs. (Final Report). National Highway Traffic Safety Administration; Washington, DC: 1995.

National Highway Traffic Safety Administration. Fatality Analysis Reporting System (FARS). U.S. Department of Transportation [online database of traffic fatalities]; 2007. Available at: ftp://ftp.nhtsa.dot.gov/fars/

National Highway Traffic Safety Administration. Traffic Safety Facts, Law: Graduated Licensing System. (DOT HS 810 888W). National Highway Traffic Safety Administration; Washington, DC: 2008.

National Highway Traffic Safety Administration. Digest of State Alcohol-Highway Safety Related Legislation, 21st Edition (DOT HS 809 435). U.S. Department of Transportation; Washington, DC: 2004.

Romano E, Kelley-Baker T, Voas RB. Female Involvement in Fatal Crashes: Increasingly Riskier or Increasingly Exposed? Accid Anal Prev. 2008; 40:1781–1788. [PubMed: 18760108]

Sagberg, F. Month-by-month changes in accident risk among novice drivers. Paper presented at the 14th International Congress of Applied Psychology; Washington, DC: American Psychological Association; 1998.

Senserrick, T.; Haworth, N. Young driver research: Where are we now? What do we still need to know?. Road Safety Research, Policing, and Education Conference; 2004; Perth, Australia/ Clayton, Victoria, Australia: Monash University; 2004. p. 13

Sivak, M.; Schoettle, B. Toward Understanding the Recent Large Reduction in U.S. Road Fatalities (UMTRI-2010-12). University of Michigan, Transportation Research Institute; Ann Arbor, MI: 2010.

STANDUP Act. Safe Teen and Novice Driver Uniform Protection Act (H.R. 1895/S. 3269). Washington, DC: 2011. saferoads4teens.orgAvailable at: http://www.saferoads4teens.org/standup-act

U.S. Census Bureau. National Population. U.S. Census Bureau; 2009. Last, 2010. Available at: http://www.census.gov/

U.S. Government Accountability Office. Report to the Committee on Transportation and Infrastructure and Its Subcommittee on Highways and Transit, House of Representatives. (GAO-10-544). U.S. Government Accountability Office; Washington, DC: 2010. Teen Driver Safety, Additional Research Could Help States Strengthen Graduated Driver Licensing Systems.

Vanlaar, W.; Mayhew, D.; Marcoux, K.; Wets, G.; Brijs, T.; Shope, J. An Evaluation of Granduated Driver Licensing Programs in North America. Traffic Injury Research Foundation; Ottawa, ON: 2009.

Voas RB, Fell JC, Tippetts AS, Blackman K, Nichols J. Impact of Primary Safety Belt Laws on Alcohol-Related Front-Seat Occupant Fatalities: Five Case Studies. Traffic Inj Prev. 2007a; 8:232–243. [PubMed: 17710712]

Voas RB, Tippetts AS, Fell J. Assessing the Effectiveness of Minimum Legal Drinking Age and Zero Tolerance Laws in the United States. Accid Anal Prev. 2003; 35:579–587. [PubMed: 12729821]

Voas RB, Tippetts AS, Fell JC. The Relationship of Alcohol Safety Laws to Drinking Drivers in Fatal Crashes. Accid Anal Prev. 2000; 32:483–492. [PubMed: 10868751]

Voas RB, Tippetts AS, Romano E, Fisher DA, Kelley-Baker T. Alcohol Involvement in Fatal Crashes under Three Crash Exposure Measures. Traffic Inj Prev. 2007b; 8:107–114. [PubMed: 17497512]

Wagenaar A, Maldonado-Molina M, Ma L, Tobler A, Komro K. Effects of Legal BAC Limits on Fatal Crash Involvement: Analyses of 28 States from 1976 through 2002. J Safety Res. 2007; 38:493–499. [PubMed: 18023634]

Williams, AF. Magnitude and Characteristics of the Young Driver Crash Problem in the United States. In: Simpson, HM., editor. New to the Road: Reducing the Risks for Young Motorists. Youth Enhancement Service, Brain Information Service, UCLA School of Medicine; 1996. p. 19-25.

Williams AF, Ferguson SA. Rationale for Graduated Licensing and the Risks It Should Address. Inj Prev. 2002; 8:ii9–ii13. [PubMed: 12221025]

Williams AF, Ferguson SA. Driver Education Renaissance? Inj Prev. 2004; 10:4–7. [PubMed: 14760019]

Williams AF, Shults RA. Graduated Driver Licensing Research, 2007-Present: A Review and Commentary. J Safety Res. 2010; 41:77–84. [PubMed: 20497792]

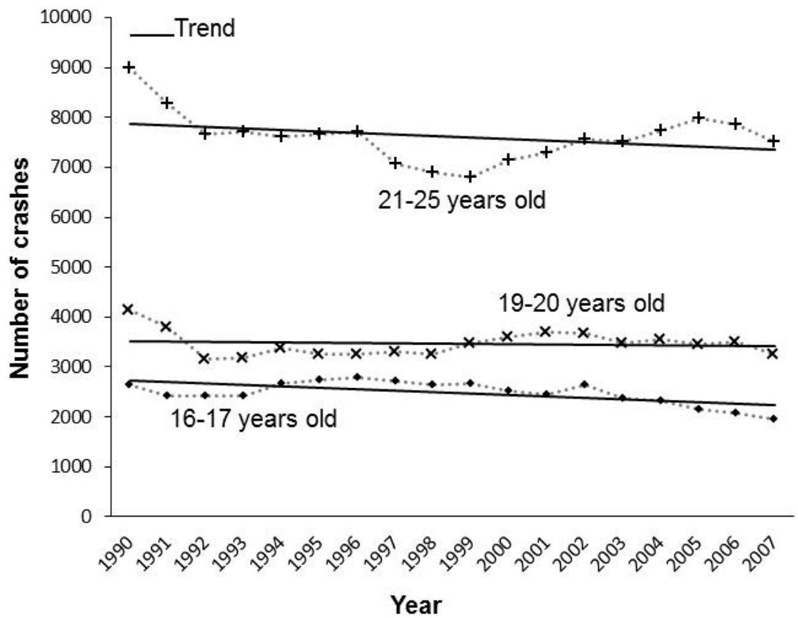

Figure 1.
Fatality Analysis Reporting System data, 50-state total crash involvement by age group, years 1990–2007

Table 1

Fatality Analysis Reporting System sample sizes (N) for age groups used in analysis of GDL laws

Ages	Years	N[a] (Drivers involved in fatal crashes)
16–17	1990–2007	43,499
19–20	1990–2007	60,922
21–25	1990–2007	133,560

[a]Total for 50 states; state-years with Ns <10 excluded.

Table 2

Estimated percentage of reduction in mean proportion of 16- and 17-year-old drivers[a] involved in fatal crashes attributed to the adoption of GDL laws alone, and to GDL laws in the presence of selected covariates.

Effect measured	% change with "Any" GDL law		% change with only "Good" GDL law	
	Calculation 1[c]	Calculation 2[d]	Calculation 1[c]	Calculation 2[d]
GDL law alone	10.2	27.6	9.9	27.3
GDL law with all covariates	6.8	24.8	9.0	26.6
GDL law with primary seat belt law (SB)[b]	7.7	25.5	7.7	25.5
GDL law with zero tolerance law (ZT)[b]	11.1	28.3	12.7	29.6
GDL law with .08 BAC limit law (.08)[b]	7.6	25.4	8.4	26.1
GDL law with use & lose law[b]	9.3	26.8	8.4	26.1

[a]Age ratio used for estimate: 16–17/21–25.

[b]SB=states with primary enforcement seat belt laws; ZT=states with laws for zero tolerance of any alcohol for drivers <21 years in which drivers' license is forfeited; .08=states with a blood alcohol concentration legal limit of .08 g/dL for all drivers; Use & Lose=states with laws in which persons <21 years caught with alcohol in any situation lose their driver's license.

[c]Calculation performed assuming no change in ratio denominator (16–17/21–25) pre- and post-passage of GDL laws.

[d]Calculation performed using actual change in ratio denominator (16–17/21–25) pre- and post-passage of GDL laws.

Table 3

Coefficients from time-series regression models testing the effects of the passage of GDL laws[a] on the variance of age group ratios. Coefficients indicate variance attributable to GDL laws alone and in the presence of selected covariates.

Age ratio	Model	Any GDL law[a]		Good GDL laws[a]		< Good GDL laws[a]	
		coeff	P	coeff	P	Coeff	P
16–17/19–20	GDL alone	−0.089	0.0001	−0.112	0.0003	−0.061	0.1016
	GDL with all covariates	−0.081	0.0057	−0.123	0.0012	−0.010	0.8320
	GDL with SB[b]	−0.065	0.0058	−0.094	0.0018	−0.030	0.4369
	GDL with ZT[b]	−0.117	<.0001	−0.144	<.0001	−0.070	0.1207
	GDL with .08 limit[b]	−0.077	0.0054	−0.110	0.0034	−0.010	0.8134
	GDL with Use & Lose[b]	−0.078	0.0011	−0.099	0.0017	−0.047	0.2282
16–17/21–25	GDL alone	−0.108	<.0001	−0.104	0.0018	−0.120	0.0052
	GDL with all covariates	−0.070	0.0265	−0.094	0.0186	−0.027	0.6095
	GDL with SB[b]	−0.080	0.0028	−0.080	0.0196	−0.088	0.0458
	GDL with ZT[b]	−0.118	<.0001	−0.136	0.0003	−0.075	0.1456
	GDL with .08 limit[b]	−0.079	0.0085	−0.088	0.0257	−0.052	0.2740
	GDL with Use & Lose[b]	−0.097	0.0003	−0.088	0.0106	−0.117	0.0102

[a]Three levels of GDL laws were tested: “Any,” “Good,” and “< Good.” GDL laws were rated by the by the IIHS as good, fair, marginal or poor, in descending order. “Any” refers to all GDL laws regardless of rating. “Good” refers to only GDL laws rated good. “<Good” refers to GDL laws in which those rated good were excluded from analysis.

[b]SB=states with primary enforcement seatbelt laws; ZT=states with laws for zero tolerance of any alcohol for drivers <21 years in which driver’s license is forfeited; .08=states with a blood alcohol concentration legal limit of .08 g/dL for all drivers; Use & Lose=states with laws in which persons <21 years caught with alcohol in any situation forfeit their driver’s license.

NIH-PA Author Manuscript
NIH-PA Author Manuscript

Table 4

Coefficients from time-series regression models testing the effects of the passage of selected covariates on the variance of age group ratios.[a]

Ratio	Primary seat belt law (SB[b] alone		Zero-tolerance law (ZT)[b] alone		.08 BAC limit law (.08)[b] alone		Use & Lose[b] law alone	
	Coeff	**P**	**coeff**	**P**	**coeff**	**P**	**Coeff**	**P**
16–17/ 19–20	−0.164	<.0001	−0.013	0.6113	−0.065	0.0082	−0.080	0.0139
16–17/ 21–25	−0.208	<.0001	−0.046	0.0660	−0.101	0.0001	−0.094	0.0075

[a] Includes state-years with GDL laws of any IIHS rating and/or no GDL law.

[b] SB=states with primary enforcement seatbelt laws; ZT=states with laws for zero tolerance of any alcohol for drivers <21 years in which driver's license is forfeited; .08=states with a blood alcohol concentration legal limit of .08 g/dL for all drivers; Use & Lose=states with laws in which persons <21 years caught with alcohol in any situation lose their driver's license.