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Graduated driver licensing in the United States: evaluation results from the early programs

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Abstract

Background: Seventeen states enacted graduated driver licensing (GDL) programs that were implemented from 1996 through 1999 and for which evaluations are of interest. *Methods*: We received evaluation results reported for six states for which data were available. Summarizing results is difficult in other than the most global terms because of differences in pre-GDL programs, differences in GDL programs, and differences in evaluation methodology. *Results*: All states identified some crash reduction among teen drivers following GDL implementation. This positive effect was observed across different geographic regions, and with different GDL programs. Simple counts are down—fewer teens are experiencing crashes and becoming injured. After calculating crash rates to adjust for changes over time in populations or licensed drivers, reductions generally were still found. Population-adjusted risks of injury/fatal crash involvement of 16-year-old drivers in Florida and Michigan were reduced by 11% and 24%, respectively. Population-adjusted risks of any crash involvement of 16-year-old drivers in Michigan and North Carolina were reduced by 25% and 27%, respectively. Reductions in night (restricted hours) crash risk were impressive in Florida, Michigan, and North Carolina. A comparison state design was only possible in the Florida evaluation, and results showed greater crash reductions under GDL. Change-point analyses of Michigan's crash data trends over time provided additional support of GDL's effectiveness in reducing crashes. *Discussion*: Taken as a whole, and including the preliminary findings from California, Ohio, and Pennsylvania, these reports demonstrate the early effectiveness of GDL in reducing the crash risk of teen drivers. The impact of these studies and others to come will guide future research, practice, and policy.

Keywords: Graduated driver licensing; United States; Crash risk; Novice young drivers

1. Background

Unintentional injury from motor vehicle crashes is the number one cause of death among teenagers in the United States (Centers for Disease Control and Prevention, 1997; National Highway Traffic Safety Administration, NHTSA, 2002). Crash rates among young drivers age 16–19, per mile driven, are higher than those for all other age groups (Insurance Institute for Highway Safety [IIHS], 2000a) and the crash risk among 16- to 17-year-old drivers is almost three times as high as among 18- to 19-year-old drivers (IIHS, 2000b). Yet, obtaining driver licensure in the United States has been allowed at young ages and after only minimal classroom education and behind-the-wheel training.

The concept of graduated driver licensing (GDL) allows young novice drivers to gain experience and maturity under conditions of low risk before progressing to more risky driving situations. GDL addresses youthful risk taking (that may result in traffic violations or crashes) by limiting access to driving privileges and providing serious consequences, such as curtailed license privileges, for driving infractions.

Although a comprehensive approach to GDL for young novice drivers was proposed as early as the 1970s (Waller, 1977), only recently has the concept gained widespread acceptance in the United States, with many of the legislative initiatives for GDL having been undertaken in the late 1990s. Thirty-seven states in the United States and the District of Columbia have now adopted a three-level GDL system for new beginning drivers (Williams & Mayhew, 2002), and 47 states and the District of Columbia have one or more elements of GDL (IIHS, 2002). This article focuses on the states that have had a comprehensive GDL program in place long enough to evaluate, and for which at least preliminary evaluation results are available.

As Table 1 shows, 17 states enacted GDL programs that were implemented fairly early, from 1996 through 1999

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Table 1
States with GDL programs effective before 2000

State	GDL effective date	Evaluation result citation
Florida	7/1/96, amended 2000	Ulmer et al. (2000)
Michigan	4/1/97	Elliott and Shope (2003) and Shope et al. (2001)
Georgia	7/1/97, amended 2001	
North Carolina	12/1/97	Foss et al. (2001)
Illinois	1/1/98	
Louisiana	1/1/98, amended 2001	
New Hampshire	1/1/98	
California	7/1/98	Automobile Club of Southern California (2001) and Smith et al. (2001)
Massachusetts	11/4/98	
Iowa	1/1/99	
Nebraska	1/1/99	
Ohio	1/1/99	Office of the Governor's Highway Safety Representative (2001)
Rhode Island	1/1/99	
Colorado	7/1/99	
Delaware	7/1/99	
Maryland	7/1/99	
Pennsylvania	12/22/99	Commonwealth of Pennsylvania Department of Transportation (2002) and Nissley (2001)

Effective dates based on personal communication from Allan Williams (October 2002).

(Williams, 2002). Three of these (Florida, Georgia, and Louisiana) were amended more recently to strengthen their programs. Of the 17 states, evaluation results were available from Florida, Michigan, North Carolina, Louisiana (discussed in David Preusser's article and not included further herein), California, Ohio, and Pennsylvania. Some of these results have been published in peer-reviewed journals and can be considered fairly solid findings, while others remain quite preliminary.

Table 2 shows the key features of the GDL programs of the six states for which evaluation results will be discussed and summarized. As can be seen from Table 2, four states have a learner's stage lasting 6 months (California, Michigan, Ohio, and Pennsylvania); Florida and North Carolina require a 12-month learner's stage. The minimum age for attaining a learner's stage license ranges from 14 years, 9 months in Michigan to 16 years in Pennsylvania (with California, Florida, and North Carolina at 15, and Ohio at 15 years, 6 months). Fifty hours of supervised driving are required in the learner's stage by all these states except North Carolina. Florida's requirement was not added until October 2000 (IIHS, 2002). In Pennsylvania, the supervised practice can occur at any time, while in California, Florida, Michigan, and Ohio, 10 of the hours must occur at night. The minimum age for attaining the intermediate stage is 16 in all states except Pennsylvania, where it is 16 years, 6 months. All states have a night driving restriction in the intermediate stage, although the hours vary. North Carolina's restriction begins at 9:00 p.m., Florida's and Pennsylvania's at 11 p.m. (for 16-year-olds), California's and Michigan's at midnight, and Ohio's at 1 a.m. Only California and North Carolina have enacted passenger restrictions, with implementation to begin in January of 2003 and December of 2002, respectively. Driver education is required of license applicants under age 18 in California, Michigan, and Ohio. In Michigan, two segments of driver education are required; the first segment prior to the learner's stage and the second prior to the intermediate stage. All these states have requirements for crash/conviction-free periods before young licensees can progress to the next stage (Williams & Mayhew, 2002).

2. Methods

Typically, evaluations of GDL programs have used state crash data to determine the effect of the new GDL program on crashes, comparing crashes after the program to crashes before the program. Few evaluations have been able to include more than a year or two of data before and after program implementation, although a longer series would be desirable. Usually, a crash rate is determined based on the number of licensed drivers in the age group of interest, or based on the size of the state's population in the age group of interest. All crashes have been considered, as well as various subtypes of crashes (fatal, injury, property damage only, single or multiple vehicles) and the time of day of crashes. Changes in conviction rates have yet to be reported. There are many complexities and challenges in evaluating GDL programs, not the least of which are the availability of accurate, complete, and usable traffic records, and committed resources to conduct an evaluation. It is also essential that a considerable time elapse (often at least a year) before new young drivers have worked their way through and are fully affected by a new GDL system, and comparisons involving an adequate length of independent driving before and after GDL can be made. Careful consideration must be given to the state's pre- and postprogram characteristics so that the outcomes being evaluated can be directly compared as accurately as possible. Statistical adjustments must also be made to account for trends in the general population of drivers in a state where traffic safety laws or enforcement levels may have changed over time.

Summarizing GDL evaluation results is difficult to do in other than the most global terms because of differences in pre-GDL young driver programs, differences in GDL programs, and differences in the methodology used to assess changes following GDL. For these reasons and others, direct comparisons among states' evaluation results are problematic. Their GDL programs include different components, and different requirements for progression through the

Table 2
Characteristics of GDL programs in Florida, Michigan, North Carolina, Ohio, and Pennsylvania

State	Learner stage			Intermediate stage		
	Minimum age	Holding period	Supervised driving	Minimum age	Night restriction	Passenger restriction
Florida	15 years	12 months	50 hours, 10 of which must be at night	16 years	11 p.m. to 6 a.m. (age 16) 1 a.m. to 5 a.m. (age 17)	none
Michigan[a]	14 years, 9 months	6 months	50 hours, 10 of which must be at night	16 years	midnight to 5 a.m.	none
North Carolina	15 years	12 months	none	16 years	9 p.m. to 5 a.m.	no more than 1 passenger (family members exempted); if family member under 21, then no other nonfamily members under 21 (effective 12/1/02)
California[b]	15 years	6 months	50 hours, 10 of which must be at night	16 years	midnight to 5 a.m.	*first 6 months:* no passengers younger than 20 unless supervised by driver 25+ years old *second 6 months:* no passenger midnight to 5 a.m. unless supervised by driver 25+ years old (effective 1/1/03)
Ohio[c]	15 years, 6 months	6 months	50 hours, 10 of which must be at night	16 years	1 a.m. to 5 a.m.	none
Pennsylvania	16 years	6 months	50 hours	16 years, 6 months	11 p.m. to 5 a.m.	none

Adapted from IIHS (2002).

[a] Permit applicants younger than 18 years in Michigan must have completed the first segment of driver education; license applicants younger than 18 must have completed the second segment of driver education. Neither driver education nor an intermediate license is required for license applicants 18 and older. The night restriction is for 6 months or until age 17.

[b] Students enrolled in driver education in California may drive while supervised by an instructor. License applicants who do not take driver education must wait until age 18 for a license. They are not required to go through an intermediate license stage.

[c] Driver education is required of license applicants younger than 18 years.

stages (age, performance, time). Different research designs, outcome measures, statistical techniques, interpretation, and presentation may have been used. Even the available crash data may differ by reporting thresholds, injury severity definitions, accuracy, and level of detail. The ages of drivers covered by a particular GDL program or its evaluation may differ. The period since GDL implementation and the age/stage of young drivers may differ. Different denominators (licensed drivers or population) may have been used to calculate rates of crashes. Finally, different adjustments for general population traffic safety trends may have been used (drivers age 25–54, drivers over 25, a specific age group, an outside control group). The results obtained from the various evaluations, therefore, will be presented below in sequence, not all in one table, and a general summary will follow.

3. Results

Florida's GDL program was implemented July 1, 1996. The published evaluation of that program used pre- (1995) and post-program (1997) comparisons of 15- to 17-year-old driver fatal and non-fatal-injury crash rates (per capita), as well as a comparison with a border state, Alabama, which did not have GDL (Ulmer, Preusser, Williams, Ferguson, & Farmer, 2000). A reference group of older persons (25–54 years old) unaffected by the program was used in the analyses. Overall, there was a 9% reduction in fatal/injury crashes for 15- to 17-year-olds from 1995 to 1997. The reduction was greatest among 15-year-olds—19%, and was 11% for 16-year-olds and 7% for 17-year-olds. There were no significant reductions for any age group in Alabama. Crash reductions were not different by gender. Larger reductions, however, were found among White rather than non-White teens and among urban rather than rural teens. Crashes occurring at night declined more than those occurring in the day. A nighttime curfew implemented in 1996 for teens in one county did not result in their crash reduction being significantly different from the reduction elsewhere. These per capita crash reductions occurred at a time when rates of licensure in this age group were even increasing.

Michigan's GDL program was implemented April 1, 1997. Its early effects on 16-year-old drivers were assessed in two published studies. In the first (Shope, Molnar, Elliott, & Waller, 2001), population-based crash risks from pre-

GDL data (1996) were compared with post-GDL data (1998 and 1999), adjusting for trends among drivers 25 years or older. The overall risk of being involved in a crash in 1999 was 25% lower than in 1996. Statistically significant reductions in risk were also found for non-fatal-injury crashes (24%) and combined fatal/non-fatal-injury crashes (24%); 5 a.m. to 8:59 p.m. (24%), 9 to 11:59 p.m. (21%), and midnight to 5 a.m. crashes (51%); and single- (29%) and multiple-vehicle crashes (23%). The decrease seen in the risk for fatal injury crashes (26%) was desirable, although it did not achieve statistical significance, very likely due to the relatively small numbers of such crashes. The 1999 crash risks were lower than the crash risks in 1998, as expected because the new cohort of teen drivers subject to the GDL program had to work its way into the 16-year-old driving population. In 1998, about two-thirds of the 16-year-olds were under the new licensure new system, and in 1999, nearly all the 16-year-olds were licensed under the GDL system. It was not possible to calculate driver-based crash risks because prior to GDL, learner permits were not part of the state's driver record system. From 1996 to 1999, Michigan experienced a 22% decrease in the proportion of 16-year-olds licensed to drive independently.

In the second Michigan evaluation (Elliott & Shope, 2003), GDL's effects were examined using a linear change-point model. In the previous comparisons of before- and after-GDL crash rates, the periods (one calendar year before GDL and two calendar years after GDL) were chosen on a reasonable, albeit ad hoc basis. To examine whether these comparisons may have been confounded by underlying trends independent of GDL (that the absence of a control group made it difficult to sort out), a linear change-point model was constructed that took into account the uncertainty regarding when GDL effects, if any, began and ended, and whether a "rebound" in crash rates may have occurred. This approach allowed (1) construction of mean crash rate estimates that captured nonlinear trends, (2) assessment of posterior probability that change-points (if any) occurred within time frames that can be directly associated with GDL introduction, (3) inferences about the impact of GDL that include variability due to the uncertainty in estimating when the impact began and ended and whether the observed rate changes are plausibly related to GDL, (4) inferences made about any "rebounds" in crash rates, and (5) summary model checks of functional and distributional forms via posterior predictive distributions. An important feature of the model is that one point is not favored over another a priori; that is, the data are used to identify where the crash rates change, not prior preconceptions or even observations of the time series plots (which can be prone to optical illusions). For crashes overall through 2000, GDL appeared more likely than not to have had a substantial effect, dropping crash rates among Michigan 16-year-olds by approximately 25% during the 12–18 months following its implementation. The effect on single-vehicle crashes and night crashes was less certain, with reductions likely due in part to longer term trends among this age group.

North Carolina's GDL program was implemented on December 1, 1997. Its published evaluation of effects on 16-year-old drivers showed comparisons of population-based crash risks from 1996 and 1997 pre-GDL data with 1999 post-GDL data (Foss, Feaganes, & Rodgman, 2001). Similar, although somewhat smaller crash risks per licensed driver were found, but not reported because the types of licensure were not directly comparable before and after GDL was implemented. Reductions in relative risks were found as follows: crashes overall 23%, fatal crashes 57%, injury crashes 28%, minor/no injury crashes 23%, 5 a.m. to 8:59 p.m. crashes 20%, 9 p.m. to 4:59 a.m. crashes 43%; single- 29% and multiple-vehicle crashes 21%. Only the overall crash risk adjusted for population trends was reported, and that was 27%. There was no difference in crash risk by urban–rural quartiles. Licensing among 16-year-olds declined only slightly over the period studied.

California's GDL program was implemented July 1, 1998. An evaluation of its impact on the injury crashes of 16-year-old drivers in just San Diego County compared the 1997 pre-GDL rates with the 2000 post-GDL rates (Smith, Pierce, Ray, & Murrin, 2001). While there was a 20% population-based decrease in the crash rate, the driver-based crash rate did not decline. The authors pointed out that the percentage of 16-year-olds with a driver's license was 19% lower in 2000 than in 1997, essentially accounting for the population-based rate reduction. They found little change in night crashes (midnight to 5 a.m.), very likely because large portions of the county had preexisting curfew laws for minors. For 15- to 19-year-old passenger injuries, however, there was a 41% decline in the population-based rate, and a 23% decline in the driver-based rate.

A press release from the Automobile Club of Southern California (2000) examined statewide crash counts in 1994, 1998, and 1999 for fatal and injury crashes in which 16-year-old drivers were considered at-fault and reported a decline of 20% from 1998 to 1999, compared to a 6% decline for 18-year-olds. Before GDL, the average annual changes for 16- and 18-year-olds were each less than 1% per year. A subsequent press release from the same organization (2001) reports post-GDL decreases in simply the numbers of 16-year-old driver crashes (compared to 19-year-old driver crashes) that were at fault, and that involved preteen and teen passenger deaths/injuries, but population- or driver-based rates were not included. Between 1998 and 2000, at-fault fatal and injury crashes among 16-year-old drivers declined 24% and at-fault property-damage-only crashes declined 17%. No such declines were found among 19-year-olds.

Ohio's GDL program was implemented January 1, 1999, and appeared in a detailed preliminary report to have had a positive effect on young drivers 1 year after its implementation (Office of Governor's Highway Safety Representative, 2001). In overall trends, youthful driver (age 16 and

17) crashes decreased. When comparing pre-GDL and GDL groups, the crash involvement rate of the GDL group (after adjusting for changes in the population age 25–54) was 23% less than that of the pre-GDL group (from 3.37 per 10,000 licensed drivers to 2.61 per 10,000 licensed drivers) and the at-fault crash rate of the GDL group was 1% less than the pre-GDL group (from 4.05 to 3.99). This effect seemed most apparent among male novice drivers. In addition, the fatal crash involvement rate of the GDL group was 24% less than that of the pre-GDL group and the at-fault fatal crash rate was 7% less than that of the pre-GDL group. There were also reductions in crashes during the night restriction hours. The conviction rate of the GDL group was 15% less than that of the pre-GDL group. With GDL's new suspension and changes in rules for suspension, rates of the GDL group were dramatically higher than that of the pre-GDL group.

Pennsylvania's GDL program was implemented December 22, 1999. Based simply on a review of crash counts, Nissley (2001) reported reductions in crashes, injuries, and fatalities among 16-year-old drivers between 1999 and 2000, with crashes dropping 27%, injuries by nearly a third, and fatalities by 58%. A more recent update on fatalities revealed a drop of 45%, from 60 in 1999 to 33 in 2001 (Commonwealth of Pennsylvania Department of Transportation, 2002).

To summarize the findings reported above, every one of the six states identified some type of crash reduction among young novice drivers following the implementation of GDL. This overall positive effect was typically observed in the years 1999 and 2000, across different geographic regions, and with different GDL programs. In all cases, the simple counts are down—fewer teens are experiencing crashes and becoming injured. After calculating crash rates to adjust for changes over time in populations or licensed drivers, reductions generally are still found. As discussed above, for many reasons it is inappropriate and difficult to directly compare the various results. However, a few of the findings were obtained by reasonably similar, sound methods and stand out as noteworthy. The population-adjusted risks of injury/fatal crash involvement of 16-year-old drivers in Florida and Michigan were reduced by 11% and 24%, respectively, following implementation of GDL. The population-adjusted risks of any crash involvement of 16-year-old drivers in Michigan and North Carolina were reduced by 25% and 27%, respectively, following implementation of GDL. Reductions in the night (restricted hours) crash risk were particularly impressive in Florida, Michigan, and North Carolina. A comparison state design was only possible in the Florida evaluation, but the results clearly showed greater crash reductions under GDL than under a previous type of licensing system. It is too early to look at GDL effects on passengers because only California currently has a passenger restriction. The change-point analyses of Michigan's crash data trends over time provide additional support of GDL's effectiveness in reducing young driver crashes. Taken as a whole, and including the preliminary findings from California, Ohio, and Pennsylvania, these reports demonstrate the early effectiveness of GDL in reducing the crash risk of young novice drivers.

4. Discussion

It is too soon to know if the observed crash reductions are due to young people driving more safely than previous to GDL. More likely, the reductions are due to reduced exposure. None of the studies above reported young drivers' exposure in terms of driving mileage or driving time so that it could be determined whether decreased driving exposure contributes to the decreased crash risk. However, there are indications that it is taking longer than previously for teens to become fully licensed to drive, resulting in their being older when they are licensed. There also may be fewer licensed teens than before GDL. These changes continue to need monitoring in order to shed light on the contribution that delay in licensure makes to crash reductions. The impressive drop in the risk of night crash-involvement relative to day or evening crash-involvement in several reports suggests that night driving restrictions during the intermediate stage of licensure have been very effective in reducing exposure at a high-risk driving time. Not all the reports included reference to teen curfews that might also be contributing to the reduction. Understanding which components of GDL have contributed to the crash reductions is difficult because programs are implemented as a total package. Only the night restriction is possible to directly assess. The requirement for parental certification of the supervised practice hours is more difficult. Optimal ages and lengths for each stage also would be worth study.

Few subgroup analyses have been reported to examine differential effectiveness of GDL programs. Florida and Ohio were the only states where evaluations reported GDL effects by gender. Florida found no difference in crash reductions for young men compared with young women. The Ohio evaluation examined changes in crash rates before and after GDL by gender. Young men had higher crash rates than young women both before and after GDL. Urban/rural differences were examined and reported in the Florida and North Carolina studies. In Florida, declines were greater in urban than rural areas, possibly driven by urban curfews. In North Carolina, there were no differences found between urban and rural areas.

These and other studies of the effectiveness of GDL have several limitations that must be recognized. First, design issues are considerable, because a randomized control group cannot be assigned and even comparison states are now practically impossible to identify. So quasi-experimental designs must be used and interpretations of data made very carefully. Second, there is often a long phase-in period, so that it is challenging to know when to evaluate and who to include. Third, all the evaluations above were done early

after implementation, and longer term effects will need further study. Fourth, the state records that must be used can be challenging and data or reporting requirements sometimes change during the evaluation period. Fifth, all these studies were conducted on whole age groups—none reported crash reductions by GDL level (although at least one jurisdiction outside the US has examined crash risk by GDL level; Mayhew, Simpson, Williams and Desmond, 2002). When this can be done, a more precise understanding of the changes in crash risk can be achieved. Sixth, other factors that were not evaluated could have contributed to the crash reductions, such as parental restrictions imposed on teens in addition to the GDL program. This type of information would add to our understanding. Finally, to date, only three evaluations (Florida, Michigan, and North Carolina) completed a peer-reviewed publication process. Having more studies benefit from the critical thinking and input of other scientists and evaluators will enrich the knowledge base regarding GDL's effectiveness.

Future analyses need to address crash risk by GDL level, an issue of considerable interest, as well as length of time and age in each GDL level. Efforts are also needed to assess the longer term effects of GDL, particularly on older teens who are driving on a full license without restrictions—their driving behavior will reflect the full effect of the GDL system. Crashes occurring during each evening hour can also be examined as a basis for reviewing the effectiveness of the night restriction currently in place. Future analyses should also examine gender effects, as well as violations, safety belt use, and the presence of young passengers on the crash experience of teen drivers before and after the introduction of GDL to determine whether these behaviors were positively, if indirectly, affected by GDL.

While these early results in preventing crashes among young drivers are impressive, and encouraging, there are several implications for future research. Evaluation over the longer term is needed to see if the crash reductions are maintained as new cohorts of teen drivers enter and progress through the system. In addition, evaluation results from other jurisdictions are needed to determine if such positive results are achieved elsewhere. Other jurisdictions' evaluations may also help to assess the relative contributions of the different components to the overall effect of GDL programs. This task will be complex, given the variations among former licensing laws, as well as the considerable differences in the GDL programs being adopted.

There are several approaches for enhancing the effectiveness of GDL that should be implemented and evaluated. Compliance with GDL restrictions is largely up to parents and their teen drivers—there may be several ways to enhance compliance. How can parental involvement be enhanced? Do parent/teen contracts enhance GDL's effects? What materials and assistance help parents influence their teen's safe driving? Are there additional materials, assistance, or interventions that could be targeted to teen drivers? What about enforcement—are enforcement officers aware of the GDL program's details? Are they enforcing its requirements? If not, the perception of enforcement necessary for compliance will quickly be eroded in this young population.

There are considerable challenges ahead to continue learning how best to reduce teen motor vehicle morbidity and mortality. However, at this point, in reviewing the early United States' evidence of effectiveness, a GDL system for licensing young drivers seems an extremely promising approach. The impact of these studies and others to come will continue to guide future research, practice, and policy in reducing injury from motor vehicle crashes among teenagers.

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