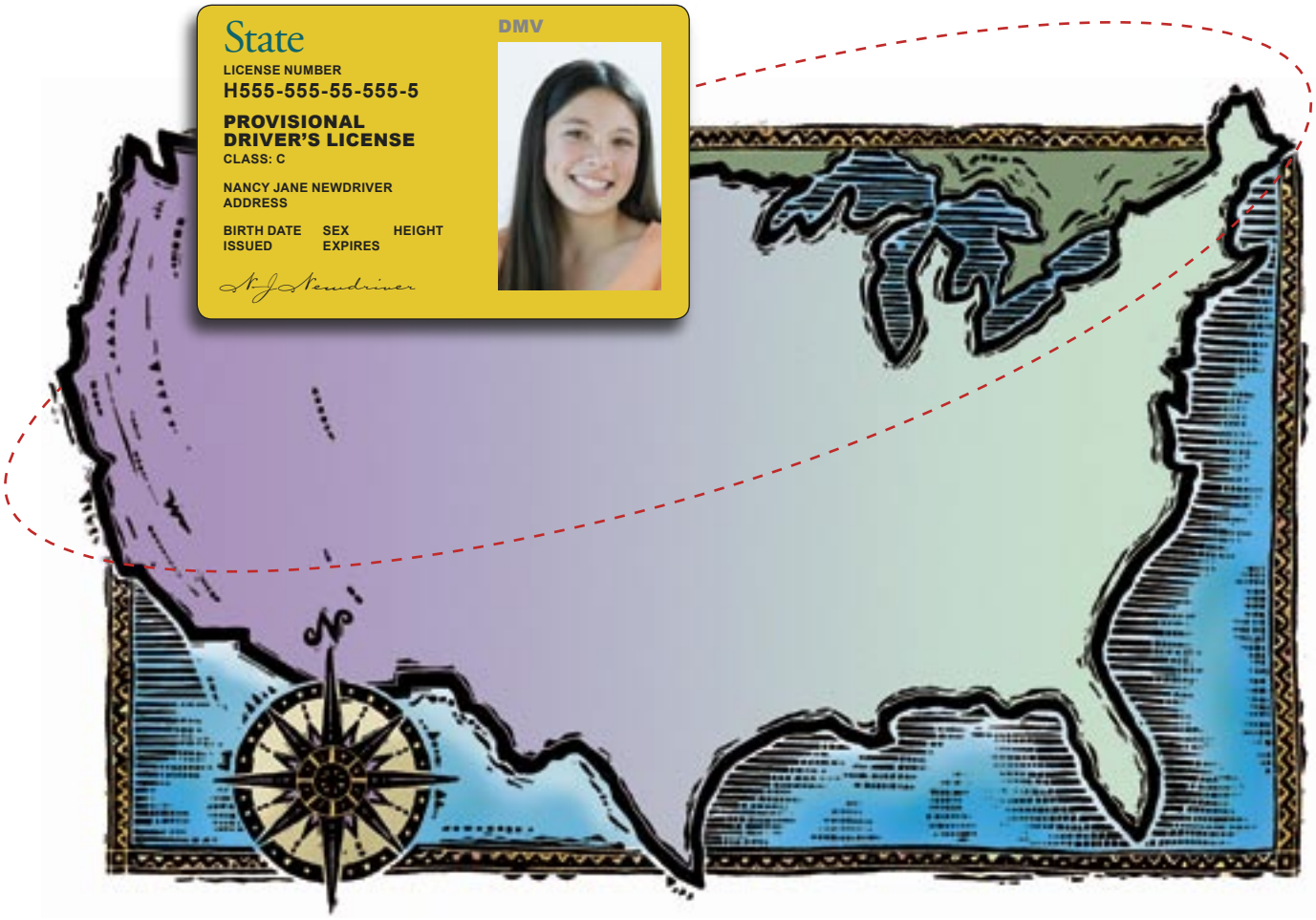
Nationwide Review of
Graduated Driver Licensing



Prepared by

Susan P. Baker, MPH
Li-Hui Chen, PhD, MS
Guohua Li, MD, DrPH

Johns Hopkins Bloomberg School of Public Health
Center for Injury Research and Policy
624 N. Broadway, Baltimore MD 21205

Prepared for

AAA Foundation for Traffic Safety

607 14th Street, NW, Suite 201
Washington, DC 20005
800-993-7222
www.aaafoundation.org

February 2007

ABOUT THE SPONSOR

This study was funded by the AAA Foundation for Traffic Safety in Washington, D.C. Founded in 1947, the AAA Foundation is a not-for-profit, publicly supported charitable research and education organization dedicated to saving lives by preventing traffic crashes and reducing injuries when crashes occur. Funding for this report was provided by voluntary contributions from AAA/CAA and their affiliated motor clubs, from individual members, from AAA-affiliated insurance companies, as well as from other organizations and sources.

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ACKNOWLEDGEMENTS

This research was funded by the AAA Foundation for Traffic Safety and in part by the Center for Injury Research and Prevention, Centers for Disease Control and Prevention (Grant CCR302486). The National Highway Traffic Safety Administration (NHTSA) supported much of the data acquisition that laid the groundwork for this research, under a cooperative agreement with Johns Hopkins University (DTNA22-03-H-05123), and provided data from the State Data System; Paul J. Tremont, PhD was the NHTSA Project Officer. AAA Government Relations & Traffic Safety Advocacy provided or verified information about some state programs. Annie Michaelis, BA and Jennifer Taylor, MPH contacted states for data. Hirut Gebrekristos, MPH performed the literature review and built the reference file. C. Raymond Bingham, PhD and Robert D. Foss, PhD reviewed this report at various stages and contributed to the design and interpretation of the research. Brian C. Tefft and J. Scott Osberg, PhD of the AAA Foundation for Traffic Safety also contributed to the design, execution, and interpretation of the research.

Executive Summary

Background

Each year more than 1,000 16-year-old drivers are involved in fatal crashes. Injuries are the primary cause of death of teenagers, and 41% of all injury deaths at ages 15-19 involve motor vehicle crashes. Many diverse approaches, from minimum drinking age laws to driver education, have attempted to reduce the toll of motor vehicle crashes involving young drivers. During the past decade, 44 states and the District of Columbia have passed legislation for Graduated Driver Licensing (GDL) programs.

GDL involves a three-stage approach to licensure of teenage drivers, usually beginning around age 15½ to 16. A typical three-stage GDL program comprises a "learner" stage, during which all driving must be supervised, followed by an "intermediate" (or "provisional") stage, during which unsupervised driving is allowed but is subject to certain restrictions and conditions, and finally by unrestricted licensure. The objective is to provide novice drivers with supervision during their initial months on the road, and then to reduce their exposure to certain more-hazardous situations, for example by restricting driving at night and setting limits on carrying passengers.

Evaluations in various states have consistently shown that GDL is beneficial, with reported impacts as great as 34% reduction in the involvement rate of 16-year-old drivers in injury crashes and 19% reduction in their fatal crash involvement rate. Nationally, overall estimates of fatal crash reductions associated with GDL implementation have ranged from 6% to 11% for ages 15 through 17 combined. To date, reported national estimates of the benefit of GDL have been limited to fatal crashes and have neglected to focus on the value of improving weaker programs.

Objectives

The objectives of this research were to provide answers to the following questions:

- What was the overall reduction in involvement of 16-year-old drivers in fatal crashes and injury crashes?
- Did crash involvement rates decline as the number of restrictive components in GDL programs increased?
- How much could crashes of 16-year-old drivers be reduced if all states had GDL programs as effective as the programs associated with the largest reductions?
- If an association is found between GDL and lower crash rates, does it appear to be a causal relationship?

Method

This study is based upon analysis of data on fatal crashes, compiled and made available to the public by the National Highway Traffic Safety Administration; midyear population estimates, compiled and made available to the public by the U.S. Census Bureau; data on injury crashes, compiled by individual states and obtained specifically for this study with the permission of each respective state; and information on state GDL legislation, provided by AAA Government Relations & Traffic Safety Advocacy, the Insurance Institute for Highway Safety, and representatives of individual states.

Population-based rates of fatal crash involvement and injury crash involvement were calculated for drivers aged 16, 20-24, 25-29, and 30-54, in each state included in the analysis, for each quarter-year ("state-quarter"). Analyses of fatal crashes were based upon data from 43 states, spanning years 1994 through 2004. Included were 36 states that had a three-stage GDL program in effect for at least part of the period of the study, and 7 that did not[†]. Analyses of injury crashes were based upon data from 35 states, from 1994 through 2003, though not all years of data were available for all states. Included were 28 states that had a three-stage GDL program in effect for at least part of the period analyzed, and 7 that did not.

[†] Minnesota's licensing process has included both a learner stage and an intermediate stage since 1999; however, Minnesota's intermediate stage does not include any form of nighttime driving restriction or passenger restriction. For this reason, Minnesota sometimes is not classified as having a three-stage GDL program (e.g., IIHS (2006)); however, for the purpose of this study, Minnesota was classified as having a three-stage GDL program.

The licensing system for young drivers in effect in each state-quarter was characterized first on the basis of whether or not it included both a learner stage and an intermediate stage prior to full licensure, and second according to the number of its program components that were consistent with the following definitions:

- A minimum age of **at least 16 years** for gaining a learner's permit.
- A requirement to hold the learner's permit for **at least 6 months** before gaining a license that allows any unsupervised driving.
- A requirement for certification of **at least 30 hours** of supervised driving practice during the learner stage.
- An intermediate stage of licensing with a minimum entry age of **at least 16 years and 6 months.**
- A nighttime driving restriction for intermediate license holders, beginning **no later than 10 p.m.**
- A passenger restriction for intermediate license holders, allowing **no more than one passenger** (except family members).
- A **minimum age of 17 years** for full licensure.

For each age group and each type of program, crash involvement rates were calculated for the period of the 5th to 8th quarters before and the period of the 5th to 8th quarters after implementation. The four quarters immediately before and four quarters immediately after GDL implementation were excluded from the analysis to avoid capturing the effects of possible short-term perturbations in the licensing of young drivers immediately before and after changes in licensing policy. Negative binomial regression models were used to examine the associations between GDL programs and crash incidence, while accounting for state-, year-, and quarter-related correlations in the data.

Results

- Population-based fatal crash involvement rates of 16-year-old drivers were 11% lower overall in state-quarters with three-stage GDL programs (i.e., programs that included a learner stage and an intermediate stage prior to full licensure),

and injury crash involvement rates were 19% lower overall, compared with state-quarters without three-stage GDL programs. Both differences were statistically significant at the 95% confidence level. These figures include the results for states with a wide range of programs, including the less successful programs.

- Overall fatal crash and injury crash involvement rates of drivers aged 20-24, 25-29, and 30-54 did not change in association with the implementation of three-stage GDL programs. Drivers in these older age groups were exposed to driving environments similar to those of novice drivers but were unlikely to be influenced by GDL enactment. The lack of changes in older drivers' crash rates suggests that GDL enactment was largely responsible for the lower rates in 16-year-old drivers.

- Programs with any five of the seven previously defined GDL components were associated with fatal crash rates of 16-year-old drivers that were 38% lower, and injury crash involvement rates that were 40% lower, relative to the corresponding rates in state-quarters with none of the seven components (Note: The maximum number of components in effect in any state-quarter in the study was five.)

- Similar reductions were not seen for drivers aged 20-24, 25-29, or 30-54. Reductions were absent, or much smaller, and/or did not achieve statistical significance. The general absence of comparable changes in crash rates of these somewhat older drivers suggests that the changes for 16-year-old drivers were related to GDL.

- For both fatal and injury crashes, crash involvement declined as the number of GDL program components increased from one to five. Thus, risk of crash involvement decreased in an apparent dose-response fashion as the restrictiveness of GDL programs increased.

- The results of this research suggest that the association between Graduated Driver Licensing and lower rates of crash involvement among 16-year-old drivers is likely to be a causal relationship.

Conclusions

The most restrictive graduated driver licensing programs are associated with reductions of 38% and 40% in fatal crashes and injury crashes, respectively, of 16-year-old drivers. The overall reductions, for all three-stage programs combined (i.e., irrespective of the number of specific components that they included, thus including the weakest of programs), were 11% and 19% for fatal crashes and injury crashes, respectively.

The difference between crash involvement rates that were 38% - 40% lower in state-quarters with any five of the seven defined GDL components, and the apparent lack of effect of programs with very few components, point to the enormous safety benefit that might be achieved by strengthening GDL regulations in states without three-stage GDL programs or with less comprehensive programs.

Introduction

Graduated Driver Licensing (GDL) is a fairly recent addition to highway safety programs in the United States. Developed to address high crash risks among teenaged drivers, GDL programs are increasingly popular, but whether they are reaching their full potential is not known.

Background

Teens have a greater chance of death in motor vehicle crashes than from any other cause (Centers for Disease Control and Prevention 1999; Cvijanovich et al. 2001; Foss 2000). Injuries are the primary cause of death of teenagers, and 41% of injury deaths at ages 15-19 involve motor vehicle crashes (Centers for Disease Control and Prevention 2006). In 2004, 7,898 drivers aged 15 to 20 years were involved in fatal crashes (National Highway Traffic Safety Administration (NHTSA) 2004). In addition to the lives lost in motor vehicle crashes, the annual economic cost of police-reported crashes among teen drivers is a staggering USD $40.8 billion (NHTSA 2002).

Purpose and description of Graduated Driver Licensing (GDL)

Two factors, age and inexperience with the driving task, have been proposed as causes of the higher crash risk among young novice drivers (Mayhew and Simpson 1990). GDL, an intervention proposed in the 1970s (Waller 2003), targets both immaturity and inexperience by delaying age of full (unrestricted) licensure and by restricting driving under specified hazardous conditions prior to full licensure. A major purpose of GDL is to provide practical driving experience prior to allowing unrestrained driving freedom.

GDL programs comprise three major stages. During an initial "learner" stage, all driving must be supervised—usually by a parent or guardian. After the learner stage, a new driver under a three-stage GDL program receives an "intermediate" (or "provisional") license, which permits unsupervised driving, subject to some restrictions (e.g., prohibition on driving after a certain nighttime hour or a limit on the number of young passengers that can be transported). Finally, after completion of the intermediate stage, the driver receives a full-privilege license.

The specific GDL restrictions that have been implemented by states vary; typically they include age specifications for each of the three phases, a minimum number of hours of supervised driving, a learner period with a minimum duration before applying for an intermediate license, limits on the number of passengers, and restrictions on driving after certain nighttime hours. In some cases, new drivers are also restricted from driving on certain roadways (e.g., Interstate highways), and face stricter penalties than full-privilege license-holders for traffic violations, convictions, and/or crashes.

GDL programs were first introduced in New Zealand in 1987. In the U.S., the first state to implement a three-stage GDL program was Florida, which did so in 1996. In most states, individual components of GDL programs (e.g., minimum age for receiving a learner's permit or driver's license) predate the implementation of three-stage programs. As of February 15, 2007, 44 states and the District of Columbia had introduced three-stage programs. GDL programs in the U.S. apply only to individuals under 18 years of age, even though the required age and duration of the learner stage and the age for full licensure vary among states. Other restrictions also vary across jurisdictions, especially restrictions in the intermediate stage relating to nighttime driving and carrying passengers. Appendix 1 describes the components of the GDL program in effect in each state as of February 15, 2007, based upon information provided by AAA Government Relations & Traffic Safety Advocacy.

Despite the existence of a large and growing body of research indicating that GDL is effective in reducing the crash involvement of young drivers, several factors remain unclear. First, because national evaluations (e.g., Dee et al. 2005; Morrisey et al. 2006) have focused on fatal crashes, we know little about the nationwide impact of GDL on non-fatal crashes. Second, although previous research by the authors of the present report documented the relationship between changes in crash involvement rates and the number of GDL program components (Chen, Baker, and Li 2006), the results of the previous study likely underestimated the effect of some of the stronger GDL programs.

In that previous study, program components were dichotomized as present or absent (e.g., whether a nighttime driving restriction prohibiting unsupervised driving between the hours of 1 a.m. and 5 a.m. counted as “night restriction present” or “night restriction absent”), according to criteria that were weaker than existing recommendations (e.g., recommendations from the Insurance Institute for Highway Safety (IIHS) and AAA); it is likely that the inclusion of less restrictive variations of some components (e.g., night restrictions that do not take effect until after midnight) resulted in estimates of program effectiveness that were lower than what would have been obtained from a study based upon stricter inclusion criteria. Third, the potential for improvement in crash rates of novice drivers through improved GDL programs has not been adequately measured.

Objectives of this research

This report describes an analysis of the nationwide public health impact of GDL programs, quantified in terms of the effect of GDL programs on the per-capita fatal crash and injury crash involvement rates of 16-year-old drivers. Specifically, the following questions were addressed:

- What was the overall reduction in involvement of 16-year-old drivers in fatal crashes and injury crashes?
- Did crash involvement rates decline as the number of restrictive components in GDL programs increased?
- How much could crashes of 16-year-old drivers be reduced if all states had GDL programs as effective as the programs associated with the largest reductions?
- If an association is found between GDL and lower crash rates, does it appear to be a causal relationship?

Literature Review

Rationale for GDL programs

Injuries resulting from motor vehicle crashes are the number one cause of death among teenagers in the United States. The highest rate of fatal crashes is found for 16-year-old drivers (Williams and Shabanova 2003). Graduated Driver Licensing was proposed in the early 1970s because research showed that younger drivers had the greatest probability of being involved in crashes, were more likely to experience crashes when driving between the hours of midnight and 6 a.m., and were at greater risk when carrying teenage passengers (Waller 2003).

U.S. statistics on motor vehicle crash injuries among teen drivers

Crash involvement rates in the United States for 16-, 17-, and 18-year-olds have been estimated at 35, 20, and 14 per million miles driven, respectively (Williams 1999). These rates are much higher than rates for drivers in their 20s (8 per million miles driven) and drivers 30 to 69 years of age (4 per million miles driven) (Williams 2000). Similarly, population-based rates of fatal motor vehicle crash involvement were much higher for drivers 16 to 19 years old than for ages 20 and older (15 vs. 9 per 100,000). The difference in death rates of passengers aged 16 to 19 years compared with passengers aged 20 and older (10 vs. 3 per 100,000 population) is also great (Williams 2001).

Evaluation of GDL programs

Other countries' experience

GDL programs began taking shape during the late 1980s to mid-1990s, in vari-

ous countries including New Zealand, Canada, and Sweden as well as in several states in the United States.

In 1987 New Zealand established a GDL program applying to new drivers aged 15 to 24 years. In one of the earliest evaluations of New Zealand's GDL program, a reduction of 23% in the rate of motor vehicle-related injury hospitalization among 15- to 19-year-olds was reported over the period 1978 to 1992. During this same period, a smaller reduction of 16% in motor vehicle-related hospitalizations was observed among the 25 and older age group, who were not directly affected by the GDL legislation (Langley, Wagenaar, and Begg 1996). Over a 12-year period from 1987 through 1998, the rate of motor vehicle occupant fatalities and hospitalizations declined by approximately half (Begg and Stephenson 2003). Early reports of the success of the New Zealand program helped to fuel U.S. interest in developing similar legislation (Begg et al. 1995; Frith and Perkins 1992).

In Canada, GDL implementation was followed by lower rates of crashes of young drivers who were licensed or holding a learner permit. In Ontario, reductions of 16% and 31% in novice driver crashes were reported per licensed driver and for all drivers (including those holding a learner permit), respectively (Boase and Tasca 1998). Similarly, in Quebec, the reductions in fatal and non-fatal novice crashes per licensed driver were 4.9% and 14.4%, respectively (Bouchard, Dussault, and Simard 2000).

Experience of individual states in the U.S.

Evaluation of GDL programs enacted in various states of the U.S. between 1996 and 1999 reported reductions of 11% to 32% in crash rates of novice drivers (McKnight and Peck 2002). A review of early results of GDL programs showed reductions in crashes of young drivers in six states (Shope and Molnar 2003). Shope et al. reported a 25% decline in crashes of 16-year-old Michigan drivers (2001). Foss et al. (2001) reported a 19% decline in crash rates per licensed 16-year-old driver and a 23% decline in crashes per 100,000 population following GDL implementation in North Carolina; the greatest reductions were seen in nighttime crashes, single-vehicle crashes, and alcohol-related crashes (Foss et al. 2001). More recently, Shope et al. (2004) evaluated Michigan's GDL program and found a 19% reduction in crashes involving 16-year-old drivers, adjusted for other factors reflected in trends in crashes of older drivers. A recent evaluation of California's GDL program revealed that the greatest change in crashes of 16-year-old

drivers occurred in those crashes where the drivers had teenage passengers, which decreased by 38%, compared with 12% for crashes without passengers (Zwicker et al. 2006).

The comparison of crash experience before and after GDL program implementation in states with GDL has been used to assess the relationship between GDL and crashes. This comparison is more complex than it may appear. Several challenges have limited causal inference. First, the denominators used to compare crash injuries before and after GDL programs in different states have differed. For example, some state evaluations have computed crash rates per unit of population, whereas others have computed crash rates per licensed driver, thus complicating attempts to compare them. Second, counts of crashes can include those resulting in fatality, injury, or property damage, and states differ in reporting requirements for non-fatal crashes. Third, the GDL program components being compared vary among states in their restrictiveness (e.g., nighttime driving restrictions apply during different hours in different states). Fourth, some estimates of GDL effects have not taken into account the influence of other factors besides GDL, such as changes in other laws and long-term trends, on crash rates. Lastly, a major determinant of the impact of GDL is compliance, which is likely to reflect parental restrictions, peer pressure, and law enforcement. Such factors likely vary among states and are difficult to measure.

Common GDL program components

GDL program components affect crash rates of novice drivers in three ways: by reducing exposure, increasing supervised practice, and decreasing unsupervised driving under hazardous conditions such as driving late at night or with passengers. The following are some of the key components of GDL programs.

The learner stage

The age at which a teenager can apply for a learner permit directly affects exposure and, accordingly, the possibility of crash involvement. The primary goal of extending the learner phase is to promote safe driving by requiring that an adult be present during all driving. Raising the age of entry into the learner phase, or extending the duration of the learner phase, can also reduce or at least delay unsupervised driving. For example, lengthening the learner period increases the amount of time that the

learner drives under adult supervision, so that experience is gained under circumstances where crashes are rare because of the restraining influence of the adult.

Commonly, states require six months of driving in the learner phase, and between 30 and 50 hours of supervision before issuing an intermediate license. There is wide variation among states in the specific combination of requirements included in the learner phase and the requirements for transition to an intermediate license, as illustrated in Appendix 1.

Analyses from several settings indicate that crash risk is low and serious crashes are rare during supervised driving that occurs during the learner stage (Agent et al. 2001; Mayhew et al. 2003; Williams et al. 1997). For example, when Kentucky introduced a 6-month learner period prior to full licensing: crashes plummeted even without an intermediate license stage (Agent et al. 2001). It has been proposed that extending the learner phase may result in the greatest reduction in crash rates relative to other stages of GDL programs (Morrisey et al. 2006).

Although lower rates of crashes have been observed in states that have extended the duration of the learner stage, the reported reductions usually are affected by other changes in addition to the extended learner' periods. In Sweden, however, the learner phase was extended from 6 months to 1½ years by lowering the age at which the learner permit can be issued from 17½ to 16½ years and keeping the age of full licensure at 18 years. Comparing teens receiving an additional year of supervised driving to those receiving only 6 months of supervised driving, Gregersen et al. reported 24% fewer crashes for those supervised for 1½ years (Gregersen et al. 2000). The length of the learner stage in various jurisdictions in the U.S., however, is generally much shorter than that found in Sweden. Evidence suggests that in the U.S., even GDL programs with shorter learner stages before transitioning to full licensure are associated with reductions in crash rates (Agent et al. 2001; Ulmer et al. 2000).

Age of supervisors. Little attention has been given to the age requirement for supervising drivers during the learner stage. In some states, the requirement is simply that the supervisor must be at least 21 years of age and have held a license for three years; in others, the supervising driver must be at least 25 years old. NHTSA has recommended that the supervising driver be at least 21 years old (NHTSA 2006).

Williams and Shabanova, however, recommend that a supervisor at least 30 years of age should be present if passenger restrictions are waived during the intermediate stage (Williams and Shabanova 2003). Their recommendation was based in part on the fact that seat belt use is greater in the presence of a driver 30 or older, and is consistent with the finding by Chen et al. that the fatality rate in crashes of 16-year-old drivers was higher in the presence of passengers aged 20-29; the crash fatality rate was lowest with passengers aged 30 or older (Chen et al. 2000). This finding suggests that when crashes occur, they are more serious if passengers are in their twenties, and that more mature passengers have a beneficial effect on the safety of novice drivers. Whether it is common for passengers who meet an age requirement of 21 years to serve as 'supervisors,' and whether those who do actually play a role in assuring the safety of a trip, are questions worthy of research. Since no states yet require supervising drivers in the learner or intermediate stage to be aged 30 or older, it is not possible to evaluate the benefit of such a requirement.

Intermediate stage

The intermediate phase of GDL programs allows unsupervised driving that is restricted to relatively low-risk situations. The restrictions on the intermediate stage can be grouped into those that reduce exposure to high-risk situations and those that promote safer driving (McKnight and Peck 2003). Reduction of high-risk driving exposure during the intermediate phase of GDL includes nighttime driving restrictions and teenage passenger restrictions.

Nighttime restrictions. Prior to GDL, although only 15% of total miles for 16- and 17-year-old drivers were driven between 9 p.m. and 6 a.m., approximately 40% of their fatal crashes occurred during those hours (Williams and Preusser 1997). Nighttime driving is now restricted during the intermediate stage in a number of state GDL systems that allow nighttime driving only under adult supervision or, in some cases, when driving for school- or work-related purposes. As of February 15, 2007, GDL programs in 44 states and the District of Columbia states include some form of nighttime driving restriction; however, the restricted hours vary by state, as Appendix 1 illustrates. In many states, night driving restrictions are in effect only after midnight, a period during which 16-year-old drivers do very little of their driving, thereby minimizing the potential impact of the restriction. Because of the higher death rates per trip of teen drivers from

10 p.m. to midnight compared with daytime driving, Foss (2000) recommends that GDL systems not permit driving after 10 p.m. during the intermediate stage.

The effectiveness of nighttime driving restrictions in reducing crashes has been examined in two ways. First, nighttime restrictions existing separately from a complete GDL program have been evaluated. The estimated reductions in 16-year-old drivers' crash involvement during restricted hours were 69%, 62%, 40%, and 25% in Pennsylvania, New York, Maryland, and Louisiana, respectively (Preusser et al. 1984). These findings were consistent with a larger study using data from 47 states over a 10-year period. Examining the effect of nighttime driving restriction on 15- to 17-year-olds, Levy et al. (1988) reported 28% and 25% reductions in driver fatalities in multi-vehicle and single-vehicle collisions, respectively. In addition, in a study using FARS data, a similar reduction (23%) in deaths of 13- to 17-year-olds was observed in 149 cities in 32 states (Preusser, Zador, and Williams 1993).

Second, nighttime restrictions as components of GDL programs have also demonstrated significant crash reductions. Ulmer et al. (2000) reported a 9% reduction in nighttime crash involvement of 15- to 17-year-old drivers in Florida, where 16- and 17-year-old drivers are restricted from unsupervised driving from 11 p.m. to 6 a.m. and 1 a.m. to 6 a.m., respectively. After implementation of the North Carolina GDL program, crashes involving 16-year-olds during nighttime restriction hours (9 p.m. to 5 a.m.) decreased by 43% (Foss et al. 2001).

Separating the effect of nighttime restrictions from concurrent reductions in licensure has been challenging for understanding the effect of including nighttime restrictions in GDL programs. The lower rates observed in Florida, however, occurred while there was an increase in the number of 15- and 16-year-olds receiving licenses, indicating that the reduction in crash involvement was not due to fewer individuals obtaining licenses (Ulmer et al. 2000).

Teen passengers. In about half of fatal crashes of 16- to 17-year-old drivers, there are one or more passengers aged 20 or younger present in the teen-operated vehicle, and no passenger of supervisory age (i.e., 21 years or older) present (AAA Foundation for Traffic Safety unpublished). Carrying passengers, especially teenage passengers, has been shown to be associated with higher crash risks (Aldridge et al. 1999; Chen et al. 2000; Williams and Ferguson 2002), and restricting the carrying of

teenage passengers has been associated with lower rates of crashes of novice drivers (Cooper et al. 2005).

Although the specific mechanism by which teenage passengers may influence driving safety is not completely understood, some of the likely relationships between the number of teenage passengers and crash risk include passengers distracting novice drivers and implicitly or explicitly encouraging risk-taking behaviors. Chen et al. (2000) found that 16-year-old drivers' trip-based death rates were 5 times as high if there were 3 or more passengers, compared with no passengers. Other studies have found a lower risk of crashes in the presence of older passengers.

Table 1 provides an overview of studies related to GDL.

Table 1: Review of Key Published Studies Evaluating GDL Programs in the USA and Other Countries.

Authors	Pub Year	Jurisdiction	Study Method	Participants	Study Period	Outcome Measures	Reported Effects
Agent et al.	2001	Kentucky	Ecologic study	16-year-olds	1993-95 (pre-GDL) & 1997-99 (post-GDL)	Fatal, nonfatal and property damage reported to state police before and after GDL program	32% reduction in per-driver crash rate among 16-year-olds.
Aldridge et al.	1999	Kentucky	Ecologic study	16-20-year-old drivers	1994-1996	Relative crash involvement ratios	The lowest propensity to cause single- or two-vehicle crashes when traveling with adults and/or children is associated with the youngest drivers.
Boase et al.	1998	Ontario	Ecologic study	All novice drivers	1993 (pre-GDL) & 1995 (post-GDL)	Fatal, nonfatal, and property damage rate per 10,000 licensed novice drivers	31% reduction in per-driver crash rate comparing pre- to post-GDL periods; 20% reduction in the fatal crashes for novice drivers aged 16-19 comparing pre- to post-GDL periods.
Bouchard et al.	2000	Quebec	Ecologic study	Learners and licensed drivers 18-24 years old	1995-1996 (Pre-GDL) & July 1997-June 1999 (Post-GDL)	Number of persons killed and injured per 100,000 in crashes involving learners or probationary drivers	17% reduction in per-driver injury rate involving learners and probationary drivers comparing pre- and post-GDL periods; 7% reduction in per-driver fatality rate involving learners and probationary drivers comparing pre- and post-GDL periods
Chen et al.	2000	USA	Prospective study	16-17-year-old drivers	1992-1997	Driver crash fatality rate per 10 million trips	Compared with drivers of the same age without passengers, the relative risk of death per 10 million trips was 1.39 (95% CI, 1.24-1.55) for 16-year-old drivers with 1 passenger, 1.86 (95% CI, 1.56-2.20) for those with 2 passengers, and 2.82 (95% CI, 2.27-3.50) for those with 3 or more passengers. The relative risk of death was 1.48 (95% CI, 1.35-1.62) for 17-year-old drivers with 1 passenger, 2.58 (95% CI, 2.24-2.95) for those with 2 passengers, and 3.07 (95% CI, 2.50-3.77).

Authors	Pub Year	Jurisdic-tion	Study Method	Participants	Study Period	Outcome Measures	Reported Effects
Cvijanovich et al.	2001	Utah	Cross-sectional study	16-17 & 18-59 year-old drivers	1992-1996	Fatal and non-fatal crash involvement; crash-related hospital charges	16-17-year-old drivers comprise 5.8% of the study population and were involved in 19% of motor vehicle crashes. Crashes involving 16-17-year-old drivers resulted in $11 million in hospital charges. 11% of all crashes and 19% of fatal crashes involving 16-17-year-olds occurred between 10 p.m. and 6 a.m. hours.
Dee et al.	2005	48 states[1]	Prospective study	15-17, 18-20, 21-23, and 24-26-year-old drivers	1992-2002	Number of fatal crashes for individuals aged 15-17, 18-20, 21-23, 24-26 by state and year	5.6% reduction in traffic fatalities among 15-17-year-olds over the period under study (post-GDL).
Ferguson et al.	1996	USA	Cross-sectional study	Parents of 16- and 17-year-olds with licensing experience	November 1994	Percent of parents supporting licensing process	Over half of the parents interviewed were satisfied with the licensing process in their own state. 41% of parents surveyed thought that it should be more difficult to obtain a license. 97% of parents supported curfews starting at or before midnight and zero blood alcohol concentration for teenage drivers. 43% of parents supported a restriction on teenage passengers during the first few months of driving. 58% of parents supported licensure system involving many months of supervised practice, a night driving curfew, and restrictions in carrying teenage passengers.
Foss et al.	2001	North Carolina	Ecologic study	16-year-old drivers	1996-1997 (Pre-GDL) & 1999 (Post-GDL)	Rates of motor vehicle crashes per 10,000 population	Comparing pre-GDL to post-GDL period, the following was reported: 57% decline in fatal crashes; 23% decline in crashes with no or minor injuries; 43% decline in nighttime crashes and 20% reduction in daytime crashes.

Authors	Pub Year	Jurisdic-tion	Study Method	Participants	Study Period	Outcome Measures	Reported Effects
Goodwin et al.	2004	North Carolina	Cross-sectional survey	Parents and teen drivers applying for intermediate or full licensure	February–June 2003	Knowledge, adherence, and enforcement of GDL system (percent of teenagers and their parents)	98% of parents and 96% of teenagers who were aware of the night restriction knew that it began at 9 p.m. 23% of teenagers reported violating the night restriction, either with or without parents' knowledge. 96% of parents and 98% of teenagers knew drivers with intermediate licenses are limited to one teenage passenger. 34% of teenagers reported violating the passenger restriction, either with or without parents' knowledge. 33% of parents and 34% of teenagers were aware of penalties for violating the passenger research. 53% of parents 40% of teenagers reported passenger restriction is enforced.
Gregersen et al.	2000	Sweden	Ecologic study	16-year-old drivers with 2 years of driving training, 17½-year-olds with 6 months of driving training before driving reform, and 17½-year-old drivers with 6 months of driving training after the driving reform.	1992-1997	Crash risk per 10 million kilometers	Lowering the age limit for practicing driving from 17½ to 16 year-old resulted in a 15% reduction in the crash risk of novice 18 and 19 year-old drivers. 40% decline in crash risk of novice drivers learning to driver under the new age limit (16-year-old) relative to those without the prolonged (2 years) learning period.
Langley et al.	1996	New Zealand	Ecologic study	15-19, 20-24, and >25-year-olds	1979-1992	Number of public hospital admission for drivers and passengers (excluding readmission for same injury)	23% reduction in vehicle crashes among 15- to 19-year-old drivers during the period 1979-1992.

Authors	Pub Year	Jurisdic-tion	Study Method	Participants	Study Period	Outcome Measures	Reported Effects
Levy	1998	47 states[2]	Ecologic study	15-17-year-old drivers	1975-1984	Multiple- and single-vehicle crash fatality rates per population in jurisdictions with and without curfews	28% reduction in multiple vehicle driver fatality rate and 25% decline in single vehicle driver fatality rate among 15- to 17-year-olds in states with driving curfews.
Mayhew et al.	2003	Nova Scotia	Prospec-tive study	All novice drivers	1990-1993	Pre-GDL crashes per novice licensed driver	Crash rate declined most dramatically in the first 6 months of driving from 123 (first month) to 73 (seventh month) per 10,000 novice drivers, a 41% reduction. The rate of decline is gradual through the 24th month. 60% reduction in crash rate comparing the first to the 24th month.
Morrisey et al.	2006	48 states[3]	Prospective study	15-17-year-old drivers from the FARS	1992-2002	Teen driver fatality rates per 100,000	"Good" and "Fair" programs (as designated by the Insurance Institute for Highway Safety) reduced total fatalities among young drivers by 19.4% and 12.6% respectively.
Preusser et al.	1984	6 US states[4]	Prospective study	16-year-old drivers	1974-1990[5]	Expected number of crash involvements from linear regression compared to actual involvement in states with driving curfews and those without curfews[6]	Crash involvement of 16-year-olds during curfew hours reduced for: Pennsylvania (69%), New York (62%), Maryland (40%), and Louisiana (25%).
Preusser et al.	1993	USA	Cross-sectional survey	Teenagers 13-17-years of age in cities of >100,000 population	1984-1990	Fatal injuries per 100,000 for 13- to 17-year-olds between 9 p.m. and 5:59 a.m. in cities with and without curfews	23% reduction in fatal injury for 13- to 17-year-olds in cities with curfews.
Shope et al.	2001	Michigan	Ecologic study	16-year-old[7]	1996 (pre-GDL) & 1998-1999 (post-GDL)	Fatal, nonfatal, and property damage crashes reported to state or local police	25% decline in per capita crash rate; 24% reduction in per capita injury crash rate among 16-year-old drivers.

Authors	Pub Year	Jurisdiction	Study Method	Participants	Study Period	Outcome Measures	Reported Effects
Shope et al.	2004	Michigan	Ecologic study	16-year-old drivers	1996 (pre-GDL) & 1998-2001 (post-GDL)	Fatal and nonfatal crash risk per 1,000 among 16-year-old drivers	44% reduction in fatal crash risk. 59% and 31% reduction in nighttime and daytime fatal and nonfatal crash risk. 32% and 28% reduction in single-vehicle and multi-vehicle crashes.
Ulmer et al.	1997	USA	Ecologic study	16 & 17-19 year-old drivers	1993	All crashes (nonfatal, property damage, and fatal) as recorded in the general estimates systems	Crash involvement per 1000 licensed drivers was highest for 16-year-olds (197) compared to 17-year-olds (149), 18-year-olds (136), and 19-year-olds (115).
Ulmer et al.	2000	Florida	Before/ after study	15-17-year-olds	1995 vs. 1996-1997	Fatal and injury crash involvement rate per 10,000 among 15-17-year-olds	9% reduction in the fatal and injury crash involvement rate in Florida during 1997 (first full year of GDL) compared with 1995 (before GDL).
Williams et al.	2003	USA	Cross-sectional study	All drivers	1996-2000 (FARS data)	Age-specific fatal crash rates	16-year-old drivers have the highest rates of fatal crashes involving one or two passenger vehicles (55 per 100,000). The rate of fatal crash involvement in one- or two-passenger vehicle-crashes per 100,000 drivers declines with age until age 70.
Williams et al.	1997	USA	Cross-sectional study	15- and 16-year-old drivers	1989-1993 (FARS data)	Number of fatal crashes	57% of 15-year-old drivers involved in fatal crashes did not hold a learner's permit and 16% were operating in violation of the terms of their permit at the time of the crash. There were few fatal crash involvements for 15 year-old learner permit holders engaged in supervised practice driving as permitted by state law. 88% of fatal crashes among 16-year-olds involved licensed drivers.
Williams et al.	1998	5 US states[8]	Cross-sectional survey	Parents of 15-year-olds	July 1996	Percent of parents supporting GDL and its elements	90% of parents supported requiring a minimum period of supervised driving before teenagers can get a driver's license. 77% of parents thought the new law would make teens better and safer drivers.

Authors	Pub Year	Jurisdic-tion	Study Method	Participants	Study Period	Outcome Measures	Reported Effects
Williams et al.	2002	California	Ecologic study	Teenagers <18 and parents	1998-1999	Behavior and attitudes of teenagers and parents (percent of teenagers and parents)	81% of parents in the post-GDL group and 67% of parents in the pre-GDL group thought their son or daughter had driven at least the 50 hours required. The median number of reported practice-driving miles was much greater among post-GDL teenagers (500) than pre-GDL teenagers (200). 40% of pre-GDL and 60% of post-GDL teenagers reported parents maintained a restriction on driving after midnight for at least 6 months of driving. 6% of the pre-GDL group and 39% of the post-GDL group reported that transporting passengers was not permitted for 6 months or longer. 4% of the pre-GDL and 20% of post-GDL group reported they never transported teenage passengers during the first 6 months of licensure. 69% of pre-GDL and 86% of post-GDL parents supported passenger restriction. 38% of pre-GDL and 43% of post-GDL teenagers supported the passenger restriction.
Williams et al.	2005	USA	Longitu-dinal study	16-year-old drivers	1993-2003	Fatal crashes of 16-year-old drivers	26% reduction in per capita crash rate for 16-year-olds over the period of study (1993-2003).
Zwicker et al.	1995-2003	California	Ecologic study	16-year-old drivers	1995-2003	Fatal and injury crash involvements of 16-year-old drivers per 10,000 population	23% reduction in fatal and injury crash involvement rate of 16-year-old drivers. 38% reduction in their crashes with injured teenage passengers.

[1] Excluding Alaska, Hawaii and the District of Columbia
[2] Excluding Alabama, DC, Massachusetts, and Vermont
[3] Excluding Alaska, Hawaii and the District of Columbia
[4] Louisiana, Maryland, Mississippi, New York, Ohio, Pennsylvania
[5] 1978-1980: New York, Pennsylvania, and Ohio; 1976-1980: Louisiana, Mississippi; 1974-1978 and 1979-1990: Maryland.
[6] States with curfew laws: Louisiana, Maryland, New York, and Pennsylvania. States without curfew laws: Mississippi and Ohio.
[7] Adjusted for trends in drivers 25 years and older
[8] Connecticut, Florida, Delaware, New Jersey, and New York

Methods

Unit of analysis

The basic unit of analysis for all analyses reported in this study was the state-quarter, which comprised:

- The age-specific number of fatal crash and injury crash involvements of drivers,
- An age-specific exposure estimate, and
- Indicators for the presence or absence of each of the GDL components (below) analyzed,

in a given state, during a given quarter-year. Quarters were defined by month of the year. Quarters were used rather than calendar years because various components of state GDL programs became effective at different points throughout the year. The four quarters were defined as January 1 – March 31, April 1 – June 30, July 1 – September 30, and October 1 – December 31.

The involvement of 16-year-old drivers in fatal crashes and in injury crashes was analyzed in relation to the GDL programs in effect in each respective state-quarter, using several methods described in the following sections, to draw inferences regarding the effectiveness of GDL programs in general and of programs characterized by the number of their program components meeting specific criteria. To assess the extent to which differences observed in the crash rates of 16-year-old drivers may or may not be attributable to GDL, the crash involvement of drivers aged 20-24, 25-29, and 30-54 was also analyzed in each respective state-quarter, under the assumption that these relatively older drivers should not have been impacted by GDL.

Driver involvements in fatal crash and injury crashes, rather than driver deaths and driver injuries, were analyzed, both to acknowledge the fact that the public health impact of crashes involving 16-year-old drivers is not limited to the deaths and injuries of crash-involved 16-year-old drivers themselves, and to allow more cases to be included in the study.

Population-based crash rates were selected over alternative rates, such as crashes per licensed driver or crashes per mile driven, because the outcome of interest was the public health impact of GDL; that is, the impact of GDL on the impact on the number of fatal crashes and injury crashes that occur.

Categorization of GDL programs

GDL Legislation

Information on GDL programs and their effective dates was obtained from IIHS, AAA, state government websites, and personal contacts with state personnel. IIHS has been tracking GDL programs since 1996, the earliest year in which any state adopted graduated licensing programs. Three lists were provided by IIHS: a list of components of graduated licensing programs for each state in 1996; a list including enacted, effective dates and details of licensing amendments for states that have changed their programs since 1996; and a list of components of graduated licensing programs for each state in 2005 (IIHS 2006). State government web sites were used to confirm the programs, resolve inconsistencies, and in some cases obtain the dates of changes in the programs. Additionally, AAA Government Relations & Traffic Safety Advocacy provided and/or verified information about state laws and their effective dates.

Although each GDL program has some distinct features, the main provisions of GDL program components generally fall into seven categories: minimum age for a learner permit, mandatory waiting period before applying for an intermediate license, minimum hours of supervised driving during the learner stage, minimum age for an intermediate license, nighttime driving restriction, passenger restriction, and minimum age for full licensing. Each of these GDL program components has been implemented with numerous variations over time and across states. To facilitate the statistical modeling that follows, the following criteria were used to dichotomize GDL components as present or absent. Table 2 shows how each component was dichotomized, and shows the number of states included in each analysis with each component present or absent.

Table 2: Definition of GDL components examined.

GDL component	N (%) of states used in fatal crash analysis. Total=43	N (%) of states used in injury crash analysis. Total = 35
Minimum age for learner permit		
• Minimum age 16 years for obtaining a learner permit	7 (16)	4 (11)
• Reference: less than 16 years	36 (84)	31 (89)
Mandatory holding period		
• Minimum 6 month holding period after obtaining a learner permit before applying for an intermediate license	31 (72)	24 (69)
• Reference: no mandatory holding period or less than 6 months	12 (28)	11 (31)
Minimum hours of supervised driving		
• Minimum 30 hours of supervised driving	19 (44)	18 (51)
• Reference: no required supervised driving or required less than 30 hours	24 (56)	17 (49)
Minimum entry age for intermediate stage		
• Minimum age 16½ years for obtaining intermediate stage license	4 (9)	2 (6)
• Reference: less than 16½ years	39 (91)	33 (94)
Minimum age for full licensing		
• Minimum age 17 years for full licensing	23 (53)	19 (54)
• Reference: less than 17 years	20 (47)	16 (46)
Nighttime restriction		
• No unsupervised nighttime driving after 10 p.m.	7 (16)	4 (11)
• Reference: no nighttime restriction or restriction beginning after 10 p.m.	36 (84)	31 (89)
Passenger restriction		
• No unsupervised driving with >1 passenger age <20	14 (33)	9 (37)
• Reference: no passenger restriction or >1 permitted <20 years	29 (67)	26 (63)

Description of components

The qualifying components were:

- A minimum age of **at least 16 years** for gaining a learner's permit.
- A requirement to hold the learner's permit for **at least 6 months** before gaining a license that allows any unsupervised driving.

- A requirement for certification of **at least 30 hours** of supervised driving practice during the learner stage.

- A nighttime driving restriction for intermediate license holders, beginning **no later than 10 p.m.**

- A passenger restriction for intermediate license holders, allowing **no more than one teenaged passenger** (except family members).

- An intermediate stage of licensing with a minimum entry age of **at least 16 years and 6 months.**

- A **minimum age of 17 years** for full licensure.

The first five of the criteria above are consistent with the GDL program component definitions for which IIHS awards the highest scores (IIHS 2006). The last two age restrictions were related to the first two in some but not all cases, and were analyzed as separate components. For example, if a state has a minimum age of 16 for a learner's permit, and requires the learner to hold the permit for at least 6 months prior to obtaining an intermediate license, then the state has a de facto minimum age of 16 years and 6 months for intermediate licensure. However, in some cases, an older minimum age was specified for intermediate licensure (e.g., 16 years and 9 months), such that a driver who received a learner's permit at age 16 years and 3 months (or later) would have been subject to the minimum permit holding period of 6 months, but a driver who received a learner's permit at an earlier age would be required to hold the learner's permit for longer than the specified minimum holding period, until reaching the entry age for the intermediate stage.

For the purpose of the analyses that follow, the effective dates of state GDL legislation, pertaining to three-stage GDL programs or to any of the seven components specified previously, were assigned to the quarter-year in which they became effective. Exploratory analysis revealed that 83% of the changes in GDL legislation that occurred during the study period occurred at the beginning of a quarter. Therefore, to simplify subsequent analyses, quarters during which GDL legislation became effective were classified as if the relevant legislation had been effective for the entire quarter.

Crash Data

Fatal crashes

Data on fatal crashes occurring during years 1994 through 2004 were obtained from NHTSA's Fatality Analysis Reporting System (FARS) database. FARS is a census of all traffic crashes within the U.S. that involve a motor vehicle traveling on a public road and result in a death within 30 days of the crash. For crashes involving a driver aged 16, 20-24, 25-29, or 30-54, driver age, crash state, crash month, and crash year were extracted for analysis. The unit of analysis was the driver; if a crash involved more than one driver aged 16 or 20-54, each was counted separately.

Injury crashes

Data on injury crashes occurring between 1994 and 2003 were obtained from NHTSA and from individual states. For the purpose of this study, crashes coded on police accident reports as having resulted in any injury to a vehicle occupant or non-motorist were classified as injury crashes and were included in the analysis. In the case of states reporting injury on the "KABCO" scale, crashes resulting in any K-, A-, B-, or C-level injury were included.

Fatal crashes were included in analyses of injury crashes. Therefore, analyses of fatal crashes and injury crashes reported here are not strictly independent; however, only about 1% of the injury crashes analyzed in this study were fatal, so the extent to which the results of the analyses of injury crashes were influenced by the inclusion of fatal crashes should have been minimal.

Property-damage-only crashes (i.e., crashes not resulting in any police-reported injury; also known as "PDO crashes" or "O" on the KABCO scale) were not included in the analysis, because the extent to which PDO crashes are represented in state crash databases is not consistent across states. Some states do not require PDO crashes to be reported to the police, and other states have a minimum dollar value threshold for estimated property damage, below which crashes are not reported, and this threshold varies across states.

NHTSA has been obtaining computerized data files coded from data recorded on police accident reports from states for several years. These data are referred to collectively as the State Data System (SDS). States that were participating in the SDS at the time of data collection were contacted for permission to use the data files that they had provided to NHTSA for use in the SDS. Data files were requested separately from representatives of non-SDS states. Ultimately, data were obtained from 40 states.

Computerized data files obtained from NHTSA and from individual states were received in various formats. Driver age, crash month, and crash year were recoded into a format common to all states and the recoded data from all states were merged using SAS.

Data used for analysis

Four quarters after the effective date of each GDL program or component (i.e., the quarter during which the program or component became effective, plus the three quarters that followed) were excluded from analyses, because licensing restrictions would not have affected drivers who already had their licenses when the legislation took effect, and it can be as long as four quarters (one full year) before all 16-year-old drivers in a state are subject to the legislation. Four quarters before the effective date were also excluded, because some teenagers might hasten to get their licenses in the period prior to new GDL legislation taking effect, thus possibly leading to short-term increases in crashes of novice drivers during those quarters. Thus a total of eight quarters (two years, but not necessarily calendar years) were excluded from the analysis for each occasion on which new GDL legislation became effective.

This study intended initially to analyze data from all of the contiguous 48 states (i.e., exclusive of Alaska and Hawaii), over the entire study period. However, data from several states were excluded from subsequent analyses for various reasons.

First, as a result of the state-quarter exclusion procedure described previously, it was determined that states with more than two changes in GDL legislation during the study period would be excluded from the study, because the exclusion procedure would have fragmented the data from these states to a degree such that their crash rates before and after the changes in legislation could not have been analyzed meaningfully.

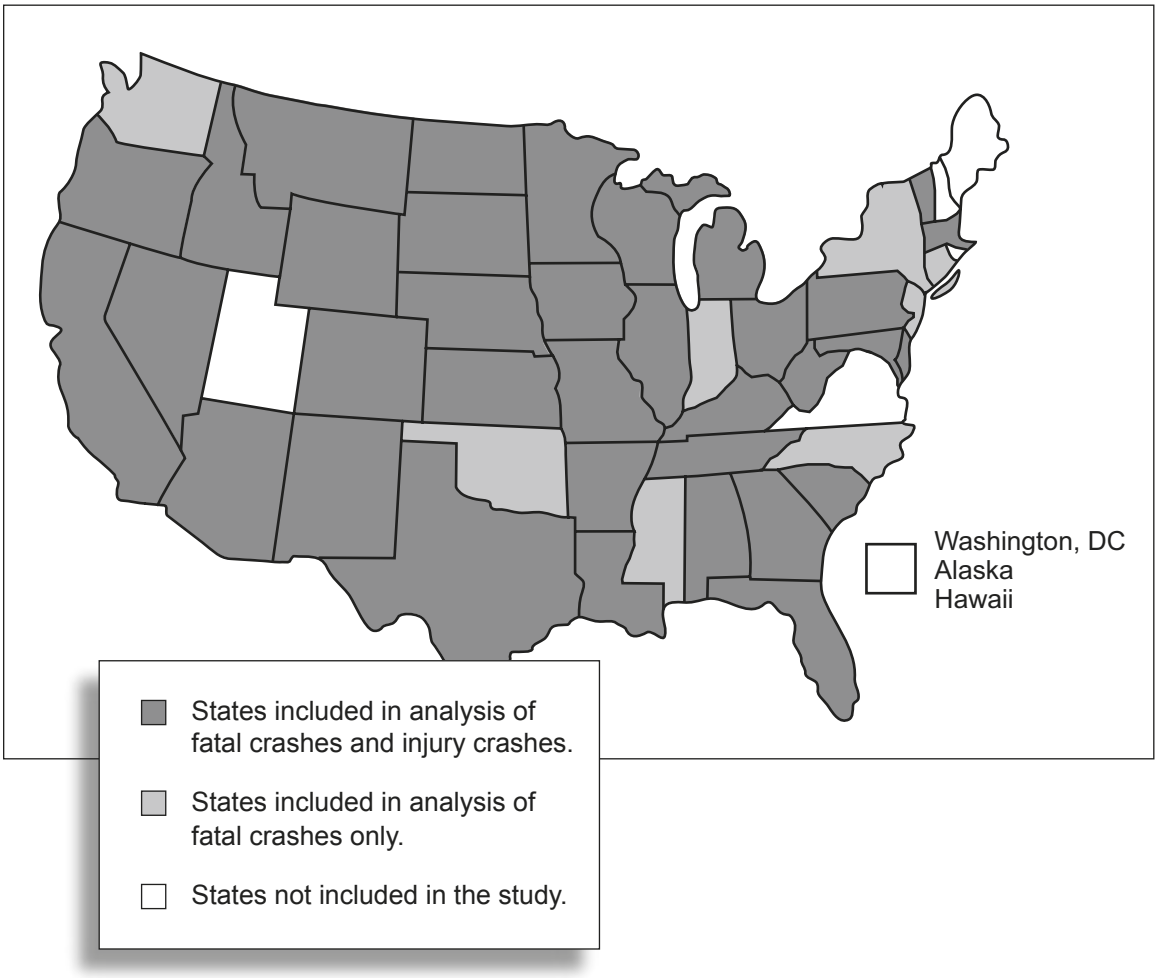
For example, if a state changed its GDL laws 3 times during the study period, each change would result in the exclusion of two full years of data. Thus, if three changes in laws occurred without any overlap between periods excluded, a total of six full years of data would have been excluded. The impact of changes in legislation occurring within two years of one another could not be evaluated, because the exclusion of four quarters after the first change and four quarters before the second change would eliminate all data after the first change and before the second. As a result, Maine, New Hampshire, Rhode Island, Utah, and Virginia were excluded from analyses due to the frequency and/or timing of changes in their GDL legislation.

Additionally, Washington D.C. was excluded from subsequent analyses, because early exploratory analyses showed that many fatal crash involvements of its residents occur in other jurisdictions, and a large proportion of fatal crashes occurring in Washington D.C. involved drivers from neighboring jurisdictions.

Finally, data from some additional states, for part or all of the study period, were excluded from analyses of injury crashes due to specific problems with the data files that were provided to the researchers. First, data that could not be recoded in SAS into the common format for analysis were necessarily excluded. Additionally, the data were explored to assess the quality of each state's data. Frequencies of all studied variables for each state and year were analyzed using SAS, and then evaluated to assess whether the values were plausible and generally consistent from year to year. The crash data codebook from each state was reviewed to determine whether or not there were any major changes in the state's data system. States whose data appeared to be deficient in quality (e.g., showed implausibly large increases or decreases in crash frequencies from year to year) were excluded from subsequent analyses. As a result of these considerations, data from two states were completely excluded; obvious discrepancies in data resulted in excluding data for one or two years in five states, as well as four years of data in one state. Appendix 3 shows the specific states and years of data used in analyses of injury crashes.

Ultimately, a total of 43 states were included in analyses of fatal crashes, and 35 states were included in analyses of injury crashes. These states are shown in Figure 1, below.

Figure 1: States included in the study.



Exposure Data

Midyear population estimates for each state from 1994 to 2004 were obtained from the U.S. Census Bureau. The age-specific exposure estimate of each state-quarter, expressed in person-years, was taken as the midyear population estimate for the corresponding age, state, and year, divided by four. These data were merged with the crash data in order to compute age-specific crash involvement rates in each state-quarter.

Analysis and Results

Unadjusted crash rates in relation to GDL program components

In order to examine the unadjusted effect of each GDL component, aggregate crash involvement rates of 16-year-old drivers (fatal crash involvement rates per 100,000 population and injury crash involvement rates per 1,000 population) were calculated for all states having each respective GDL component and for all states lacking each respective component. The calculations were based on the data that excluded one full year before any change in GDL legislation, as well as one full year after the change, as described previously.

Fatal crashes. Of the 1,480 state-quarters for which fatal crashes were analyzed, 237 (16%) had a three-stage GDL program in effect. During these state-quarters, 3,230 16-year-old drivers were involved in fatal crashes, yielding a crude rate of 25 fatal crashes per 100,000 person-years. The corresponding rate was 32/100,000 for state-quarters without three-stage GDL programs. These results are illustrated in Table 3.

For each of the GDL components, Table 3 also presents the number of state-quarters during which each respective component was in effect and the number of drivers involved in fatal crashes during those state-quarters. In all cases, the rates were lower in state-quarters having any given component in effect than in state-quarters not having that component. However, it is important to note that, in most cases, multiple components were in place in a given state-quarter, and that crash rates in a given state-quarter are influenced by all GDL program components in effect as well as by other factors unrelated to GDL, hence the differences in crash rates shown in Table 3 cannot be attributed solely the restriction in question.

Table 3: State-quarters with specified GDL program components, and corresponding involvement of 16-year-old drivers in fatal crashes[1]

Component	Categories	N (%) of State-quarters		N (%) of 16-year-old drivers in fatal crashes		Rates[2]
		(Total 1,480)		(Total 8,953)		
GDL programs	Yes	237	(16)	3,230	(36)	25
	No	1,243	(84)	5,723	(64)	32
Minimum age for learner permit	16 years	474	(32)	1,131	(13)	16
	< 16 years	1,006	(68)	7,822	(87)	33
Mandatory waiting period	6+ months	285	(19)	2,979	(33)	26
	None or <6 months	1,195	(81)	5,974	(67)	31
Minimum hours of supervised driving	30+ hours	285	(19)	1,775	(20)	24
	None or <30	1,195	(81)	7,178	(80)	31
Minimum age for intermediate stage	16½ years	53	(4)	176	(2)	10
	None or <16½ years	1,427	(96)	8,777	(98)	30
Minimum age for full licensing	17 years	492	(33)	3,273	(37)	21
	< 17 years	988	(67)	5,680	(63)	37
Nighttime restriction	Starts 10 p.m. or earlier	131	(9)	613	(7)	19
	None or starts after 10 p.m.	1,349	(91)	8,340	(93)	31
Passenger restriction	≤1 under 20 years old	172	(12)	979	(11)	19
	2+ allowed or no restriction	1,308	(88)	7,974	(89)	31
Total		**1,480**	**(100)**	**8,953**	**(100)**	**29**

[1] United States, 1994-2004, for the 43 states studied
[2] Driver fatal crash involvement rate per 100,000 person-years for relevant state-quarters

Injury crashes. Unadjusted rates of injury crashes are presented in Table 4. Note that not all state-quarters in the fatal crash analyses were included in the injury crash analyses, so a direct comparison with rates of fatal crash involvement is not appropriate. Note that for fatal crashes, 32% of state-quarters analyzed (474 of 1,480) had a minimum age of 16 years for obtaining a learner's permit, whereas for injury crashes, only 11% of state-quarters analyzed (90 of 850) had a minimum age of 16. One of the states included in the analysis of fatal crashes but not in analysis of injury crashes was New Jersey. New Jersey has a very low per-capita fatal crash rate for 16-year-old drivers,

most likely attributable to the fact that the minimum age for obtaining an intermediate license in New Jersey is 17; consequently, all (legal) driving by 16-year-olds in New Jersey must be supervised. Thus, without controlling for the presence or absence of other components, a component-by-component comparison of Tables 3 and 4 is likely to be misleading due to biases associated with the exclusion of some states from Table 4 that were included in Table 3.

Table 4: State-quarters with specified GDL program components, and corresponding involvement of 16-year-old drivers in injury crashes[1]

Component	Categories	N (%) of State-quarters		N (%) of 16-year-old drivers in injury crashes		Rates[2]
		(Total 850)		(Total 489,836)		
GDL programs	Yes	254	(30)	156,436	(32)	24
	No	596	(70)	333,400	(68)	31
Minimum age for learner permit	16 years	90	(11)	65,232	(13)	26
	< 16 years	760	(89)	424,604	(87)	28
Mandatory waiting period	6+ months	233	(27)	134,911	(28)	23
	None or <6 months	617	(73)	354,925	(72)	30
Minimum hours of supervised driving	30+ hours	147	(17)	90,099	(18)	21
	None or <30	703	(83)	399,737	(82)	30
Minimum age for intermediate stage	16½ years	19	(2)	8,663	(2)	14
	None or <16½ years	831	(98)	481,173	(98)	28
Minimum age for full licensing	17 years	249	(29)	183,388	(37)	24
	< 17 years	601	(71)	306,448	(63)	31
Nighttime restriction	Starts 10 p.m. or earlier	32	(4)	3,651	(1)	25
	None or starts after 10 p.m.	818	(96)	486,185	(99)	28
Passenger restriction	≤1 under 20 years old	54	(6)	29,564	(6)	16
	2+ allowed or no restriction	796	(94)	460,272	(94)	29
Total		**850**	**(100)**	**489,836**	**(100)**	**28**

[1] United States, 1994-2004, for the 28 states studied; most states did not provide data for all years, see Appendix 3 for list of states and years included

[2] Driver crash involvement rate per 1,000 person-years for relevant state-quarters

Statistical modeling of crash rates and GDL programs nationwide

The association between GDL programs and crash incidence was assessed using negative binomial regression models based on generalized estimating equations (GEE) (Diggle et al. 2002; Hardin and Hilbe 2003). The negative binomial distribution approximates the counts of crashes within state-quarters and the GEE approach takes into account the correlations among crash counts in states, quarters, and years due to factors that influence crash counts across states (e.g., demographics or level of urbanization), seasonal variation (e.g., weather or travel patterns), and over time (e.g., time trends across all states included in the study). Statistical software SAS® was used for the analysis (SAS 2003).

The basic units for analysis were individual state-quarters. Within the 11-year period from 1994 through 2004, 1,480 state-quarters were examined in the analyses of fatal crashes, and over the 10-year period from 1994 through 2003, 850 state-quarters were examined in the analyses of injury crashes.

Independent variables. The independent variable of primary interest was the presence or absence of GDL or its provisions. Two different approaches were used to characterize the GDL programs.

In the first approach, a dichotomous variable was used to indicate whether or not a three-stage GDL program was in effect in a given state-quarter, as defined by the inclusion of a learner stage and an intermediate stage in the licensing process. This analysis yielded the combined overall effect of all three-stage GDL programs that were in place over the study period. Note that the characterization of a GDL program as "a three-stage GDL program" refers only to whether or not it includes both a learner stage and an intermediate stage prior to unrestricted licensure, irrespective of how many of the specific program components defined in Table 2 that it included[†].

In the second approach, the licensing system for young drivers in each state-quarter was characterized on the basis of how many of the seven components specified

[†] Minnesota's licensing process has included both a learner stage and an intermediate stage since 1999; however, Minnesota's intermediate stage does not include any form of nighttime driving restriction or passenger restriction. For this reason, Minnesota sometimes is not classified as having a three-stage GDL program (e.g., IIHS (2006)); however, for the purpose of this study, Minnesota was classified as having a three-stage GDL program.

in Table 2 were included. Categorization of programs was based solely on the number of components included, irrespective of the presence or absence of a formal intermediate stage. This analysis yields the overall effect of all n-component programs in effect over the study period, relative to the overall effect of programs with none of the components meeting the criteria specified in Table 2.

Models based on the two approaches described above were fitted for the fatal crash and injury crash involvement of drivers aged 16, 20-24, 25-29, and 30-54.

Dependent variable. The outcome variable was the natural logarithm of the number of drivers of each respective age group that were involved in fatal crashes or in injury crashes in each respective state quarter. Separate models were fitted for each age group, and separate models were fitted for fatal crashes and for injury crashes.

Covariates. The model included covariates for state, year, and quarter. The state variables controlled for unmeasured state-specific variations that affect the number of crashes (e.g., demographics, level of urbanization). The quarter variables controlled for seasonal variations in crashes. The year variable controlled for nationwide variation in counts of fatal crashes over the years studied. Also included was the natural logarithm of the age-specific exposure estimate of the state-quarter, in person-years.

The basic model comparing state-quarters with GDL programs to state-quarters without GDL programs is as follows:

$$\text{Log}(y) - \text{Log}(\text{person-year}) = \alpha + ß_1\ (\text{GDL}) + ß_2(\text{Year}) + \sum_{i=1}^{3} ß_i(\text{Quarter}_i) + \sum_{j=1}^{n} ß_j(\text{State}_j) + \varepsilon$$

Where:

- Outcome y = count of fatal crash involvement of drivers of the age being analyzed, in a specific state-quarter
- Offset variable = age-specific person-years in that state-quarter.
- GDL =
  - 1 if a three-stage GDL program is in effect in the state-quarter, 0 otherwise (first model)
  - the number of the components defined in Table 2 in effect in the state-quarter (second model)

- Year = calendar year of the state-quarter being analyzed.
- $Quarter_1$ to $Quarter_3$ as dummy variables for quarters
- $State_1$ to $State_n$ as dummy variables for states (n = 42 in analysis of fatal crashes; n = 35 in analysis of injury crashes).

The states were the clusters for GEE estimates. An exchangeable working correlation structure was assumed.

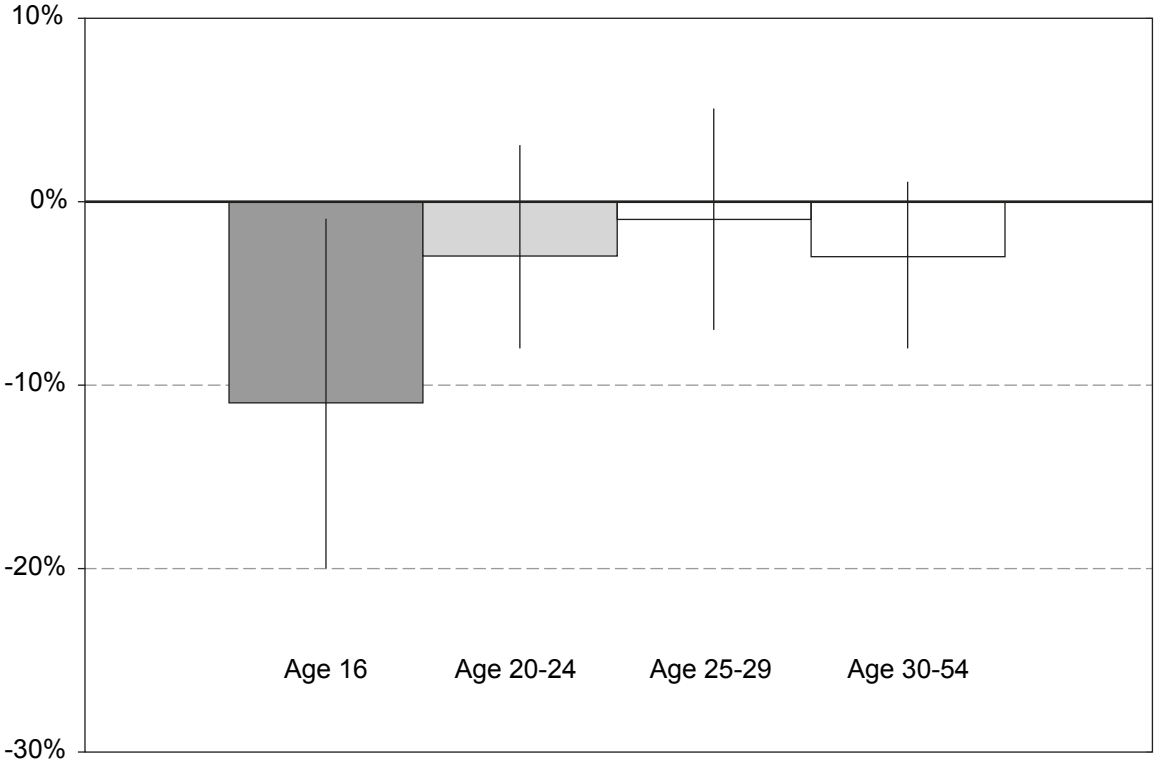
Outcome Measure. The outcome measure was the Incidence Rate Ratio (IRR), which is the exponential of the regression coefficient of the GDL variable. In the first model, the IRR is the ratio of the rate of fatal or injury crash involvement of 16-year-old drivers per person-year in state-quarters with three-stage GDL programs in effect, relative to the rate in state-quarters without three-stage GDL programs, adjusted for differences associated with state-, year-, and quarter-fixed effects. In the second analysis, the IRR is the ratio of the rate of crash involvement of 16-year-old drivers per person-year in state-quarters in which n of the seven GDL components from Table 2 were in effect, relative to the corresponding rates in state-quarters in which none of those components were in effect, adjusted for differences associated with state-, year-, and quarter-fixed effects. An IRR lower than 1.00 indicates that having the type of GDL program being analyzed (i.e., a three-stage GDL program in the first model, or an n-component GDL program in the second model) is associated with lower crash rates relative to the reference program type.

Incidence rate ratios in relation to all three-stage GDL programs

Fatal crashes. The statistical modeling described previously found that having a three-stage GDL program in effect was associated with an overall fatal crash involvement rate of 16-year-old drivers that was 11% lower, adjusted for state-, year-, and quarter-fixed effects, compared with state-quarters without a three-stage GDL program (IRR 0.89, CI 0.80-0.99). Fatal crash involvement was also analyzed for drivers aged 20-24, 25-29, and 30-54 in the same state-quarters. Drivers in these older age groups were exposed to driving environments similar to those of novice drivers but were unlikely to be influenced by GDL programs. The apparent reductions in fatal crash involvements

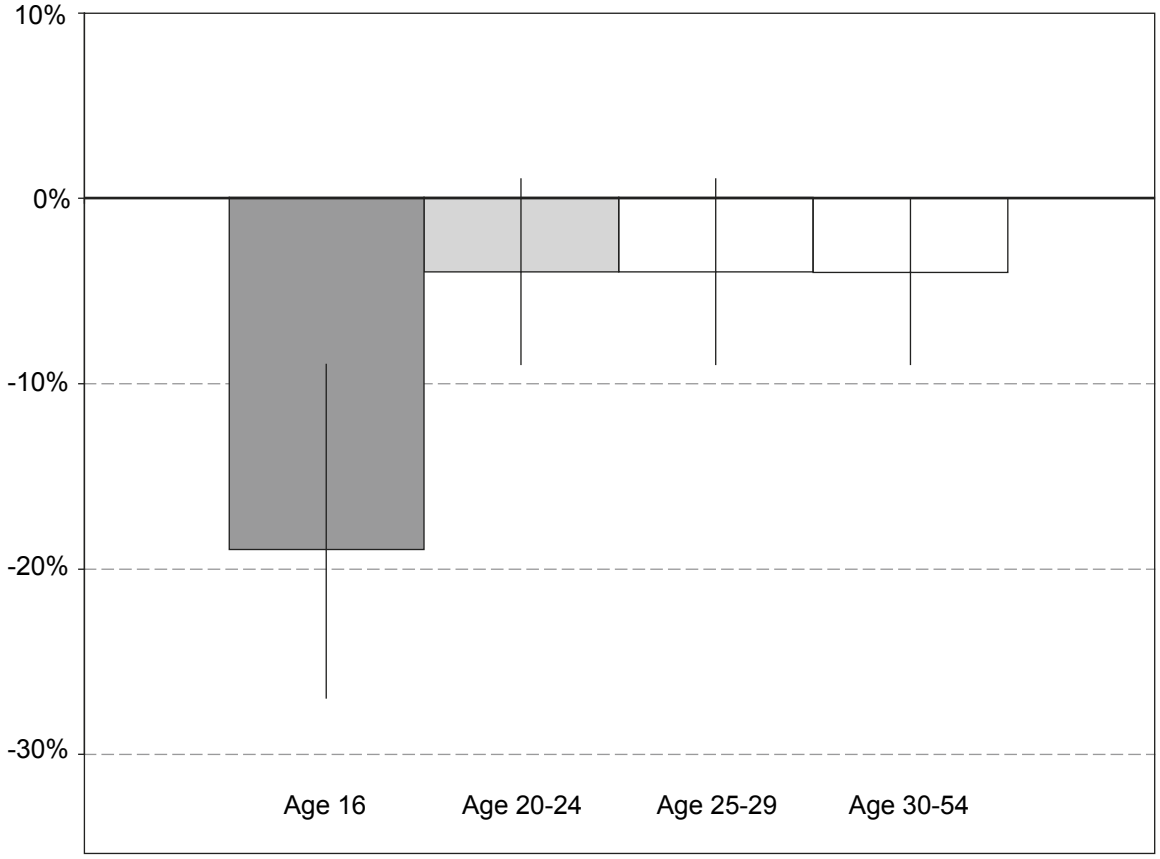
for these older comparison drivers were smaller (i.e., their incidence rate ratios were closer to 1), and were not statistically significant at the 95% confidence level, suggesting that the overall fatal crash involvement rates of drivers aged 20-24, 25-29, and 30-54 did not change in association with the implementation of three-stage GDL programs. These results are shown in Figure 2 and in Table A2-1 in Appendix 2.

Figure 2: Percentage difference in fatal crash involvement rates in relation to driver age and presence of a three-stage GDL program. Solid vertical lines represent 95% confidence intervals.



Injury crashes. The overall injury crash involvement rate of 16-year-old drivers was 19% lower in state-quarters with three-stage GDL programs in effect, relative to state-quarters without a three-stage GDL program (IRR 0.89, CI 0.80-0.99). As with fatal crashes, the three groups of older comparison drivers did not experience any statistically significant reduction in injury crash involvement rates. These results are shown in Figure 3 and in Table A2-2 in Appendix 2.

Figure 3: Percentage difference in injury crash involvement rates in relation to driver age and presence of a three-stage GDL program. Solid vertical lines represent 95% confidence intervals.

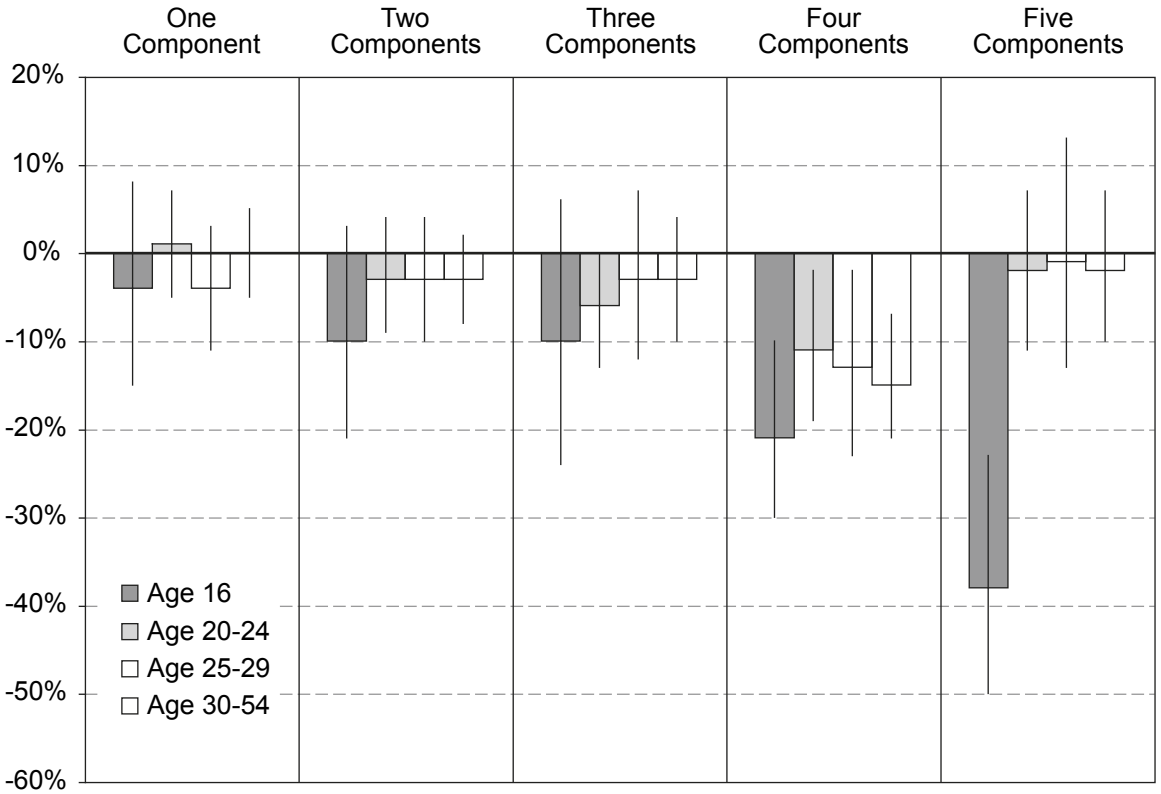


In summary, the fatal crash and injury crash involvement rates of 16-year-old drivers were 11% lower and 19% lower, respectively, in state-quarters with three-stage GDL programs in effect than in state-quarters without three-stage GDL programs, adjusted for state-, year-, and quarter-fixed effects. Again, this finding represents the overall impact of the full range of three-stage GDL programs, including the weakest and least effective, analyzed without regard to the number or strength of their components, and is not indicative of the full benefits of stronger GDL programs.

Incidence rate ratios in relation to number of program components

Fatal crashes. Relative to their rates in state-quarters with no GDL program components meeting the definitions provided in Table 2, the fatal crash involvement rates of 16-year-old drivers were 38% lower in state-quarters with five GDL program components in effect (IRR 0.62, CI 0.50-0.77), and 21% lower in state-quarters with four GDL program components in effect (IRR 0.79, CI 0.70-0.90). Note that five was the greatest number of components meeting the definitions provided in Table 2 in any state-quarter included in the study. Apparent reductions associated with programs having three or fewer components in effect were smaller and were not statistically significant at the 95% confidence level. These findings are shown in Figure 4 and summarized in Table 5.

Figure 4: Percentage difference in fatal crash involvement rates in relation to driver age and number of GDL program components. Solid vertical lines represent 95% confidence intervals.



Injury crashes. Results of analyses of injury crash involvement rates in relation to the number of program components showed that the injury crash involvement rate of 16-year-old drivers was 40% lower in state-quarters with five GDL program components in effect (IRR 0.60, CI 0.44-0.83), and 36% lower in state-quarters with four

GDL program components in effect (IRR 0.64, CI 0.45-0.91), relative to the injury crash involvement rates of 16-year-old drivers in state-quarters with no program components meeting the definitions provided in Table 2. Unlike the results for fatal crashes, programs with only two or three program components experienced statistically significant—albeit smaller—reductions in the injury crash involvement rate of 16-year-old drivers. These findings are shown in Figure 5 and summarized in Table 5.

Figure 5: Percentage difference in injury crash involvement rates in relation to driver age and number of GDL program components. Solid vertical lines represent 95% confidence intervals.

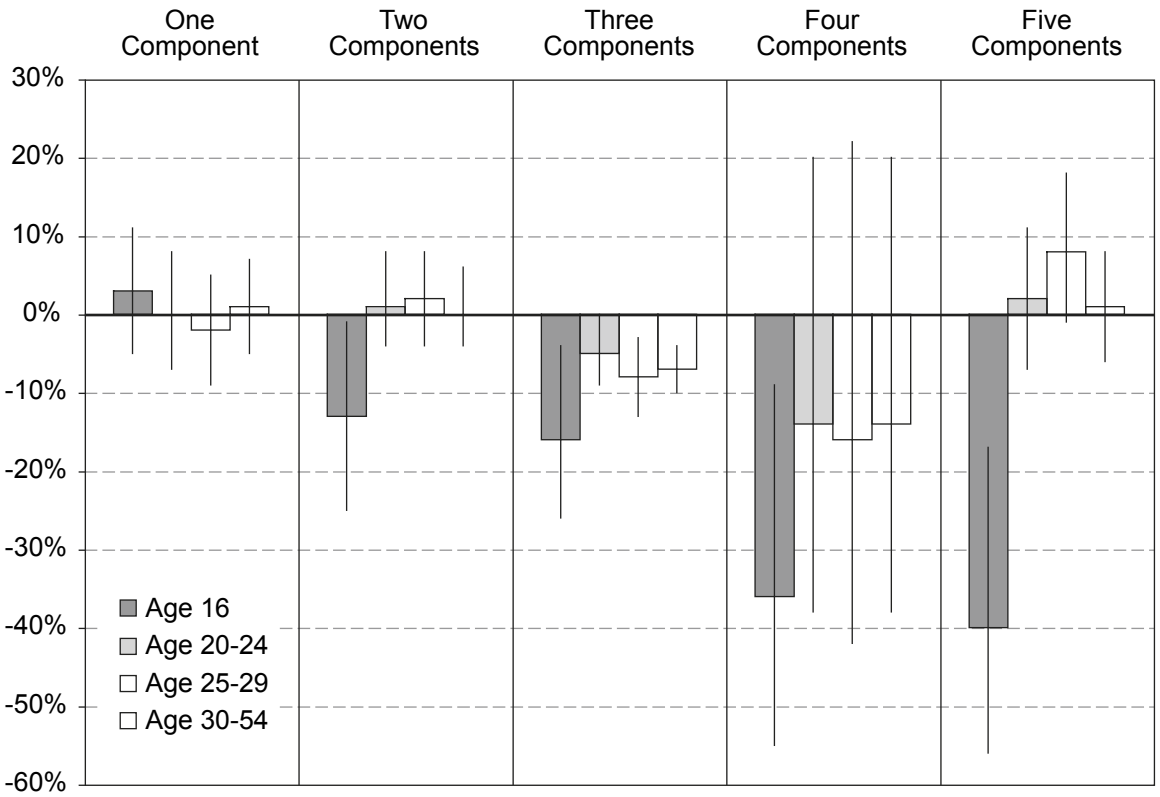


Table 5: Incidence Rate Ratios (IRRs) and 95% Confidence Intervals (CIs) for 16-year-old drivers in fatal crashes and injury crashes in relation to number of GDL program components.

Number of GDL components[1]	Fatal crashes[2]	Injury crashes[3]
One	0.96(0.85-1.08)	1.03(0.95-1.11)
Two	0.90(0.79-1.03)	0.87(0.75-0.99)
Three	0.90(0.76-1.06)	0.84(0.74-0.96)
Four	0.79(0.70-0.90)	0.64(0.45-0.91)
Five	0.62(0.50-0.77)	0.60(0.44-0.83)

[1] Compared to State-quarters with none of the 7 components in Table 2

[2] 1994-2004

[3] 1994-2003

Comparisons with older drivers. Fatal crash involvement rates of drivers in age groups 20-24, 25-29, and 30-54 did not change significantly in association with the number of GDL components, with the exception of rates for state-quarters with four components. In those state-quarters, the three groups of older comparison drivers experienced apparent reductions of 11% to 15%, relative to their rates in state-quarters with zero components in effect. Possible explanations for this unexpected finding are suggested in the Discussion section of this report.

Discussion

This report presents, for the first time, data on injury crashes from a large number of states that have been subjected to a common analysis of their GDL programs, plus an identical analysis of fatal crash data obtained from FARS. This nationwide research on GDL programs has demonstrated a strong association between multi-component GDL programs and lower crash rates of 16-year-old drivers. The analyses point to significantly lower involvement rates in fatal crashes and injury crashes of 16-year-old drivers exposed to programs with the most components: 16-year-old drivers' rates of involvement in fatal crashes and injury crashes were lower by 38% and 40%, respectively, after implementation of GDL programs with five of the seven components analyzed.

In addition to including injury crashes, this research differs from research reported by the same authors in an earlier, related project addressing the involvement of 16-year-old drivers in fatal crashes (Chen, Baker, and Li 2006), in that the criteria for most of the qualifying components were stricter in this current study. This is discussed further below.

Summary of findings

Fatal crashes

Fatal crash involvement rates of 16-year-old drivers were lower by 21% and 38%, respectively, when programs had four or five GDL components in effect, based upon comparisons with state-quarters with no GDL components. State-quarters with fewer than four components were not associated with statistically significant reductions in fatal crash rates of 16-year-old drivers.

Fatal crash involvement rates of the older comparison drivers aged 20-24, 25-29, and 30-54 generally did not show an association with GDL programs—that is, their rates in the same state-quarters did not decline significantly. An exception was the case of the fatal crash involvement rates of the comparison drivers in state-quarters with four GDL program components in effect. Surprisingly, all three groups of comparison drivers appeared to experience statistically significant reductions in their fatal crash involvement rates. It is statistically unlikely that all three of these unexpected, statistically significant reductions occurred due to chance. It is possible that the apparent reduction was associated with factors not accounted for in the statistical model, e.g., that control for temporal trends was not adequate and/or that there were other safety-relevant occurrences in some or all of the state-quarters in which four GDL program components were in effect. It is also possible that this unexpected result is attributable, at least in part, to broader societal attitudes in general, which may have both allowed these relatively strong GDL programs to be enacted, and also influenced safety in other ways. The present study is not able to explain this unexpected finding.

For all GDL programs combined, regression analyses pointed to an overall reduction of 11% in fatal crash involvement of 16-year-old drivers compared with non-significant reductions of 3% or less in older drivers. The 11% reduction was based upon all types of GDL programs, including the weakest, and therefore does not reflect GDL's full potential. Compared with the lowering of rates that was seen in association with the most effective programs, the results suggest that substantial improvement in the national average could be achieved if states were to improve their programs to the greatest extent possible.

Injury crashes

Results for injury crashes were similar to the results for fatal crashes, but with somewhat greater reductions in crash involvement rates of 16-year-old drivers than were found in fatal crashes. For all GDL programs combined, including weaker programs, an overall reduction of 19% was shown by regression analyses that adjusted for state and time. For programs with five components, a reduction of 40% was seen in involvement rates of 16-year-old drivers.

As in the case of fatal crashes, findings are strengthened by the fact that drivers aged 20 and older, who generally would not have been affected by GDL implementation or changes, did not experience reductions similar to those seen for 16-year-old drivers.

Figures 5 and 6 illustrate the progressively greater reductions in both fatal crashes rates and injury crash rates of 16-year-old drivers associated with increasing GDL program restrictiveness, as measured by the number of GDL components in effect. Thus, risk of crash involvement decreased in an apparent dose-response fashion as the restrictiveness of GDL programs increased.

Comparisons with other research

Studies evaluating GDL programs find them to be associated with reductions in fatal and nonfatal crash injuries (Agent et al. 2001; Shope and Molnar 2004; Williams 1999). Reductions in crashes ranging from 4% to 60% have been reported for GDL programs in New Zealand, Canada, and the U.S (Simpson 2003). Although the magnitude of crash reduction is variable given the wide range of reductions observed, the direction of GDL effect has consistently been positive. The variability associated with the magnitude of crash reductions may result from differences in compliance, in specific components of GDL programs, and/or in the research designs and analytic procedures used to evaluate GDL programs (Simpson 2003).

This research differs from earlier research by the same authors in that it includes analyses of injury crashes, based on police-reported data for 35 states. Furthermore, it provides comparison data for drivers aged 20-24, 25-29, and 30-54. Most importantly, the seven components were defined to be more restrictive than in the previous study (Chen, Baker, and Li 2006). For example, in this study, a qualifying passenger restriction allowed no more than one passenger, whereas, in the previous study, any nominal passenger restriction was counted, even if it allowed as many as three passengers. In the previous study, components were dichotomized primarily on the basis of the numbers of state-quarters that would be needed for analysis. In this study, a special effort was made to estimate the effectiveness of what would appear to be relatively “stronger” programs. In the previous study, programs with six or seven components (as defined in that study) were associated with a 21% reduction in the fatal crash involvement of 16-year-old drivers, programs with five components were associated with an 18% reduction, and programs with fewer than five components were not associated with statistically significant reductions. In contrast, using the stricter program component definitions in the current study, no state-quarter had more than five program components in effect, and programs with five components (as defined in this study) were associated with a 38% reduction in the fatal crash involvement of 16-year-old driver,

and programs with four components were associated with a 21% reduction that was still statistically significant.

Other national evaluations

All of the national evaluations to date have been restricted to fatal crashes. It is possible that drivers involved in non-fatal crashes are more responsive to GDL restrictions, since the most serious crashes are generally more common among drivers who are least susceptible to behavioral interventions. For example, drivers with the highest blood alcohol concentrations are at the greatest risk of being in a fatal crash (Zador, Krawchuk, and Voas 2000).

Research reported by Dee et al. (2005) examined fatal crash rates of drivers aged 15 to 17 in 48 states and found a 6% reduction in that inclusive age group in state-years with GDL. Unlike the research presented in this report, the specific effect on 16-year-old drivers (as opposed to ages 15-17 as a group) was not examined. As a result, the reported reduction was no doubt smaller than it would have been if limited to 16-year-olds drivers. The analysis did not differentiate between weaker and stronger programs.

Morrisey et al. (2006) also studied drivers aged 15-17, but took a different approach, comparing the relationship between their fatal crash rates and the IIHS's rating system for GDL programs (IIHS 2005). Programs categorized as "good" were associated with a 19% reduction in fatalities, whereas "fair" and "marginal" programs failed to produce a significant change. "Fair" programs were associated only with a 13% reduction that was limited to nighttime crashes (Morrisey et al. 2006).

The findings of Morrisey et al. (2005) are consistent with the findings of the current study, in that only programs meeting a number of criteria based on restrictive regulations were associated with measurable reductions in crash rates of 16-year-old drivers. However, because the current study focused on 16-year-old drivers, it was able to identify substantially greater benefits than were seen for 15- to 17-year-olds as a group exposed to "good" programs.

Evaluations of single jurisdictions

In the U.S. and Canada, the effect of GDL has been evaluated in many individual states and provinces. Virtually all of the published evaluations have reported GDL-re-

lated reductions in crashes of novice drivers. The major limitation of the U.S. studies is that they are generally missing for state programs where GDL-related reductions have not occurred or are not significant, judging from previous unpublished analyses of individual states conducted by the authors of this study. Many of the missing states are too small for any changes to have achieved statistical significance. Their inclusion in the current study is of benefit because it provides a realistic appraisal of the effect of GDL programs in general, rather than emphasizing the more successful programs or the larger states.

Results of studies evaluating programs in individual states are difficult to compare because programs differ in their components, analytic methods vary, and some studies report changes in crude rather than adjusted rates. In some cases rates are reported per licensed drivers rather than per population, the more common denominator.

It is not possible to distinguish the benefits of a regulation, per se, from the benefits of implementation, enforcement, and compliance with that regulation. It is possible that when there is no reduction in crash involvement in association with a particular GDL program, it is because compliance is low. This could be due to a lack of publicity, enforcement, and/or parental involvement. Parents are essential to the enforcement of the supervised driving restriction as well as any night driving. Passenger restrictions are especially difficult for parents to monitor. Goodwin and Foss, however, found through surveys of teen drivers and their parents that passenger-carrying and night-driving restrictions generally were observed (Mayhew et al. 2006). Parental support for nighttime restrictions is high, with 74%-94% approval (Ferguson and Williams 1996; Mayhew et al. 1998; Williams et al. 1998; Williams, Nelson, and Leaf 2002). Passenger restrictions have a somewhat lower level of favor among parents, with 43%-72% approval (Ferguson and Williams 1996; Ferguson et al. 2001; Goodwin and Foss 2004; Mayhew et al. 2006).

Limitations of the research

GDL is not a simple point-in-time intervention but a complex change involving licensing, enforcement, and parental involvement as well as other effects that may be difficult to recognize or analyze. All of these factors vary among the dozens of states analyzed. Although the statistical model used in this study controlled for true state-fixed effects (e.g., topography), year-fixed effects (e.g., time trends across all states included

in the study), and quarter-fixed effects (e.g., seasonal weather or travel patterns), it could not control for factors other than GDL that may have changed at different times in different states over the course of the study (e.g., changes in socioeconomic factors that may have impacted some but not all states or impacted different states differently, or changes in non-GDL legislation that occurred at different times in different states).

The study did not investigate the mechanisms by which GDL results in lower crash rates. Existing research suggests that GDL achieves its effects through some combination of the following (Foss et al. 2001):

- teens licensed under GDL drive less than teens not licensed under GDL,
- teens licensed under GDL programs generally drive more safely than teens not licensed under GDL,
- teens licensed under GDL do less driving under hazardous conditions than teens not licensed under GDL, and/or
- after GDL is implemented, more teens postpone their applications for licenses.

Population was used as our exposure measure because we were interested in the public health impact of GDL. Population-based crash rates are lower than rates per licensed driver. Population-based rates are preferable when one wishes, as we did, to measure the overall effect of GDL on fatal crashes and injury crashes of a group such as 16-year-olds. Studies attempting to analyze the impact of GDL on the safety of licensed drivers might wish to analyze crash rates per licensed driver rather than per unit population, and similarly, studies attempting to analyze the impact of GDL on the safety of the driving that is done by new drivers might wish to analyze crash rates per mile driven. However, at present, there is no national data source that could supply driving mileage data for drivers by state, calendar year, and single year of age. Additionally, existing driver licensing data would present some difficulties for such a study. For example, license data for several states do not include drivers with provisional licenses, whereas crash data do not typically differentiate between provisional licenses and full-privilege licenses of the drivers, thus preventing computation of meaningful crash rates (IIHS 2006b).

Without information on driver licensing, it was not possible to determine how much of the effect of GDL was due to reduced exposure because of 16-year-olds delay-

ing licensure until an age when they would not be affected by GDL. By excluding the four quarters before the effective date of new GDL legislation, this study minimized the effect of changes in the numbers of licensed drivers that may occur when 16-year-olds hasten their licensure in the interest of becoming licensed before new restrictions take effect. Four quarters were also excluded after the effective date of new GDL legislation, because it can be as long as one full year before all 16-year-olds in a given state are covered by a new restriction.

Assessment of the relative effectiveness of individual components, while desirable, would be extremely problematic because a GDL program in any given state is implemented in its entirety and works as a whole. To break down GDL programs into individual components for evaluation could lead to misleading results. Similarly, although it would be ideal to be able to determine the optimal combination of GDL components, the number of state-quarters in which various combinations have actually been implemented limits examination of this issue for each of the myriad combinations in the dataset.

When counting components, the analysis gave equal weight to all seven components meeting the inclusion criteria in this study (Table 2), even though some are probably more important than others. In many preliminary analyses we experimented with omitting various components, but the results did not show the value of excluding any component(s). Until their relative importance has been established by other research, the number of components appears to be the only way to assess the effect of adding various components to GDL programs. In states with large populations that add a single component, it should be possible to evaluate the effect several years later.

This study was not able to differentiate among the many variations in each type of restriction—for example, the hours during which nighttime driving restrictions are in effect. To do so would have required increasing the number of components analyzed and resulted in having too few state-quarters for meaningful analysis of each component. The limited numbers of state-quarters having each type of restriction required us to dichotomize variables such as “night restriction beginning no later than 10 p.m: ‘present’ or ‘absent’.”

Policy-makers and those who advise them about teen driving issues should not interpret these findings to mean more than they do. For example, although the compo-

nents analyzed included state requirements for at least 30 hours of supervised driving practice, the results do not prove that this is ideal. Sixty or 100 hours of supervised driving may well be preferable to 30 hours, but because of data limitations we could not address this question. Moreover, there may be some very effective GDL programs whose components do not match the definitions of the seven program components that were analyzed here. For example, North Carolina does not require a specified number of hours of supervised driving; rather, an intermediate license is not issued until at least a year after the beginning of the learner period, during which all driving must be supervised. Parent and teen surveys suggest that teens are receiving substantially more than 50 hours of practice during that year and that parents strongly endorse the lengthier learner period (Goodwin and Foss 2004). Foss et al. found that program to be very effective (2001).

Missing data from some states have the potential to create two problems: First, some states did not provide data. This would be a problem if there were any relationship between the success of the GDL program and states' ability to provide data. While this may be unlikely, it could result in an overestimate of the effectiveness of GDL. Second, a few states did not have data for certain years or had data quality problems in certain years. This appeared to have occurred at random and should not have influenced the results of this study. Where data problems were evident, the data were not used.

The use of midyear census estimates of populations was necessary because the study examined changes in crash rates over the period 1994 through 2004, during which the decennial census occurred only once (in 2000). Thus, the exposure estimates used in all rate calculations is subject to some degree of random error. It is unlikely that any errors would have seriously biased our findings; however, the result is that the confidence intervals reported in figures and tables are therefore artificially narrow.

Finally, this research was not intended to identify risk factors for crashes of novice drivers; this important topic has been addressed in a number of publications (Begg and Stephenson 2003; Bingham and Shope 2005; Elliot et al. 2006; Hedlund, Shults, and Compton 2006; Simons-Morton and Ouimet 2006).

Indications of a causal association

The results of this research suggest that the association between Graduated Driver Licensing and lower rates of crash involvement among 16-year-old drivers is probably a causal relationship, based on the following considerations:

1. **Strength of the association:** Three-stage GDL programs are associated with an 11% reduction in fatal crash risk and 19% reduction in injury crash risk, reductions that are of practical as well as statistical significance. Even greater reductions are associated with GDL programs having five of the identified components

2. **Temporality:** The analyses compared state-quarters after implementation to state-quarters before implementation.

3. **Specificity:** The apparent effect was greatest in the case of 16-year-old drivers, the focus of the intervention.

4. **Dose-response relationship:** The safety benefit of GDL increased with the number of restrictive components.

5. **Consistency:** Results are consistent across studies, places, and populations.

6. **Plausibility:** GDL is based on developmental theory and aims to regulate exposure to driving hazards during the early experience-building stage for novice drivers. Empirical data from population-based surveys indicate that GDL programs have the intended effects on driving behaviors and parental supervision. Thus, the safety benefit of GDL reported in this and other studies is completely plausible.

Recommendations

Recommendations for states

Based upon our findings that the most restrictive GDL programs are associated with the greatest reductions in crashes of 16-year-old drivers, states should move to have a full complement of meaningful restrictions in their GDL programs. There appeared to be substantial difference between the reductions (38% for fatal crashes, 40% for injury crashes) that were seen in connection with GDL programs having five of the components analyzed and the smaller reduction seen for all three-stage GDL programs combined (11% for fatal crashes, 19% for injury crashes). This difference indicates the potential for improvement in the safety of novice drivers, as well as the safety of their passengers and those who share the roads with them. Upgrading weaker programs therefore should be a high priority for states wishing to reduce traffic-related deaths and injuries. An intermediate phase is generally needed that restricts driving in hazardous circumstances, yet gives novice drivers a chance to drive without supervision under less hazardous conditions.

Also important is the need for states to upgrade the specific parameters of the various components—for example, to change a nighttime restriction so that it begins at 9 or 10 p.m. rather than at midnight or later. At present, the IIHS categorization of GDL programs (IIHS 2006) is widely considered to be a gold standard. In order to be categorized as having a "good" GDL program, a state would need a program that achieved 6 points on the IIHS scale. As evidence accrues, the IIHS standard may change, or states may wish to set their own goals.

States have a vital role to play in the process of providing parents and the law enforcement community with the relevant information on GDL. Both police and parents need to be informed about the specific requirements of the GDL programs in their states and the rationale for them. In particular, requirements for adult supervision and restrictions on passengers and nighttime driving require knowledge and commitment on the part of parents as well as law enforcement.

A broad approach to reducing crashes of novice drivers might also include skills training, attitude training, and involvement of communities, parents, and the teenagers themselves.

Recommendations for advocates

Advocates for safer driving by teenagers should first become familiar with the rapidly expanding knowledge base about GDL. Opportunities to convey this knowledge to parents, teens, and the wider community include interchanges with the media and the schools.

Advocates can play a role in strengthening GDL programs by encouraging the inclusion of parental involvement as a critical element of state programs. Parents are responsible for making sure their children adhere to GDL requirements. In addition, collaboration among parents may encourage parental enforcement to be consistent within the neighborhood or within children's peer groups -- thus reducing pleas such as "Aw Mom, all the other guys are allowed to . . ."

Legislators depend upon information from informed sources about the content, purpose, and scientific background for changes in traffic safety laws. Advocates have a crucial role to play in shaping the opinions of legislators and members of the public about graduated driver licensing.

The topic of graduated driver licensing is of interest to the media, and advocates have an opportunity to enlist the media in their efforts to improve teenage drivers' safety on the road.

Recommendations for researchers

Evaluation of GDL programs should continue as data become available for more states and for longer time periods. With larger databases, examination of specific combinations of components may be possible. Future research may be able to provide guidance as to the specific benefits of the various components of GDL systems.

Research is needed to determine whether GDL affects the crash involvement of older teenage drivers, especially those aged 17 or 18. Unlike drivers 20 and older, their involvement rates could be affected either negatively or positively by GDL. They were omitted from these analyses for that reason.

Future research should also investigate the effectiveness of specific components of GDL programs (e.g., nighttime driving restrictions), including evaluation of different variations of similar components (e.g., the hours during which a nighttime driving restriction is in effect). Research to determine the appropriate minimum age for supervising drivers is also needed.

Finally, future research should investigate how other aspects of program implementation (e.g., publicity and enforcement) influence the effectiveness of GDL programs.

Conclusions

Graduated driver licensing programs with the largest number of components meeting the definitions used in this study are achieving reductions of 38% and 40% in fatal crashes and injury crashes, respectively, of 16-year-old drivers. The association between GDL and lower crash rates of these novice drivers appears to be a causal relationship.

Our results underscore the potential value of strengthening state GDL programs. States whose programs included five of the seven components defined in this study experienced 38% and 40% reductions, respectively, in the fatal crash involvement and injury crash involvement of 16-year-old drivers, as compared to the nationwide average reductions of only 11% and 19% for all three-stage GDL programs taken together and analyzed irrespective of the number of components that they included. The sizeable reductions in crash rates associated with the more comprehensive programs demonstrate that substantial nationwide crash reductions are attainable.

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APPENDIX 1: State Graduated Driver Licensing laws

Table A1: State Graduated Driver Licensing laws in effect as of February 15, 2007.

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
Alabama (CCF)	15	6	16	Midnight to 6 a.m.	No more than 4 passengers (3 teens plus a parent/guardian)	17	30 (waived for students who complete driver ed.)
Alaska (CCF)	14	6	16	1 a.m. to 5 a.m.	No passengers under 21 (siblings exempt)	16 and 6 mo	40 [10]
Arizona	15 and 7 mo	5	No intermediate license stage			16	25 [5] (waived for students who complete driver ed.)
Arkansas (BELT, CCF, DE)	14	6	No intermediate license stage			16	None
California (CCF, DE)	15 and 6 mo	6	16	11 p.m. to 5 a.m.	First 12 mo no passengers younger than 20 unless supervised by a 25-yr-old driver. (Family members exempt.)	17	50 [10]

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
Colorado (BELT, CELL, DE)	15 (w/ driver ed., classroom & behind-the-wheel course) 15 and 6 mo (w/ defensive driving course) 16 (w/out formal ed.)	12	16	Midnight to 5 a.m.	First 6 mo no passengers under age 21. Second 6 mo only 1 passenger under age 21 (family members exempt).[1]	17	50 [10]
Connecticut (CELL)	16	4 (w/ driver ed.) 6 (w/out driver ed.)	16 and 4 mo	Midnight to 5 a.m.	First 3 mo no passengers. Second 3 mo no passengers (family members exempt).	18	20
Delaware (CCF, CELL, DE)	16	6	16 and 6 mo	10 p.m. to 6 a.m.	No more than 1 passenger (family members exempt)	17	50 [10]

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
D.C. (CELL)	16	6	16 and 6 mo	Sep – Jun: Starts 11 p.m. (Sun-Thu) and midnight Fri-Sat nights), ends 6 a.m. Jul – Aug: midnight to 6.a.m.	First 6 mo no passengers unless supervised by 21-yr-old driver (family members exempt). Thereafter, no more than 2 passengers under 21 (family members exempt).	18	Learner: 40 Intermediate: 10 (night)
Florida (CCF)	15	12	16	11 p.m. to 6 a.m. (age 16) 1 a.m. to 5 a.m. (age 17)	None	18	50 [10]
Georgia (CCF, DE)	15	12	16	Midnight to 6 a.m.	First 6 mo no passengers (family members exempt). Second 6 mo no more than 3 passengers younger than 21 (family members exempt).	18	40 [6]

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
Hawaii (BELT, CCF, DE)	15 and 6 mo	6	16	11 p.m. to 5 a.m.	No more than 1 passenger under the age of 18 (household members exempt)	17	None
Idaho (BELT, CCF)	14 and 6 mo	4	15	Sunset to sunrise	None	16	50 [10]
Illinois (BELT, CCF, CELL)	15	3	16	Starts 11 p.m. Sun–Thu, midnight Fri and Sat night. Ends 6 a.m.	First 6 mo no more than 1 passenger younger than 20 (family members exempt)	Night: 17 Passenger: 16 and 6 mo	50 [10]
Indiana (BELT, DE)	15	2	16 and 1 mo	Starts 11 p.m. Sun-Thu, 1 a.m. Fri and Sat night 11 p.m. Ends 5 a.m.	First 90 days no passengers unless supervised by 21-yr-old driver (family members exempt)	Night: 18 Passenger: 16 and 4 mo	None
Iowa (BELT, CCF, DE)	14	6	16	12:30 a.m. to 5 a.m.	None	17	Learner: 20 [2] Intermediate: 10 [2]

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
Kansas (BELT, DE)	14	6	No Intermediate license stage			14 and 6 mo	50 [10]
Kentucky (CCF, DE)	16	6	16 and 6 mo	Midnight to 6 am	No more than 1 person under 20	17	60 [10]
Louisiana (CCF, DE)	15	6	16	11 p.m. to 5 a.m.	None	17	None
Maine[2] (CELL, DE)	15	6	16	Midnight to 5 a.m.	First 180 days no passengers unless supervised by 20-yr-old driver (family members exempt)	16 and 6 mo	35 [5]
Maryland (CCF, CELL, DE)	15 and 9 mo	6	16 and 3 mo	Midnight to 5 a.m.	First 5 mo no passengers under the age of 18 yrs. (family members exempt and secondarily enforced)	Night: 17 and 9 mo Passenger: 16 and 8 mo	60 [10]
Massachusetts (CCF, DE)	16	6	16 and 6 mo	Midnight to 5 a.m. Starts at 12:30 a.m. *effective 3-1-07*	First 6 mo no passengers younger than 18 unless supervised by 21-yr-old driver (family members exempt)	Night: 18 Passenger: 17	12 Increases to 40 (30 if completed advanced driver training course) *effective 9-1-07*

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
Michigan (CCF)	14 and 9 mo	6	16	Midnight to 5 a.m.	None	17	50 [10]
Minnesota (BELT, CCF, CELL, DE)	15	6	16	Intermediate license stage has no restrictions, just cell phone ban, crash/ conviction-free provision, and required practice driving time		17	Learner: 30 [10] Intermediate: 10
Mississippi (CCF, DE)	15	6	15 and 6 mo	10 p.m. to 6 a.m.	None	16	None
Missouri (BELT, CCF)	15	6	16	1 a.m. to 5 a.m.	First 6 mo no more than 1 passenger under age 19 (family members exempt). Then, no more than 3 passengers under age 19.	18	40 [10]
Montana (BELT, CCF, DE)	14 and 6 mo	6	15	11 p.m. to 5 a.m.	First 6 mo 1 passenger under age 18. Second 6 mo 3 passengers under age 18.	16	50 [10]
Nebraska (DE)	15	None	16	Midnight to 6 a.m.	None	17	50 in lieu of driver ed.

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
Nevada (CCF, DE)	15 and 6 mo	6	16	10 p.m. to 5 a.m.	First 3 mo no passengers younger than 18 (family members exempt)	Night: 18 Passenger: 16 and 3 mo	50 [10]
New Hampshire (BELT, DE)	15 and 6 mo	None	16	1 a.m. to 5 a.m.	First 6 mo no more than 1 passenger younger than 25 (family members exempt)	Night: 17 and 1 mo Passenger: 16 and 6 mo	20
New Jersey (BELT, CCF, CELL, DE)	16	6	17	Midnight to 5 a.m.	No more than 1 passenger (family members exempt)	18	None
New Mexico (CCF, DE)	15	6	15 and 6 mo	Midnight to 5 a.m.	No more than 1 passenger under 21 (family members exempt)	16 and 6 mo	50 [10]
New York (BELT, DE)	16	Up to 6 mo	16 and 6 mo	9 p.m. to 5 a.m.	No more than 2 passengers younger than 21 unless supervised by 21-yr-old driver (family members exempt)	17 (w/ driver ed.) 18 (w/out driver ed.)	20

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
North Carolina (BELT, CCF, DE)	15	12	16	9 p.m. to 5 a.m.	No more than 1 passenger younger than 21 (family members exempt). If a family member younger than 21 is already a passenger then no other passengers younger than 21 who are not family members.	16 and 6 mo	None
North Dakota (CCF, DE)	14	6	No intermediate license stage			14 and 6 mo	None
Ohio (BELT, DE)	15 and 6 mo	6	16	Midnight to 6 a.m. for 16-yr-olds. 1 a.m. to 5 a.m. for 17-yr-olds.	None. No more than 1 passenger for 16-yr-old drivers (family exempt) *effective 4-4-07*	17	50 [10]
Oklahoma (DE)	15 and 6 mo (w/ driver ed.) 16 (w/out driver ed.)	6	16 (w/ driver ed.) 16 and 6 mo (w/out driver ed.)	11 p.m. to 5 a.m. (exempts work, school & church)	No more than 1 passenger (exempts parents, guardians or a licensed driver over age 21)	16 and 6 mo (w/ driver ed.) 17 and 6 mo (w/out driver ed.)	40 [10]

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
Oregon (CCF)	15	6	16	Midnight to 5 a.m.	First 6 mo no passengers under 20. Second 6 mo no more than 3 passengers under 20 (family members exempt).	17	50 (100 w/out driver ed.)
Pennsylvania (BELT, CCF, DE)	16[3]	6	16 and 6 mo	11 p.m. to 5 a.m.	None	17 (w/ driver ed.) 18 (w/out driver ed.)	50
Rhode Island (BELT, CCF, DE)	16	6	16 and 6 mo	1 a.m. to 5 a.m.	No more than 1 passenger under age 21 (immediate family members exempt)	17 and 6 mo	50 [10]
South Carolina (CCF)	15	6	15 and 6 mo	6 p.m. to 6 a.m. EST 8 p.m. to 6 a.m. EDT	No more than 2 passengers unless supervised by driver at least 21 (family members and students to and from school exempt)	16 and 6 mo	40 [10]
South Dakota (CCF)	14	6 (3 w/ driver ed.)	14 and 6 mo (14 and 3 mo w/ driver ed.)	10 p.m. to 6 a.m.	None	16	None

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
Tennessee (BELT, CCF, CELL)	15	6	16	11 p.m. to 6 a.m.	No more than 1 passenger unless supervised by 21-yr-old driver (family members exempt)	17	50 [10]
Texas (CCF, CELL, DE)	15	6	16	Midnight to 5 a.m.	No more than 1 passenger under 21 (family members exempt)	16 and 6 mo	None
Utah (BELT, DE)	15	6	16	Midnight to 5 a.m.	First 6 mo no passengers under 21 (family members exempt)	Night: 17 Passenger: 16 and 6 mo	40 [10]
Vermont (CCF, DE)	15	12	16	None	First 3 mo no passengers. Second 3 mo same as first 3 mo (family members exempt).	16 and 6 mo	40 [10]
Virginia	15 and 6 mo	9	16 and 3 mo	Midnight to 4 a.m.	First 12 mo no more than 1 passenger under 18. Until age 18 no more than 3 passengers under 18 (family members exempt).	18	40 [10]

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

State	Learner Stage		Intermediate Stage			Minimum Age GDL Restrictions Lifted	Certified Driving
	Minimum Age	Holding Period (months)	Minimum Age	Nighttime Driving Restriction	Passenger Restriction		Number of Hours Including [x] at Night
Washington (CCF, DE)	15	6	16	1 a.m. to 5 a.m.	First 6 mo no passengers under 20 (family members exempt). Second 6 mo no more than 3 passengers under 20.	17	50 [10]
West Virginia (BELT, CCF, CELL, DE)	15	6	16	11 p.m. to 5 a.m.	No more than 3 passengers younger than 19	17	30 (none w/ driver ed.)
Wisconsin (CCF, DE)	15 and 6 mo	6	16	Midnight to 5 a.m.	No more than 1 passenger (family members exempt)	16 and 9 mo	30 [10]
Wyoming (DE)	15	10 Days	16	11 p.m. to 5 a.m.	No more than 1 passenger younger than 18 (family members exempt)	16 and 6 mo (w/ driver ed.) 17 (w/out driver ed.)	50 [10]

[1] This law is secondarily enforced
[2] 24 months or until age 21
[3] Pennsylvania has a nighttime restriction in the permit stage from 11 p.m. to 5 a.m.

BELT States with Seat Belt Provisions
CCF States with Crash Conviction-Free Provisions
CELL States with Cell Phone Prohibitions for Teen Drivers
DE States with Driver Education Requirements

APPENDIX 2: Supplemental tables

Table A2-1: Incidence Rate Ratios (IRRs) and 95% Confidence Intervals (CIs) for driver involvement in fatal crashes in relation to driver age and number of GDL program components.

Number of components	Age 16	Age 20-24	Age 25-29	Age 30-54
One	0.96(0.85-1.08)	1.01(0.95-1.07)	0.96(0.89-1.03)	1.00(0.95-1.05)
Two	0.90(0.79-1.03)	0.97(0.91-1.04)	0.97(0.90-1.04)	0.97(0.92-1.02)
Three	0.90(0.76-1.06)	0.94(0.87-1.00)	0.97(0.88-1.07)	0.97(0.90-1.04)
Four	0.79(0.70-0.90)	0.89(0.81-0.98)	0.87(0.77-0.98)	0.85(0.79-0.93)
Five	0.62(0.50-0.77)	0.98(0.89-1.07)	0.99(0.87-1.13)	0.98(0.90-1.07)

Table A2-2: Incidence Rate Ratios (IRRs) and 95% Confidence Intervals (CIs) for driver involvement in injury crashes in relation to driver age and number of GDL program components.

Number of components	Age 16	Age 20-24	Age 25-29	Age 30-54
One	1.03(0.95-1.11)	1.00(0.93-1.08)	0.98(0.91-1.05)	1.01(0.95-1.07)
Two	0.87(0.75-0.99)	1.01(0.96-1.08)	1.02(0.96-1.08)	1.00(0.96-1.06)
Three	0.84(0.74-0.96)	0.95(0.91-1.00)	0.92(0.87-0.97)	0.93(0.90-0.96)
Four	0.64(0.45-0.91)	0.86(0.62-1.20)	0.84(0.58-1.22)	0.86(0.62-1.20)
Five	0.60(0.44-0.83)	1.02(0.93-1.11)	1.08(0.99-1.18)	1.01(0.94-1.08)

APPENDIX 3: State data used in analyses of injury crashes

Table A3: Summary of data received from states for analysis of injury crashes.

Jurisdictions	Data Obtained	Data years	Data Used	Dropped Years
Alabama	Yes	1994-2003	YES	
Alaska	Yes	1992-2002	NO	1997-2002
Arizona	Yes	1994-2002	YES	
Arkansas	Yes	1994-2003	PART	1997 (No data)
California	Yes	1994-2002	YES	
Colorado	Yes	1998-2003	YES	
Connecticut	No		NO	
Delaware	Yes	1994-2003	YES	
District of Columbia	No		NO	
Florida	Yes	1994-2003	YES	
Georgia	Yes	1996-2004	YES	
Hawaii	No		NO	
Idaho	Yes	1994-2002	YES	
Illinois	Yes	1994-2003	PART	1996
Indiana	No		NO	
Iowa	Yes	1994-2002	PART	2001-2002
Kansas	Yes	1994-2003	YES	
Kentucky	Yes	1997-2004	YES	
Louisiana	Yes	1999-2004	YES	
Maine	No		NO	
Maryland	Yes	1994-2002	YES	
Massachusetts	Yes	1995-2003	PART	1995-1996, 2002-2003
Michigan	Yes	1994-1999	YES	
Minnesota	Yes	1994-2002	YES	
Mississippi	No		NO	
Missouri	Yes	1994-2003	YES	
Montana	Yes	1994-2003	YES	
Nebraska	Yes	1994-2002	YES	
Nevada	Yes	1998-2002	PART	DROP FOR NIGHT

Jurisdictions	Data Obtained	Data years	Data Used	Dropped Years
New Hampshire	No		NO	
New Jersey	Yes	1997-2002	NO	1997-2002
New Mexico	Yes	1994-2002	YES	
New York	No		NO	
North Carolina	No		NO	
North Dakota	Yes	1999-2002	YES	
Ohio	Yes	1994-2002	YES	
Oklahoma	No		NO	
Oregon	Yes	1994-2002	YES	
Pennsylvania	Yes	1994-2003	YES	2002 (No data)
Rhode Island	No		NO	
South Carolina	Yes	1997-2003	YES	
South Dakota	Yes	1994-2003	YES	
Tennessee	Yes	1996-2002	YES	
Texas	Yes	1994-2001	YES	
Utah	Yes	1994-2002	NO	
Vermont	Yes	1994-2002	PART	2002
Virginia	Yes	1994-2002	NO	
Washington	Yes	1994-2002	NO	1997-2002
West Virginia	Yes	1999-2004	YES	
Wisconsin	Yes	1994-2003	YES	
Wyoming	Yes	1994-2002	YES	