

Teens have the highest crash rate of any group in the United States.



Graduated Driver Licensing Research Review, 2010 – Present

November 2012



Title

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Authors

Allan F. Williams
Brian C. Tefft
Jurek G. Grabowski

Acknowledgments

This review was supported by the AAA Foundation for Traffic Safety. The authors thank Eric Williams-Bergen for conducting the literature search, and Robert Foss, Ruth Shults, and Barry Watson for reviewing an earlier draft and providing valuable comments and suggestions.

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AAA Foundation for Traffic Safety
607 14th Street, NW, Suite 201
Washington, DC 20005
202-638-5944
www.aaafoundation.org

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Abstract

This is the latest in a series of reviews of research on graduated driver licensing (GDL) published in the *Journal of Safety Research*, covering the period January 1, 2010-June 1, 2012 and work in progress. The intent is to keep researchers and policy makers current regarding the existing state of knowledge about GDL, and to identify information gaps and areas where clarification of research findings is needed. The recent research indicates that we continue to learn about ways to extend GDL benefits, but there remain important questions in need of further inquiry.

Introduction

Graduated driver licensing (GDL), a phase-in system designed to protect young beginners while they are gaining driving experience, began to be introduced in North America in the mid-1990s. GDL has replaced laws that generally allowed quick and easy access to full driving privileges; the core elements are an extended learner period during which driving must be supervised, and a restricted phase for some period after initial licensure, with limits on driving at night and carrying passengers. All jurisdictions in Canada and the United States have versions of GDL in effect, and many have substantially upgraded their original GDL legislation. In the United States, where most of the GDL research has been done, 41 states and the District of Columbia have enacted all of the core elements of GDL, with considerable variation in the comprehensiveness of these requirements. In 1995, prior to the widespread introduction of GDL, there were 2,667 drivers ages 16-17 involved in fatal crashes, a fatal crash involvement rate of 37 per 100,000 population (FARS, 2012). In 2010, there were 1,150 drivers aged 16-17 involved in fatal crashes, a rate of 13 per 100,000 population, representing a 57-percent decrease in the number of 16- and 17-year-olds involved in fatal crashes and a 64-percent decrease in the population-based fatal crash involvement rate. GDL is acknowledged to have played a lead role in that decrease (Ferguson, Teoh, & McCartt, 2007; Shults & Ali, 2010). However, there remains a substantial teenage driver problem, and many teens die each year as passengers in motor vehicles, often driven by other teens. Additional work is needed to further reduce deaths and injuries in this vulnerable population.

Good research can help in this effort, pointing the way toward evidence-based policies. The GDL movement has spurred a vast amount of research. In attempting to keep researchers and policy makers current regarding the existing state of knowledge and promising new approaches, GDL research reviews have been published covering the years 2003, 2004, 2005, 2006 (Hedlund & Compton, 2004, 2005; Hedlund, Shults, & Compton, 2006) and most recently, 2007 to early 2010 (Williams & Shults, 2010). The surge in research has continued and the present review covers the period from early 2010 to mid-2012, including work in progress. In this review, central GDL issues and information needs are identified, and the recent literature is evaluated in terms of the extent to which it addresses and answers the questions posed. This review structure provides a means for summarizing present knowledge, highlighting proven approaches, and spotlighting research gaps and areas in which clarification of research findings is needed. Attention is given to the areas identified by the Transportation Research Board (TRB) Subcommittee on Young Drivers (2009) as most in need of research. They are:

- Advancing the science base for programs and policies to reduce teenage driving risk;
- Learning to drive safely (how competence develops);
- Teenage driving exposure issues (e.g., how many miles teenagers drive, as well as contextual factors such as time of day, passenger presence, trip purpose, traffic and weather);
- Parenting issues (how parents influence teenage driving); and
- Passenger issues (how passengers influence teenage driving and crash risk).

Advancing the science base is applicable to GDL research in general. GDL is a solidly evidence-based strategy, but there is uncertainty about the optimal structure of its components (Foss, 2007). Building on the current state of knowledge about GDL in ways that will enhance its safety benefits is possible only through high-quality research that addresses appropriate questions.

Since the most recent review (Williams & Shults, 2010), two developments are notable. One is the increased availability of naturalistic studies of teen driving, in which cameras and other instrumentation record what is taking place in vehicles. Prior knowledge about in-vehicle activities has largely been based on self-reports or observations from outside the vehicle. The second development is the introduction of GDL features in Australian states that heretofore have been found only in North America and New Zealand. There are significant differences in Australian GDL systems, however. Most notably, licensing ages are higher and provisional license phases last longer. These differences will make it possible to study and compare a greater variety of GDL formats, although related research from Australia is only beginning to become available.

Scope of the Review

Articles published between January 1, 2010 and June 1, 2012 were included, along with work in progress. Previously published articles are occasionally referred to if they help to clarify current research findings, or if they were not incorporated in prior reviews. The review was restricted largely to the countries with graduated licensing systems: Australia, Canada, New Zealand, and the United States. Only topics with direct relevance to GDL are included. This means that studies of worthy topics such as alcohol-impaired driving, seat belt use, driver education, and teen driver crash characteristics were excluded unless they had a clear GDL connection.

A search was made of relevant databases, including PsychINFO, Science Direct, Science Citation Index, SafetyLit, Social Sciences Citation Index, Academic Search Complete, Google Scholar, and TRID, which is a combination of the Transportation Research information Services (TRIS) database and the International Transportation Research (ITRD) database. The search strategy was multi-faceted and involved a combination of key words and key phrases, along with their derivatives: young drivers (and related terms, e.g., teenage drivers, teenagers, adolescents); automobile driving (drivers, driving, automobiles); graduated driver licensing (graduated licensing, driver licenses). Papers published during 2010-2012 were identified. Information on work in progress was obtained through contacts with members and friends of the TRB Subcommittee on Young Drivers and other researchers in Australia, Canada, New Zealand, and the United States.

What is the Effect of GDL on Crashes for Different Age Groups?

Licensing ages vary within and across countries, and thus GDL has been applied to novices of different ages. For example, in the United States, where almost all of the recent GDL evaluations have been carried out, minimum learner ages are generally 15-16, restricted license ages are 16-16½, and full license ages 16½-18. In Canada,

the minimum learner age is generally 16, restricted license age 16-16¾, and full license age 17½-18¼. However, in the majority of provinces, “time discounts” for driver education are allowed, a safety-degrading practice (Mayhew, Simpson, & Singhal, 2005) enabling novices to obtain a learner permit at a younger age or progress through the learner stage more quickly. In Australia, minimum learner ages are generally 16, restricted license ages 17, and full licenses older than 18. In Australia, Victoria is an anomaly, with a restricted licensing age of 18 rather than 17. In the United States, New Jersey is unique, with a restricted license age of 17, making it similar to most Australian states. In addition, New Jersey subjects 18- to 20-year-olds to full GDL requirements; in almost all other states, those 18 and older are exempt from any GDL rules.

Older licensing ages, independent of GDL, provide safety benefits (Williams, McCartt, Mayhew, & Watson, in press). GDL effects may differ depending on the ages of novices subject to the rules.

Early evaluations of GDL were necessarily single-state studies. These are still being done and can provide valuable information about specific programs, including the effects of law upgrades and long-term effects. For example, a recent study of Connecticut’s GDL system over a ten-year period reported decreases in all crashes for both 16- and 17-year-olds (Rogers et al., 2011). An evaluation of Kansas’ GDL system, including upgrades in 2010, is slated to begin in 2013. An evaluation of the long-term effects of Georgia’s GDL system is being carried out at the Rollins School of Public Health, Emory University. Preusser Research Group is studying the effect of recent changes in Connecticut’s GDL program.

Most of the recent GDL evaluations have been national in scope, based exclusively or primarily on U.S. data. These more comprehensive studies are welcome, although unlike single-state studies, most of them have been limited to fatal crashes, providing an incomplete portrayal of overall effects. The two studies that have received most attention in the research community were both large and complex and used different statistical methods that in some cases produced discrepant results (McCartt et al., 2010; Masten, Foss, & Marshall, 2011). It is clear from these studies, from other recent national studies (e.g., Lyon, Pan, & Li, 2012), and from past state and national research that GDL, especially the systems that are most comprehensive, reduces all types of crashes in the age groups directly affected by the rules. In particular, all GDL evaluations indicate that 16-year-old driver crash rates have been sharply reduced. For more comprehensive GDL programs, fatal crash reductions of 41 percent (McCartt et al., 2010) and 26 percent (Masten, Foss, & Marshall, 2011) have been reported for 16-year-olds. A Cochrane review that included 34 studies of U.S. and Canadian GDL systems through to May 2009 found crash reduction effects for 16-year-olds, based on both all crashes and injury crashes. The median decrease in all crashes was 15.5 percent (Russell, Vandermeer, & Hartling, 2011). A meta-analysis based on 11 evaluations of U.S. state studies and one Canadian province (9 looking at injury crashes, 3 based on fatal crashes) reported an overall crash reduction of 22 percent for 16-year-olds (Zhu et al., 2012). It is implicitly assumed that young drivers in general share in these benefits, although the finding that Hispanic teens were not as positively affected by GDL as

other racial/ethnic groups is a warning sign that this may not be so in all populations (Romano, Fell, & Voas, 2011).

More limited evidence also indicates positive GDL effects for 17-year-olds. Seventeen-year-olds have different exposure to GDL than do 16-year-olds. Fewer of them are in the protected learner phase. In addition, graduation from GDL is possible prior to age 18 in most states, and an unknown number of 17-year-olds will not be subject to the requirements. In a comprehensive review of evaluation studies, Shope (2007) concluded that “Overall, GDL programs have reduced the youngest drivers’ crash risk by roughly 20 to 40%.” That range has been widely quoted as representing the effect of GDL. Several of the studies reviewed by Shope included only 16-year-olds, although those that included 17-year-olds reported crash reductions. In recent national studies, McCartt et al. (2010) reported a 19 percent decrease in fatal crashes for 17-year-olds; Masten, Foss, & Marshall (2011) found a reduction of nine percent; Lyon, Pan, & Li (2012) reported the strong positive effect at 16 to be “trailing off” at older ages. Other recent national studies have reported decreases in fatal crashes but were based on 16- and 17-year-old drivers combined in one case (Fell, Jones, Romano, & Voas, 2011) and 15- to 17-year-old drivers combined in another (Morrisey & Grabowski, 2011). The Cochrane review did not assess effects by single age for teens older than 16, but indicated that for all teens combined (ages 15-19 depending on the study) there were positive crash reduction effects (Russell, Vandermeer, & Hartling, 2011). The meta-analysis based on state evaluations reported a six percent decrease in injury and fatal crashes of 17-year-olds (Zhu et al., 2012). The National Highway Traffic Safety Administration (NHTSA) has funded a meta-analysis of evaluation studies that may shed further light on GDL effects by single year of driver age. The bulk of the existing evidence suggests that GDL effects on crashes at age 17 are beneficial but smaller than at 16.

At age 18, almost all teens in the United States are no longer subject to GDL requirements, and there is debate as to whether GDL-related effects at ages 18 and beyond are positive, negative, or zero. This question has not been resolved. In the study by Masten, Foss, & Marshall (2011), a statistically significant increase at age 18 in fatal crash involvements in states with comprehensive GDL systems was reported. The 12 percent increase in fatal crashes at age 18, combined with a slight increase at age 19 (5%), appeared to negate most of the crash reduction effects at ages 16 and 17: when 16- to 19-year-olds were aggregated, fatal crash involvement declined only three percent under GDL. In another analysis of GDL effects, based on all U.S. GDL programs, Fell et al. (2012) reported similar results for single age groups; that is, fatal crash reductions at 15, 16, and 17, and increases at 18 and 19.

Other studies have not found GDL associated with crash increases at ages 18 and 19. McCartt et al. (2010) reported small fatal crash reductions at these ages; Morrisey and Grabowski (2010) found a statistically significant nine percent reduction in driver fatalities among 18-20-year-old drivers in states with comprehensive GDL systems; Zhu et al. (2012) found that GDL implementation had little association with crashes at age 18, although the analysis was based on only four states.

GDL evaluation studies from Australia are beginning to become available and will indicate the effect of GDL on older novices. Victoria upgraded its licensing system in

several ways in 2007 and 2008, establishing a minimum 12-month learner period and 120 hours of required supervision, adding a new and more challenging road test, and a limitation of one passenger age 16-21 in the vehicle during the first 12-months of licensed driving. An interim report indicates that there has been a 31 percent reduction in drivers in fatal or serious injury crashes subsequent to these changes among drivers ages 18-20 in the first year of holding an initial license (Healy, Catchpole, & Harrison, 2012). Additional analyses are in progress, but the initial results suggest the robustness of the GDL concept across different ages.

Officials in New South Wales have reported preliminary results indicating substantial decreases in crashes of initial license holders ages 17 up to 24 since their licensing system was revamped in 2007 (Senserrick & Williams, 2012). Several significant changes were made, including increasing the minimum learner period from six months to one year, increasing the supervised hours requirement from 50 to 120 hours, and adding a passenger limit (one passenger under 21 between 11 pm and 5 am) for initial license holders under the age of 25.

The Learner Stage

Extending the learner permit period and requiring a minimum number of hours of supervised driving to take place are intended to better prepare beginners for independent driving. Currently in the United States, 47 of the 51 jurisdictions require new drivers to hold a learner permit for a period ranging from 6 to 12 months; 42 mandate at least 30 hours of supervised practice. It is well established that this is a period in which there is low crash risk, and that was recently confirmed in a New Zealand study (Lewis-Evans, 2010). However, there has been little information available about the kinds of practice driving done during this period. Information also is needed on the effects of differing rules on crash rates (e.g., minimum age to obtain a learner permit, length of the permit period, number of hours of supervised practice required).

In an interview survey of parents whose teens were about to enter the learner stage, parents generally recognized the importance of gaining experience under supervision, but differed in what they thought was necessary to develop safe drivers and the kinds of instruction and experiences needed (Mirman & Kay, 2012). Some parents provided considerable details about necessary driving skills, whereas most only offered abstract concepts such as “awareness” or fundamentals, e.g., knowing how to park. Parents in general tended not to mention the importance of scanning or hazard detection skills. They did not in general discuss the importance of driving on different types of roads or in different traffic environments, nor make a connection between the kind of driving a young beginner would be doing once independent driving commenced and what they should be practicing under supervision.

This latter theme is reflected in a naturalistic study of 50 drivers and their parents in North Carolina (Goodwin et al., 2010). Naturalistic studies show what drivers and their parents are actually doing on the roads, although only for a limited sample of individuals. In the North Carolina study, there was found to be little variation in the types of driving done, most of it taking place in residential areas in light traffic.

Scant evidence was found for progression toward more demanding driving situations as learners became more experienced. North Carolina requires new drivers to hold a learner permit for a minimum of 12 months but had no requirement for learners to obtain a specific number of hours of supervised practice at the time of the study. The average number of hours driven in the learner period was estimated to be approximately 85.

Another naturalistic study of learners, by the National Institute of Child Health and Human Development (NICHD) is soon to be under way involving 90 teens recruited when they receive their permit and followed from that point until 6-12 months post-licensure. Supervised practice will be monitored and related to its effects on independent driving.

In terms of the effects of learner period requirements considered in combination, Lyon, Pan, & Li (2012) compared states with comprehensive vs. less comprehensive policies, based on minimum learner age, length of permit period, and supervised hours requirements. It was found that for 16-year-olds, GDL programs with a minimum age of 16 for obtaining a learner permit, a permit period of at least six months, and a requirement for at least 30 hours of supervised driving practice were associated with fatal crash rates 58 percent lower relative to less comprehensive programs; a similar effect was observed for injury crashes. In a University of Michigan Ph.D. thesis, the unique contribution of the length of the permit period and supervised driving hours in states that implemented these components separately from other GDL components are being examined by Jonathon Ehsani.

There are several recent studies of learner policies considered singly. In regard to minimum learner age, the evidence for crash reduction benefits of older starting ages is overall positive. In the McCartt et al. (2010) study, a one-year delay, from 15 to 16, was associated with a 13 percent lower fatal crash rate. In a study of insurance collisions claims by Trempe (2009), a one-year delay reduced claims by four percent for 16-year-olds and three percent for 17-year-olds, not statistically significant in either case. Masten (2011) concluded that delaying learner driving until age 16 had the most potential for fatal crash reductions but the evidence from his study was only suggestive.

Masten (2011) reported clear crash reduction benefits of a learner period of 9-12 months, estimating a 26 percent lower fatal crash incidence for 16-year-olds and 17 percent for 17-year-olds. Learner periods of up to four months were not associated with differences in fatal crash incidence, and learner periods of five to six months appeared to have minor positive effects. Longer learner periods often indirectly raise the age of provisional licensure, which also has safety benefits (Williams et al., 2012). However, McCartt et al. (2010) and Trempe (2009) reported no independent benefits of longer learner periods apart from the benefit associated with indirectly raising the minimum age for licensure.

Evidence for the effects of the number of supervised hours required is unclear. In one series of studies, a national cross-sectional analysis comparing states in terms of supervised hours requirements found no relationship between required hours and fatal crash rates of 16- and 17-year-old drivers. A time series analysis of serious

injury and fatal crashes in the state of Minnesota did not detect any effect associated with a requirement for 30 hours of supervised driving practice, which was implemented independent of any other changes to the state GDL system. Interviews with parents in five states with varying supervised hours requirements indicated that awareness of the requirements was limited, with only about one-third of parents (15% in Minnesota) able to identify the number of required hours in their state (Foss et al., 2012; O'Brien et al., 2012).

Similarly, McCartt et al. (2010) did not find a relationship between the number of supervised hours required and fatal crashes. Earlier research, however, has reported positive effects of hours requirements on crashes (e.g., Chen, Baker, & Li, 2006), and Trempe (2009) reported reductions in insurance claim frequencies associated with 40-hour practice requirements. Thus, the question is still open. It will be interesting to see results from the Australian states New South Wales, Queensland, and Victoria in which 100-120 hours are required, twice as much as in most U.S. states.

In untangling the effects of supervised hours requirements, it is of interest to know the extent to which requiring a greater number of hours increases practice time and overall compliance. In a U.S. study based on parent interviews, it was found that a 50-hour requirement resulted in more parents reporting at least 50 practice hours (median=60) than in states mandating 20-40 hours or in states without any requirement. Two-parent involvement was associated with more practice hours (Jacobsohn et al., 2012).

In an Australian study comparing New South Wales (50 hours required) with Queensland (zero hours required), it was found that the 50-hour requirement resulted in more reported hours driven but may have discouraged the accumulation of additional hours beyond the minimum. The average number of reported hours was 73 in New South Wales and 64 in Queensland, but the Queensland distribution was bimodal, with respondents reporting either much more or much less supervised driving than the New South Wales average (Bates, Watson, & King, 2010). When Queensland instituted a requirement for 100 supervised hours, the average number of reported hours was 110 (although this figure is inflated by learners being able to claim three hours of practice for every hour of professional supervision up to a maximum of 30 hours). Only a small proportion of learners reported driving unsupervised, falsifying their logbooks, or having difficulty in obtaining supervised practice (Scott-Parker et al., 2011).

The Provisional License Period

During the provisional period, it is well established that the highest crash rate occurs during the first month and that there is a rapid decrease in crashes over the following several months. This trend is largely based on data collected before GDL was introduced (e.g., Mayhew, Simpson, & Pak, 2003). Restrictions on high risk driving during the provisional phase are designed to deal with this elevated crash profile, but data from North Carolina indicate that a highly similar crash curve exists before and after GDL, only slightly diminished post-GDL (Masten & Foss, 2010). A central question in regard to the provisional period is to explain this initial

elevation in crashes in ways that may lead to reducing it, and also to understand how competence develops; that is, what accounts for the very rapid decline in crash involvement over the first several months of driving. There also is a need to know more about the risk factors during this period, the extent to which night and passenger restrictions reduce crashes, and how to increase compliance with the rules and promote safe independent driving in general.

Some clues about the early months of independent driving are available from a study measuring month-by-month changes in crash involvements and precipitating factors in North Carolina among teens licensed to drive independently at age 16 or 17 (Foss et al., 2011). Most of the crashes involved two vehicles on moderate-speed roadways. Crash types that declined rapidly were those involving left turns, entering the road from a parking lot or driveway, overturning, and run-off-road and fixed-object crashes. Also declining rapidly were crashes involving failure to yield, improper turns, and overcorrecting. On the other hand, rear end crashes (both struck and striking) and crashes that involved following too closely declined more slowly. The authors attributed the rapid declines in some types of crashes to learning (rather than maturation), but expressed surprise and concern that the straightforward maneuvers involved in the types of crashes that declined rapidly had not been mastered during North Carolina's 12-month learner period.

Risk Factors for Provisional License Holders

Late-night driving and passenger presence, especially teen friends, are the risk factors traditionally addressed in GDL systems. Distraction in general has also become a major concern, although interventions to address distraction other than passenger restrictions and cell phone/texting bans are rare, and there has been little research addressing the specific effects of cell phone/texting bans on teenagers. The only known studies were done in North Carolina, where a cell phone ban was instituted within the GDL system. There was essentially no change in cell phone use four months after the ban went into effect (Foss et al., 2009). Two years after implementation, cell phone use had decreased in North Carolina, but also decreased by about the same amount in South Carolina, where use was legal. It was concluded that North Carolina's cell phone restriction had no long-term effect on the behavior of teenage drivers (Goodwin, O'Brien, & Foss, 2012).

Many of the studies establishing passengers and nighttime driving as risk factors were based on data now 10-20 years old. However, a recent study by the AAA Foundation for Traffic Safety, based on crash data from years 2007-2010 and driving exposure data for years 2008-2009, confirmed the persistence of the risk factors documented in the earlier studies (Tefft, Williams, & Grabowski, 2012). The study found that for drivers ages 16-17, the rate of driver deaths per mile driven was more than five times as high between the hours 10 pm-5:59 am compared with the daytime driver death rate. Having one passenger younger than 21 in the vehicle increased the driver death rate per mile driven by 44 percent compared with driving alone; two or more passengers doubled the death rate; three or more quadrupled it. Having at least one passenger age 35 or older decreased the driver death rate by 62 percent.

Williams & Tefft (2012) reported that in 2010, 43 percent of 16- and 17-year-old drivers involved in fatal crashes had at least one passenger age 13-19 and no younger or older passengers. The raw numbers of 16- and 17-year-old drivers involved in fatal crashes decreased by more than half between 1995 and 2010, but the proportion with teenage passengers decreased by only three percentage points – from 46 percent in 1995 to 43 percent in 2010. There is considerable evidence that passenger restrictions reduce crashes involving teen passengers, but state-by-state analyses indicate that both states with and without passenger restrictions have a problem involving fatal crashes in which teen drivers are transporting other teens (Williams & Tefft, 2012).

Naturalistic studies have added to our knowledge about the conditions under which passengers increase crash risk. It is generally believed that risk is heightened because of distractions that are created by the presence of multiple teens, or by risk taking that is explicitly or implicitly encouraged by passengers. In one study of newly licensed drivers in their first six months of driving, rates of hard braking were significantly higher when driving with teen passengers than when driving alone, and were especially low when driving with adult passengers (Simons-Morton et al., 2009). Rates of hard braking with teen passengers were significantly higher with male passengers and during the first month of licensure.

In another set of naturalistic studies, risky driving behaviors by teenagers were more common when they were in the presence of teen passengers, particularly multiple passengers (Goodwin, Foss, & O'Brien, 2011; Goodwin et al., 2012). Base rates for aberrant behavior in cars were quite low, but when multiple teenage peers were present, drivers were more likely to speed, to tailgate, or to show off with the vehicle. Loud conversation and horseplay were also more common, especially at night, and with multiple teen passengers. However, carrying parents, and to a lesser degree siblings, was associated with much lower likelihood of loud conversation and horseplay. Rarely did passengers directly urge drivers to take risks; apparently it was their presence alone that spurred the risk taking. Physical contact between drivers and passengers was rare.

In another naturalistic study, risky driving as indicated by elevated g-force events was actually lower in the presence of teen passengers, although risky driving was much higher among teens who said they had relatively more risky friends (Simons-Morton et al., 2011). These studies, with some results that seem contradictory, suggest the complexity of the relationships among teenagers when they travel together.

There is also evidence that precipitating factors in crashes with teen passengers differ for male and female drivers. In a study of pre-crash factors based on the National Motor Vehicle Crash Causation Survey, 16- to 18-year-old male drivers with peer passengers were more likely than lone male drivers to have been performing risky behaviors (e.g., speeding, illegal maneuvers) just before the crash, but this was not the case for female drivers. For both male and female drivers, in-vehicle distractions (e.g., looking at passenger movements or actions) were likely to have been present just prior to crashes involving peer passengers (Curry et al., 2012).

In work in progress, NICHHD and the University of Michigan Transportation Research Institute (UMTRI) are conducting a series of simulation studies addressing the effect of teenage passengers on teenage driving performance; UMTRI is conducting a set of experimental studies on the effects of teenage passengers and the mechanism for these effects; the Virginia Tech Transportation Institute is preparing a report from a naturalistic study evaluating the risks of distraction, including cell phone use, comparing risky driving behavior of teens and adults.

Effects of Night and Passenger Restrictions

In the United States, 50 of the 51 jurisdictions have nighttime driving restrictions in the provisional stage with starting times generally ranging from 9 pm to 1 am (one starts at sunset). Forty-five have passenger restrictions that vary in numbers of passengers allowed and ages covered. Night and passenger restrictions are well accepted by parents. Teenagers accept them also, although with less enthusiasm for passenger restrictions. National probability-based surveys have found that 90 percent of parents of teens and 78 percent of teens ages 15-18 approve of nighttime restrictions; 89 percent of parents and 57 percent of teens approve of passenger limits (Williams, Braitman, & McCartt, 2011; Williams, 2011).

Positive effects of night and passenger restrictions reported in earlier studies have also been found in recent research. Crash reductions associated with both types of restrictions have been reported by Fell, Todd, & Voas (2011); McCartt et al. (2010); Masten (2011); and Lyon, Pan & Li (2012). Jiang & Lyles (2011) reported positive effects for Michigan's night driving restriction. In Ehsani's Ph.D. thesis, the contributions of night and passenger restrictions are being assessed in states that implemented these components separately from other GDL policies.

In the national study by Fell, Todd, & Voas (2011), passenger restrictions were associated with nine percent fewer fatal crash involvements of 16- and 17-year-old drivers with teen passengers, and nighttime restrictions with 10 percent fewer nighttime crash involvements. Nighttime restrictions were also associated with 13 percent fewer involvements in fatal crashes in which drivers had been drinking. Alcohol-related crashes are indirectly targeted by both night and passenger restrictions. In a recent study it was reported that 88 percent of the alcohol-involved fatal crashes of 16- and 17-year-old drivers occurred at night, with passengers present, or both (Williams, West, & Shults, 2012).

More information on the relative effects of specific provisions of night and passenger restrictions has also become available. There is evidence that early starting times for night driving restrictions are more effective. For example, in the study by McCartt et al. (2010), restrictions beginning at 9 pm were associated with 18 percent lower fatal crash rates, compared with 12 percent for those starting at midnight. In the Masten (2011) study, only night restrictions beginning at 10 pm or earlier were associated with lower crash incidence; they were 19 percent lower for 16-year-olds.

Some states' passenger restrictions allow zero non-family members; others allow one (and a few even allow 2 or 3). Further research will be necessary to clarify which

policies have the greatest safety benefits. In the McCartt et al. (2010) study, the fatal crash rate of 15- to 17-year-olds was estimated to be 21 percent lower when beginners were prohibited from driving with any passengers in their vehicles, whereas allowing one passenger was associated with a seven percent lower fatal crash rate. In the Masten (2011) study, maximum safety benefits came from GDL policies allowing no more than one passenger for six months or more, yielding a fatal crash incidence for 16-year-olds that was 20 percent lower, compared with nine percent for zero-passenger limits.

State passenger restrictions vary in other ways, notably in the ages of passengers covered. Some prohibit non-family passengers of all ages, while others prohibit only those of a certain age, most often those younger than 21, but in some states 17, 18, 19, 20, or 25 (Insurance Institute for Highway Safety, 2012). This is indicative of the imperfect aim of passenger restrictions, in that in some cases they cover passengers who may lower crash risk, e.g. older adults, and in other cases exclude from coverage passengers who have been found to increase crash risk, e.g. some teens, and passengers in their twenties (Williams & Tefft, 2012). This variation in coverage has not been studied but it could be. It would also be of interest to compare the effect of passenger restrictions during the daytime versus at night, which would speak to the Australian situation in which passenger restrictions are typically applied only during nighttime hours. In Victoria, where the initial licensing age is 18, the passenger restriction (no more than one passenger age 16-21) applies at all hours of the day. The interim evaluation of this limit reported a reduction of 58 percent in fatal and serious injury crashes of new drivers 18-20 years old carrying two or more passengers of these ages (Healy, Catchpole, & Harrison, 2012). This suggests that passenger restrictions can be successful when applied to older drivers.

The positive effects of night and passenger restrictions indicate that there is considerable compliance with the restrictions, but compliance is not universal. In an analysis of night driving restrictions by Carpenter & Pressley (2012), it was calculated that 15- to 17-year-old drivers were non-compliant in about 15 percent of their fatal crashes. Lack of compliance with passenger restrictions is thought to be higher than for nighttime restrictions. This is likely reflected in the large percentage of fatal crashes of teenage drivers in which one or more teenage passengers are present (Williams & Tefft, 2012; Williams, Shults, & Ali, 2010). However, data limitations in these studies make it difficult to determine the precise proportions of crash-involved teen drivers who were in violation of passenger restrictions.

Improving Compliance with Restrictions; Fostering Safe Driving Practices

There are various ways to try to promote safe driving by teenagers, including encouraging them to follow GDL rules. In a survey of U.S. pediatricians, 89 percent said they did some counseling about driving. Forty-one percent said they discussed the dangers of transporting teen passengers, 23 percent talked about the value of parents setting limits, 21 percent about night driving, and 13 percent about GDL (Weiss et al., 2012). The effect of such counseling on the behavior of teens and parents is unknown.

Earlier research indicated that special enhanced police enforcement/publicity programs had minimal effects in promoting compliance with GDL elements (e.g., Goodwin et al., 2006). There have been no recent reports on the effects of police enforcement, but the AAA Foundation for Traffic Safety has begun a research project that investigates the numbers of citations and convictions resulting from GDL violations. New Jersey passed a law, effective May 2010, designed to facilitate police enforcement, requiring learner and provisional drivers to display highly visible, reflective decals on the front and rear license plates when they drive. License status indicators on the vehicle are required for learner and provisional license holders in all Australian states, although there have been no formal evaluations of the effectiveness of these provisions. Surveys in New Jersey have indicated that most parents and teenagers oppose the decal requirement, primarily due to concerns about the identification and potential targeting of teenage drivers by police and predators. Many teens do not use the decals when they drive (McCartt et al., 2012). Research by the Children's Hospital of Philadelphia is investigating changes in crash involvements associated with the New Jersey decal law.

In Australia, where concerns about predators and police harassment have not been reported as issues, use rates are by no means universal. In Queensland, where learners are required to display L-plates and provisional license holders to display P-plates, a survey indicated that 66 percent of learners and 56 percent of provisional license holders reported always doing so (Scott-Parker, 2012).

There are many programs that have peer-to-peer components, e.g., Teens in the Driver Seat (Henk & Fette, 2010), Operation Teen Safe Driving (www.teensafedrivingillinois.org). Such programs can help to ensure that teenagers know GDL rules and their rationale; this is an important first step, but is not necessarily sufficient to change behavior. One study in Australia used team training methods to teach teamwork and communication skills to young drivers, intended to produce driver-passenger combinations in which passengers exerted a positive influence (Lenne et al., 2011). The trained group exhibited safer driving practices on a driving simulator when accompanied by friends than an untrained group did. In general, peer-to-peer programs have unknown potential in promoting GDL compliance or other safe driving practices; research that would establish their effects is lacking or does not adhere to standard principles of scientific study design. However, researchers at the Texas Transportation Institute have conducted a study of crash rates of Texas counties with versus without the Teens in the Driver Seat program; the article is presently under review (Geedipally, Henk, & Fette, Under review). A study of the effects of Teens in the Driver Seat program at one urban and one rural high school in Montana, with comparison schools for each, is in the planning stage. Outcome variables include late-night driving and teen passenger presence. A controlled study by the Insurance Institute for Highway Safety of an educational program involving a peer-to-peer component in California (Impact Teen Driving) is currently in progress, and may provide important additional insight.

There are many studies, including recent ones, indicating the impact parents have in shaping the driving behavior of their sons and daughters (Prato et al., 2010; Miller & Taubman – Ben-Ari, 2010; Brookland et al., 2010; Brookland & Begg, 2011; Mirman et al., 2012; Taubman – Ben-Ari, & Katz – Ben-Ami, 2012). Surveys

over the years have consistently indicated strong parental support for the principles of GDL, making parents natural allies in their application. In a recent national survey of parents of 15- to 18-year-olds, it was found that they generally favored licensing policies that are as strong or stronger than in any U.S. jurisdiction, including higher permit and licensing ages, long learner periods with high practice hour requirements, plus strong and long-lasting night and passenger restrictions (Williams, Braitman, & McCartt, 2011). These views may not be shared in all states, especially in smaller and more rural locations, and particularly in regard to licensing ages. For example, whereas 66 percent of parents in the national survey favored a learner starting age of 16, less than 20 percent favored a starting age of 16 in Kansas, where the learner starting age is currently 14. However, 56 percent of Kansas parents were in favor of night driving restrictions and 82 percent supported passenger restrictions (AAA Kansas et al., 2008). A survey of parents of 16- and 17-year-olds in Iowa indicated that 79 percent were in favor of a one-passenger limit, and 82 percent endorsed a 10 pm start for night driving restrictions (McGehee & Foss, 2010). In both Iowa and Kansas, results differed little by urban/rural location. Additional data on parent views of licensing policies in other rural states – North Dakota, South Dakota, and New Hampshire – have been obtained by the University of North Carolina Highway Safety Research Center (HSRC) and will be forthcoming. UMTRI has obtained views on licensing age preferences from a national survey of parents that will also provide further information on this topic.

Despite the vested interest parents have in their children's driving safety, and their strong support for GDL, parenting styles differ markedly, and some styles are more conducive than others to managing the learning-to-drive process in an optimal fashion (Yang et al., 2012). This has led to a search for programs that will aid and influence parents to take the necessary steps to supervise and manage their children's driving. The Checkpoints Program, based on protection motivation theory, has achieved some success in this regard. The Checkpoints Program is designed to encourage parents to limit their teen's driving under high-risk conditions, and has been found to increase parent-teen communication about driving, limit setting, and reducing risky driving and traffic violations (Simons-Morton, Ouimet, & Catalano, 2008). Several studies based on the Checkpoints Program are in progress or near completion. A program in Delaware has been completed, in which Checkpoints was delivered to some families at permit time, to others at license time, and to others at both permit and license time. UMTRI and the American Academy of Pediatrics are collaborating to evaluate the translation of the Checkpoints Program for delivery to parents via a brief primary care provider intervention with referral to an interactive web site. AAA offers a Web-based version of the Checkpoints Program called StartSmart; UMTRI is separately developing a Web-based Checkpoints Program and will examine factors related to its dissemination, implementation, and health outcomes.

A recent systematic review of person-to-person interventions targeted to parents indicates that techniques are available to improve adolescent health (Burrus et al., 2012). The review of 16 studies included Checkpoints and a variety of programs targeting sexual behavior, violence, and other health-related behaviors. Intervention strategies for improving parenting behaviors differed but all had in common an education component, a discussion component, and an opportunity to practice new

skills. It was concluded that interventions delivered to parents and other caregivers across a wide range of adolescent risk and protective behaviors can lead to improvements in adolescent health. This may inspire new approaches for reaching parents of beginning drivers.

Other studies of programs aimed at parents are in progress or in the planning stages. The University of Iowa Injury Prevention Research Center is conducting a randomized trial of a parent-based intervention that equips parents to talk about, demonstrate, and practice safe driving skills with their teens (Ramirez et al., 2012). Teens in this study are at least 15 years old and are planning to obtain an intermediate license within three months. The intervention is based on health behavior and family communication theory and provides parents with instruction on motivational interviewing techniques to deliver the messages. Outcome results are not yet available, but interim findings suggest that these techniques have good potential for real world translation and delivery.

There are many types of information materials available to parents to aid them in preparing their teen for driving and guiding them through the licensing process, such as AAA's Dare to Prepare. Parent programs are mandatory in a few places (Connecticut, northern Virginia, and Massachusetts). In other states, courses for parents are available on an optional basis, generally in school settings. A survey of Connecticut parents who were the first to take the orientation course indicated that it was well received. Most parents approved of the course requirement and reported that they learned helpful information (Chaudhary, Williams, & Casanova, 2010).

There is broad interest in parent orientation courses. In national surveys, 70 percent of parents of teens and 60 percent of teens thought they should be required (Williams, Braitman, & McCartt, 2011; Williams, 2011). UMTRI has collected qualitative data indicating enthusiasm for such courses. At this point, however, what parent orientation courses accomplish in the way of behavior change of participating parents and their teens is unknown.

In other ongoing work, the University of North Carolina HSRC, in collaboration with the AAA Foundation for Traffic Safety, is developing a new approach for improving parental supervision of novice drivers, in an attempt to maximize the value of time spent practicing driving during the learner stage. It will be based on adult learning principles and will include experiential learning, with the goal of getting parents to viscerally understand critical points about the nature of safe driving and, as a result, what they need to help their teen learn during the supervised driving phase of the licensing process.

Parents can be assisted by technology in monitoring and controlling the driving behavior of their teens. There are various devices that can be installed in cars to indicate instances of aberrant driving and provide this information to parents in real time or on a delayed basis. Studies have indicated that this feedback can lead to improved driving behavior (Farmer, Kirley, & McCartt, 2010; Carney, 2012). A study by NICHHD and UMTRI looking at the effect of immediate feedback to drivers on aberrant driving, and feedback to drivers plus feedback to parents, is in the write-up stage. In-vehicle electronics could be used to monitor GDL compliance, for

example, with night driving and passenger rules, but it has not been deployed in this way to date. The Intelligent Vehicle Laboratory and the HumanFIRST program at the University of Minnesota have developed an in-vehicle smartphone-based system that monitors GDL compliance and provides feedback to the teen and parents.

Discussion and Conclusions

The introduction of graduated driver licensing represents one of the most important public health movements that has ever occurred in North America. It has had a major impact in reducing young driver crashes and associated injuries to themselves and others. In the process, many research articles have been published, documenting the effects of GDL and the contribution of its various components, and the superior benefits resulting from comprehensive systems have been well established. The number of research studies on GDL continues to grow. Since early 2010, much new information – documented in this review – has been gained, and there is an impressive amount of research in progress.

In addition to summarizing the current state of knowledge, emphasis in this review has been given to identifying what we do not know and would like to learn in order to optimize GDL effects. For example, it is known that passenger restrictions in general reduce crashes involving teen passengers, but it is not clear which calibration is most effective, a limit of zero or one young passenger. In other cases, there are more fundamental questions and knowledge gaps. More information is needed about what transpires during the learner period and the policies and practices that will best prepare beginners for independent driving. There is more to learn about how to decrease the initial high crash rate once independent driving begins, and to determine if there is anything behind the swift decline in crashes that takes place in these first few months other than a rapid learning process. There is also a need to identify evidence-based ways to further increase compliance with GDL provisions. This might be accomplished through parents, but police, health care providers, and teenagers themselves may also be able to play a role. Research is clearly needed to determine which, if any, of these avenues can be used effectively. In addition, there are opportunities that can be pursued for integrating driver education and GDL in ways that may increase safety benefits for young drivers (Thomas, Blomberg, & Fisher, 2012).

The most pressing challenge is to clarify the effects of GDL at ages 18 and 19, where there is conflicting evidence. GDL is designed to give young beginners more time to gain driving experience prior to full licensure, which could lead to positive effects beyond completion of the GDL process. It is also possible that being kept out of high-risk situations, such as late night driving, means lesser ability to deal with challenging driving tasks later. There is scant information on comparative exposure (amount and type of driving) pre and post GDL, and how going through GDL may affect exposure at age 18. There is some evidence from HSRC, based on trip diary information, that GDL did not reduce the amount or type of driving of North Carolina teens, compared with pre-GDL drivers. That is, teens going through the GDL program were driving about as much and at similar times as those who were driving before the GDL system was in place. In another North Carolina study it was

found that for 16-year-olds, there was lower crash incidence for at least five years after being licensed to drive independently through a GDL system than among those licensed under the previous system (Masten & Foss, 2010). The authors suggested that some of this effect indicates “an enduring, greater ability to avoid crashing.” This evidence for positive carry-over effects is, however, based on only one state.

It has also been suggested that many young people may be delaying the start of licensing until age 18 so that they can avoid GDL requirements altogether, making them inexperienced, although more mature, beginners. There is little reliable information on current licensure patterns and how they may have changed over time and in response to GDL. The national data file of state-by-state counts of licensed drivers is considered to be inaccurate for tracking the number of licensed teenage drivers (Insurance Institute for Highway Safety, 2007; Ferguson, Teoh, & McCartt, 2007). Studies in states with good license data systems are the most likely means by which GDL-related effects at ages 16-19 and reasons for any such effects can be investigated. Such studies would also address crashes in general, with results that may differ from GDL evaluation studies based only on fatal crashes.

There is some information available on these issues, and more is on the way. In a national probability survey of 15- to 18-year-olds conducted in late 2010, 22 percent of 18-year-olds had not yet obtained a license. Most cited cost as a reason, although about one-quarter mentioned the hassle of licensing requirements (Williams, 2011). Soon-to-be-published qualitative data from UMTRI based on discussions with parents and teens have revealed barriers to licensure that include cost issues and the amount of parent involvement required, with some saying they delayed until 18 to avoid GDL. Information on license delay and the reasons for it are currently being obtained by the AAA Foundation for Traffic Safety in a national survey of 18- to 20-year-olds. In Ehsani's Ph.D. thesis, the effects of GDL on 18-year-olds in Florida, Maryland, and Michigan are examined. The Rollins School of Public Health study of Georgia's GDL system is looking at 10½ years of post-law data and changes in fatal crash rates by single age groups, including 18- and 19-year-olds. In another study, fatal crash rates of newly-licensed 18- and 19-year-olds who either went through or bypassed the California GDL program will be compared.

Further exploration of youth licensing trends and overall GDL effects will provide the information needed to consider possible remedies, such as the practice in all other GDL countries of applying full GDL rules to older novices. Presently in the United States, only New Jersey has adopted this practice, as noted earlier.

Lack of exposure data has hampered attempts to clarify the overall effects of GDL as well as to assess teen driving risks and measure the effects of programs and policies in general. In recent years, information on driving during the restricted licensing phase has become available based on small samples of drivers in naturalistic studies (Goodwin, Foss, & O'Brien, 2011a; Klauer et al., 2011; Lee et al., 2011); less detailed data are available from 11,876 respondents ages 16-19 in the 2009 National Household Travel Survey (Federal Highway Administration, 2011); and there is information on driving exposure of 16-17-year-olds in Michigan based on travel survey data (Ehsani et al., 2010; Ehsani, Bingham, & Shope, 2011). Yet lack of high-

quality exposure data remains a significant problem in conducting research on questions of interest related to licensing systems.

Ending this report with a recital of research needs is not meant to downplay all that has been learned about GDL since the beginning of 2010, which is considerable. However, it is hoped that this review will encourage researchers to focus on filling important knowledge gaps and in so doing provide the basis for further enhancing the benefits of GDL.

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