

Graduated driver licensing: what works?

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Background: Graduated driver licensing (GDL) adds an intermediate stage to driver licensing between the learner permit and full licensure stages that is intended to ameliorate the high risk of novice drivers.

Objectives: To assess the contribution of various elements of GDL to reduction in the crash rates of young novice drivers.

Methods: An extensive review of the literature was undertaken to synthesise research findings on crash reduction.

Results: Increasing the length of the learner period and the amount practice required has reduced crash risk, partly through improved performance and partly by delaying licensure. Intervening early with traffic violators and making full licensure dependent on a clean driving record provide both general and specific deterrents to unsafe driving. Restrictions on night driving and carrying passengers are effective in reducing the increased risk of these situations. The benefits of multistage instruction and testing as well as the use of visible tags to identify novices have not as yet been adequately evaluated.

Conclusions: While graduated driver licensing has proven a generally effective means of reducing the crash risk of novice drivers, controlled research is needed to assess the benefits of its individual components.

Graduated licensing represents an attempt to lessen the hazards of the highway for novice drivers by introducing between the learner permit and full licensure stages an intermediate stage in which driving is subject to certain protective measures. The increased risk posed for and by novices is well documented in crash statistics. For each mile they travel, 16 year olds are two to three times more likely to have a crash as someone with just a few years experience, and 10 times more likely than experienced adults.¹ While the initial crash rate drops somewhat with age, the steep drop with experience prevails at all ages.² McCartt's surveys of individual teenagers show the self reported per-mile crash rate dropping by almost one half over the first 250 miles of driving and by almost two thirds over the first 500 miles (unpublished). The high initial crash rate makes the process by which novices are licensed an attractive crash reduction target.

The elements of graduated licensing were first introduced in 1964 in Victoria, Australia, followed by New South Wales in 1966. Between the learner permit and full licensure stages was a probationary license period that permitted solo operation but limited speeds and imposed special sanctions on violators. The first law creating a formal graduated driver licensing (GDL) system was enacted by Maryland in 1978, based on a model developed by the National Highway Traffic Safety Administration. California adopted GDL in 1983, followed by New Zealand in 1987. However, it was not until the 1990s that the idea began to take hold. At that time, systems were being put into effect throughout the United States and Canada, as well as some European countries.

This paper seeks to assess the separate contributions of the various GDL elements to reduction in the crashes of young novice drivers. However, ability to evaluate individual elements is hampered by absence of evaluation efforts in many jurisdictions, difficulty in separating the effects of elements introduced or modified at the same time, and variation in methodology leading to differing results. Nevertheless, it is possible to gain insight into the general effects of various elements, if not the magnitudes, particularly with the aid of research conducted outside of GDL and with certain elements directed toward particular subsets of crashes.

Since GDL constitutes a "package" of several elements, there is at least a theoretical possibility that the total GDL effect is greater than the additive sum of the individual com-

ponents. No attempt is made here to evaluate the above hypothesis since the necessary evaluation evidence is lacking. Outcome evaluation data currently exist for the following four GDL elements: extended learning, early intervention, night restrictions, and passenger restrictions. These will be discussed in the following sections. While GDL is characterized by the issuance of an intermediate license, some jurisdictions have incorporated certain of its elements outside of the GDL structure, often allowing for a more clear evaluation of those elements.

EXTENDED LEARNING

The inordinately high crash rate of novice drivers makes some enhancement of the learning process a logical element of GDL and it is, indeed, one of the most widely used. Making better use of the initial license stage has included extending the duration of the learner period to promote more practice and requiring more structured supervisory processes to make better use of time available. These elements can lower the crash rate in two ways: limiting exposure by low mileage and close supervision, while improving ability by longer and more intensive practice. The expected result would be a lower crash rate following introduction of GDL. Such reductions in overall crash rate have been evaluated using one or more of the following indices: crashes per number of licensed drivers, crashes per number eligible to drive, and crashes per number of 16/17 year olds in the population. Table 1 presents the reductions in novice crashes (per license, per driver, and per capita rates) in jurisdictions extending the minimum duration of the learner phase.

Per licensee rates

Crashes per number of licensed drivers (intermediate or full license) reflects reduction attributable to improvements in the crash avoidance skills of license drivers. The clearest assessment of the potential safety effects of extended learning comes from Sweden. Their extended learning was not part of a GDL program, so it was independent of other changes in licensing, and it did not influence the age of licensing.³ A change in the law lowered the permit age from 17½ to 16 for those willing to get a permit and be supervised either by professional driving school instructors or by adults with

Table 1 Reductions in novice accidents per licensee, per driver, and per person reported for various GDL programs

State	Date enacted	Per licensee (%)	Per driver (%)	Per capita (%)	Learner phase	Reference
California	1983	3.8		5	1 mth + 2 wk; more for test failures	Hagge and Marsh ⁶
California	1998	0		9	6 mth	Peck (unpublished)
California: San Diego	1998	0		20	6 mth	Smith <i>et al</i> ⁶
Connecticut	1997			22	3–6 mth	Ulmer <i>et al</i> ¹⁸
Florida	1996		9		6 mth	Ulmer <i>et al</i> ²⁴
Kentucky	1998			32	180 days	Agent <i>et al</i> ¹⁵
Louisiana	1993			20	Driver education	Ulmer <i>et al</i> ¹⁷
Michigan	1997			25	50 h	Shope <i>et al</i> ¹⁴
Ohio	1999	11		11	6 mth	Kilgore ⁷
New Zealand	1987			7	6 mth	Langley <i>et al</i> ¹²
North Carolina	1997			27	12 mth	Foss ²³
Nova Scotia	1994			24	6 mth	Mayhew <i>et al</i> ⁹
Ontario	1994	16	31		12 mth	Boase and Tasca ⁴
Quebec	1996	5	14		8–12 mth	Bouchard <i>et al</i> ⁶

instructor permits. Those who elected the early start averaged 2.5 times more practice driving than others and had 24% fewer crashes, when demographic differences were controlled.

Most jurisdictions reporting reductions in crashes per licensed driver have extended the learner permit stage. Although the reductions in crash rate associated with GDL cannot be attributed solely to the extended learning stage, this element appears to have the greatest potential for an overall effect in the individual jurisdictions. In Ontario, introduction of a 12 month learner period was associated with a 16% reduction in the per-driver crash rate of licensed drivers.⁴ Quebec also changed its existing GDL law to require a 12 month learning stage for all new drivers, resulting in a reduction of 5% among licensed drivers.⁵ Although both provinces lowered the learning period to eight months with driver education, separate analysis suggests that the reported crash reduction could not be attributed to the educational programs. Efforts to assess the effect of California's 1998 enhanced GDL program were carried out at the state level (unpublished) and within the city of San Diego.⁶ Neither was able to detect a reduction in crashes among licensed drivers.

In Ohio, Kilgore⁷ carried out a systematic evaluation of the Ohio's GDL law, controlling for licensing rates. The reported decline in crashes suggests that the various elements in combination had a beneficial effect on the ability of licensed 16–17 year old drivers to avoid crashes. However, certain troublesome aspects of the decline in crashes must be noted, including widely varying year-to-year crash rates over the prior 10 years, and a general downward trend in most crash categories in the preceding three years. Kilgore points out that it is not possible to estimate accurately the magnitude of any crash reduction without a longer follow up period and a more extensive statistical analysis. Using historical crash rate data contained in the Ohio report, the present authors computed per capita and per licensee crash reductions for 16 year olds of 11%, unadjusted for trend (unpublished).

Per driver rates

Crashes per number eligible to drive (including learners and licensed drivers) reflects crash reduction attributable to safer driving plus exposure reduction emanating from the greater time spent in the learner phase. Novices eligible to drive include both learners and those who have gone on to obtain licenses. In many jurisdictions, the crash reports on which GDL statistics are based do not indicate license status, making it impossible to distinguish license status at the time of a crash. Where the learner stage has been extended, novice drivers spend a greater portion of their first months of driving on a learner permit, under the supervision of a licensed adult, rather than driving on their own.

The exposure to crashes when operating on a permit is lessened in two ways. First, the requirement for adult supervision limits the amount of driving to periods when an adult is available and willing to supervise. A survey of 16 year old Tennessee learner permit holders reported driving an average of 350 miles over a three month period,⁸ which is roughly a third of the mileage driven by licensed drivers of the same age.¹ Second, the safety of learners is certain to be influenced by the presence of an adult supervisor, most often a parent. For these reasons, comparisons of crash rates that include learners are almost certain to be lower than those confined to licensed drivers. Not yet published research by Mayhew, Simpson, and Pak shows the crash rate of learners as ranging from approximately 10% that of novices during the first month to 20% over the first year.

An indication of the extent to which the delay in licensing is responsible for reduction in crashes is provided by Ontario and Quebec, where rates based on both stages of licensing are reported. The comparison, shown in table 1, indicates that half to two thirds of crash reduction experienced by all drivers could be attributed to the longer period of supervised driving. The 9% reduction found in Florida is a per capita figure but occurred where there was no reduction in the proportion of the teenage population obtaining learner permits. However, a survey of teenagers found that the requirement for a six month permit increased the length of time the permit was held, with those holding it less than six months declining from 28% to 12%.⁹ While extension of the learner phase reduces crashes among those affected, it also lessens independent mobility.¹⁰ Analysis of the tradeoff between decreased mobility and increased public safety has not yet been adequately examined in the literature.¹¹

Per capita rates

Crashes per the number of 16/17 year olds in the population reflects crash reduction attributable to safe driving plus exposure reduction due to the longer learning phase and reductions or delays in the proportion of eligible teenagers who seek a license. The majority of attempts to assess the effectiveness of GDL have employed as a criterion measure the reduction in crashes for the total eligible population irrespective of licensure or license status. This rate, in essence, combines learners and licensees, as well as those without a permit or license and are, therefore, not eligible to drive at all.

Introduction of the New Zealand GDL in 1987 was followed by an estimated 23% decline in motor vehicle related injuries among the 15–19 year age group, both passengers and drivers combined.¹² However, at the same time, crashes among the 25 and older age group, which were not affected by GDL, dropped by 16%, leaving a net decline of seven percentage points.

Moreover, examination of the numbers of licensed drivers showed a marked increase in the one and a half years preceding the GDL law, followed by a decline over the next two years. Thus, the licensure drop of about 25% strongly suggests that any effect of GDL could be traced to reductions in the numbers seeking and obtaining licenses. The authors conclude that the reduction in crashes may be attributed to an overall reduction in exposure.

In North Carolina, Foss and colleagues¹³ found a 27% per capita drop in crashes among 16 year olds in the absence of a decline in the proportion of drivers. However, his subsequent analysis of licensing showed a 24% drop in the proportion of the age group issued licenses (unpublished). It is therefore clear that a major portion of the decline in crashes can be attributed to the greater proportion of time spent driving on a permit. Shope and colleagues¹⁴ reported a 25% decline in all crashes among 16 year olds in Michigan following implementation of a 50 hour adult supervised, six month minimum driving requirement. However, at the same time, the proportion of 16 year olds licensed to drive unsupervised declined from 59.7% to 37.5%.

In Kentucky, Agent and colleagues¹⁵ reported a 32% per driver decline in crashes of 16 year olds over the three years following introduction of GDL. This effect was attributable primarily to an 83% crash reduction among those aged 16 to 16 years 6 months, who would necessarily be driving on a learner permit. In California, the 1983 GDL was associated with a 5.3% per capita decline in crashes for drivers in the 15–17 year age groups.¹⁶ Their analysis of changes in per licensee crash rates produced a slightly smaller effect (3.8%), suggesting that most of the per capita reduction could not be attributed to declines in licensure. The effects of the California GDL program as enhanced in 1998 have not yet been extensively evaluated. An evaluation of crash rates in San Diego County⁶ indicated a 20% decline in the per capita crash rates of 16 year olds, but found no evidence for an effect on per licensed driver rates. An inspection of per capita pre vs. post crash rates for the entire state indicated a 9% reduction but also revealed no evidence of a reduction in crash rates per licensed 16–17 year olds (Peck, unpublished).

Louisiana and Connecticut extended the duration of the permit phase without introducing GDL. In Louisiana, while serious crashes among 15 year olds declined by 20% in each of the two years following introduction of the requirement in 1993, the number of licensed drivers in the age group dropped by 35% and 29% for the same period.¹⁷ In Connecticut, a new law required that a learner permit issued at the earliest at age 16 should be held for 120 days with driver education or 180 days with home training. Per population fatal/injury crash rates for 16 year olds declined by 22%, in contrast with an 8% decline in a neighboring control state.¹⁸

The introduction of GDL in several jurisdictions has been accompanied by a drop in the numbers of drivers within the eligible population. Many who are eligible to drive either rush to become licensed before the law goes into effect or delay application for some time after it has been in effect. This one-time transitional effect can introduce confounding when attempting to estimate the ongoing effect of the GDL law and its individual components. For example, Mayhew and colleagues¹⁹ examined the effect of GDL implementation on the rate of licensure and found a 27% decrease in the number issued a permit in the following year. Much of this reduction was attributable to a transitional inflation in the licensure rates in the pre-GDL period. Adjusting for this effect, the authors estimated the true per driver crash reduction to be 19%. An as yet unknown proportion of this drop would be attributable to the six month permit extension phase. Evidence of a transitional effect on licensure rate was also apparent in Ohio.⁷ During the year the law went into effect (1998), the licensure rate among 17 year olds increased from 62% to 71% and then declined to 66% in 1999. Among 16 year

olds, the rate declined from 34% in 1997 to 31% in 1998 and then returned to its pre-GDL level of 34–35% in 1999.

EARLY INTERVENTION

Most jurisdictions maintain driver improvement systems under which repeated traffic offenses lead to increasingly severe sanctions, beginning with warnings and progressing through to suspension or revocation of licenses. Those with GDL typically initiate the process earlier for novices on intermediate licenses, some suspending the license on the basis of a single violation. In their evaluation of the initial California GDL law, Hagge and Marsh¹⁶ found that the accelerated interventions were associated with significant general and specific deterrent effects on subsequent citations and crashes as 16–17 year olds approached or exceeded the threshold for triggering license control actions. In Michigan, where traffic violators are sent to group meetings, a random sample of novice violators was assigned to a group meeting at a lower number of violations than were adults. Those assigned to the group meeting had 6.5% fewer crashes ($p < 0.05$) during a six month period following assignment than were those novices not subject to any action.²⁰ In another Michigan experiment, a randomly selected group of novice drivers was threatened with a short term suspension after the first violation.²¹ While females as a group evidenced lower violation rates after the threat, males did so only after being suspended.

One element of GDL that appears to strengthen the effect of early intervention is making advancement to full licensure contingent on a clean driving record. Evidence of the effect of this provision comes from the initial Maryland law, where full licensure was permitted after six months of violation free driving. This was the only element of GDL that was considered capable of leading to the 5% decline in daytime crashes that followed its implementation.²² The effectiveness of contingent advancement appeared to depend on an incentive to seek full licensure, which in Maryland was release from the night driving restriction. Making advancement contingent on violation-free driving involves a tradeoff between the incentive value of early advancement and benefits of extending the limitations imposed by the intermediate license. This conflict has been more recently resolved by maintaining a lengthy duration for the intermediate license, yet still extending it for traffic violations.

NIGHT RESTRICTIONS

Late night is a particularly dangerous time to be on the road, given the numbers of drivers impaired by alcohol and fatigue. Novice drivers, who have not yet learned to recognize danger during the day when they can see well, would be expected to be at particular disadvantage when vision and perception are compromised by darkness. In the balance between safety and mobility, night restrictions are offset by the relative absence of late night travel demands on the 16 and 17 year olds to which the restrictions largely apply.

While having restrictions that begin at midnight and earlier have produced substantial crash reductions, later restrictions involve too few crashes to yield either statistically or practically significant changes. North Carolina's 9 pm start is currently the earliest restriction imposed by a graduated license system.²³ Among 16 year olds, the overall crash reduction for total crashes was 47% for night crashes, compared with 22% for day crashes, amounting to a net reduction of 25% attributable to the night restriction itself. Since some portion of the North Carolina population was licensed before GDL and not subject to the restriction, the estimates of benefits are probably conservative. Florida's restriction, which begins at 11 00 pm yielded a 17% reduction in night crashes compared to a 7% reduction in daytime crashes.²⁴ Under Michigan's midnight to 5 am restriction, there was a 53% reduction in

night crashes compared with a 25% decline in total crashes.¹⁴ New Zealand's restriction, which commenced at 10 pm, was associated with a 37% reduction in the proportion of crashes occurring at night.²⁵

Simple curfews have also been associated with crash reductions²⁶⁻²⁷ relative to neighboring jurisdictions. Although the validity of this research is undermined somewhat by the lack of pre-curfew data and the inability to make pre-post comparisons, the fact that the findings are consistent with the above studies on GDL based night restrictions is notable.

While restrictions reduce the extent of night driving by novices, they come far from eliminating it. Many teenagers believe the chances of being apprehended or cited are very small.²⁸ Most GDL laws contain provisions for granting exceptions to the night restrictions and these waivers have been instrumental in neutralizing resistance and opposition.

PASSENGER LIMITS

A wealth of research has shown that the combination of teenage drivers and teenage passengers can increase the likelihood of accidents, first by exposing drivers to influences that lead to unsafe behavior, and second by exposing larger numbers of persons to any crash that might occur. Limiting the number of passengers that can be transported by intermediate stage license holders could reduce crash victims from both sources. Even though only about one third of all jurisdictions currently impose passenger limits, such limits are widely supported by parents. A survey in Florida and Connecticut found from 56% and 58%, respectively, of parents in the two states favored restrictions before GDL,²⁹ although passenger limits were not elements of the GDL in either state. Support for such restrictions grew to 67% in Florida and 72% in Connecticut in a survey conducted after it was introduced. It would appear that experience with graduated licensing in general helps pave the way for acceptance of passenger limits.

Chen and colleagues³⁰ estimated the potential number of deaths that would be prevented if restrictions were imposed on all passengers aged 16–19. Their estimates ranged from a 7% reduction (if compliance rates were as low as 20% and one half of the excluded drove themselves) to as high as 42% (where compliance rates were 90% and only 10% of the remainder drove themselves). However, introduction of a passenger restriction in New Zealand was followed by only a 9% reduction in the proportion of crashes involving teenage passengers of drivers on intermediate licenses.²⁵ A 23% decline in passenger injuries per licensed driver was observed in San Diego after a ban on teenage passengers became part of the California law.⁶ However, the drop occurred from the first to second year following enactment of the law. It would appear that passenger limits for teenage drivers may have greater potential in theory than in actuality. Like night restrictions, enforcement is difficult for police and lies primarily in the hands of parents.

OTHER ELEMENTS OF GDL

The elements of GDL discussed above are those whose contributions to crash reduction have been capable of assessment. Other elements include the following:

- Multistage instruction—segmentation of instruction into two phases: basic vehicle control skills followed by instruction emphasizing more complex traffic situations, including risk assessment and crash avoidance strategies
- Multistage testing—requiring passage of a second test covering higher level skills to determine if the novice has met the competency level standards of the stage 2 instruction
- Speed limits—imposing lower maximum speed limits on high speed roads for intermediate stage novices
- Visible identifiers—requiring external tags or stickers identifying that the vehicle is being driven by a learner or intermediate stage licensee

- Alcohol and restraints—special limits on alcohol use and permissible blood alcohol concentrations, and mandatory restraint use.

With the exception of alcohol and restraints, data are absent or lacking on the efficacy and impact of each of the above elements. Statutes imposing lower blood alcohol concentration threshold and selective mandatory seat belt usage are usually based on age rather than licensing stage and for that reason are not considered here to be GDL elements.

SUMMARY, CONCLUSIONS, AND FUTURE RESEARCH NEEDS

Graduated driver licensing seeks to improve the safety of novice drivers by making the licensing process more gradual. Implementation of GDL has been accompanied by reductions of up to one third in the per capita crash rate of 16 year olds. Half or more of this reduction results from decreases in the proportion of drivers who are licensed as the length of the learner stage is increased. In some jurisdictions the proportion of 16 year olds who enter the GDL process is lowered by those who either rush to gain licenses before GDL goes into effect or wait until they are 18 and are no longer subject to it. Nevertheless, there is evidence that safety and crash reduction is mediated by the GDL elements of extended learning, accelerated driver improvement interventions, night driving restrictions, and passenger restrictions. However, additional research is needed to resolve the following issues:

- Extended learning—to distinguish licensed drivers from learners and non-drivers in order to better assess the effect of the extended learner phase on the safety with which novices drive when unsupervised
- Improved practice—to determine the optimum length and method of providing adult supervised practice
- Contingent advancement—to determine the optimum period of violation-free driving that is required for advancement from provisional to full licensure
- Adult novices—to determine the feasibility and potential impact of expanding GDL provisions to adult novice drivers
- Age and GDL—to assess the effect of GDL on those who delay licensure to age 18 or later in order to avoid GDL provisions
- Passenger limits—to determine the actual compliance with passenger limits and the amount of driving by displaced passengers
- Risk-benefit relations—to determine the effects of delayed licensure on the balance between benefits of reduced risk and the costs of reduced mobility
- Individual elements and global impact—to identify the combination of elements that constitute an optimum GDL program by addressing them as they are added to, or instituted outside of, GDL programs; and by using criteria that are differentially sensitive to the individual elements.

It is beyond the scope of this paper to address the research design requirements for the above research. However, it is appropriate to conclude with some general observations about optimum quasi-experimental strategies in evaluating GDL programs. A strong case can be made for the multiple design approach exemplified by McKnight and colleagues,²² Hagge and Marsh,¹⁶ and Mayhew and colleagues.¹⁹ These investigators used interrupted time series to evaluate effects on total crash rates supplemented by a cross sectional comparison of the crash rates of teenage drivers licensed prior to and following GDL laws. These two approaches allow for an assessment of different facets of the problem and control of different sources of confounding.

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..... **DISCUSSION PAPER**

To address the question “graduated licensing: what works?”, McKnight and Peck have synthesized studies that evaluate a range of laws, programs, and licensing systems designed to reduce young driver crashes. I would like to underscore their points regarding a couple of issues, and add a few additional points that I believe are important to bear in mind as we contemplate the question “what works?”

WHAT SHOULD A GRADUATED LICENSING SYSTEM INVOLVE?

As part of their review, McKnight and Peck have undertaken the daunting task of trying to extract clear evidence from the limited research currently available that would support particular elements in a graduated driver licensing system. Among the problems they have to grapple with are: (1) the minimal amount of research on individual “elements of GDL” outside the context of GDL programs; and (2) the difficulty of isolating the effects of individual elements when evaluating a system that contains several. Adding further difficulty to this quest, is the lack of evidence to suggest the *optimal duration* of the protective restrictions included in GDL systems. Presently, almost no data are available regarding duration that can guide policy makers interested in designing an empirically grounded GDL program. The closest approximation to research that might help to answer that question are recent studies indicating that beginning driver crash rates decline relatively quickly from their extremely high initial levels.^{1,2}

Equally as frustrating as the lack of research on individual GDL elements is that future research will probably not be able to isolate the effects of many of these elements. Virtually every GDL system currently in effect is unique. There are numerous similarities, but also many differences, among the several dozen US and Canadian GDL programs in operation as of March 2002. Consequently, even as more GDL programs are evaluated, it will be difficult at best, to isolate the effects of individual elements by systematically controlling for the effects of other elements.

Beyond the logistic complexities created by the many different versions of GDL, we face a more fundamental problem in seeking an empirical answer to the question of which elements are most useful in a GDL system. None of the component elements exists alone in a GDL system. Consequently, with a few possible exceptions (for example, a night driving restriction), we cannot disentangle the effects of individual elements when evaluating a particular GDL program. At the same time, it is not necessarily appropriate to simply structure a GDL program by including, in combination, those elements that have been shown to produce crash reductions when implemented alone.

When examining the effects of particular elements separately, we are unable to see the synergistic effects that may result from the combination of elements that, by definition, a GDL program involves. For example, we might well expect an interaction between the safety benefits of requiring a clean

Table 1 Monthly average number of licensed 16 year old drivers in North Carolina, 1996–2000*

Year	Permit	License	Level 1	Level 2	Level 3	Total
1996	15369	49065	0	0	0	64434
1997	16220	49956	0	0	0	66175
1998	14301	48523	6297	33	9	69163
1999	2663	18374	24629	16647	2255	64568
2000			27329	25320	9389	62038

*Note: years run from December 1 through November 30. The GDL system was implemented on December 1, 1997.

driving record to progress beyond a particular licensing level and the restrictiveness of conditions involved at that level. If restrictions are minimal, there is little motivation to maintain a clean driving record in order to escape them. It is also not possible to detect “moderating” effects, whereby one element might render another relatively ineffective. As an obvious example of this, it would seem that a prohibition on passengers riding with drivers might substantially pre-empt the benefits of a night driving restriction that applies to the same level license.

I am led to the frustrating, but not necessarily unhappy, conclusion that it may never be possible to disentangle the separate effects of individual elements, in order to “fine tune” GDL systems based on an accumulation of empirical evidence. Fortunately, neither the limited availability of data to suggest the structure of an optimal GDL system, nor the dim prospect for obtaining clear empirical guidance in the near future, leaves us without a way to design appropriate GDL systems. We can turn to both conceptual and theoretical principles for guidance, mixing in available research results where they are available. This approach has produced recent guidelines for structuring a GDL system.^{3,4} Unfortunately, in several instances, this approach has fallen victim to the political give and take that is often necessary to enact legislation. This has resulted in enactment of GDL systems that are unlikely to produce the benefits they might have.

It may be that the “ideal” GDL system is simply one that effectively implements the following concepts: (1) provide beginning drivers with a substantial amount of driving experience, under “real world” conditions, while keeping the attendant risks to a minimum; and (2) embed in the structure of the licensing process the principle that driving is a privilege to be earned by demonstrating responsible driving behavior, not a right associated with reaching a certain age or waiting some fixed period of time. It is the combination of these mutually supportive and reinforcing elements that embodies the uniqueness of GDL among the many policies and programs whose goal is to reduce traffic crashes. Among GDL programs that implement these general principles, variation in the details may produce no meaningful differences in their overall effect. Or they may; we shall have to wait a while longer to see.

HOW DOES GRADUATED DRIVER LICENSING REDUCE CRASHES?

There is little question that GDL reduces young driver crashes, as well as the deaths and injuries that result. However, it is not yet clear how these reductions are achieved. Our present lack of understanding is underscored by the fact that similar reductions in crashes appear to have been produced by substantially different GDL programs. A better understanding of how GDL reduces crashes will help us to reconcile these puzzling findings.

In their article, McKnight and Peck suggest that the crash reductions reported in evaluations of most GDL systems to date can be attributed to reductions in licensing. Some

observers may consider this a failure of GDL to produce safer drivers. Others will interpret these results from a public health perspective, maintaining that the goal is to reduce crashes, deaths, and injuries for road users and that producing safer drivers is but one way to achieve that result. This debate is an important one; researchers, policy makers, traffic safety officials, and public health practitioners need to reach consensus on how these issues should be viewed. Although this has important ramifications, consideration of these issues is beyond the scope of the present discussion.

I would like to briefly address an important methodological consideration in the use of per-driver crash rates when examining GDL programs. It is clear that many GDL systems will reduce exposure, by reducing driving, for the youngest drivers as the programs take effect. In addition, the better systems will also materially reduce high-risk exposure for intermediate licensees. It is probably premature, however, to estimate the degree to which altered exposure, as opposed to other effects of GDL, reduces crashes. That is because we are not currently able to accurately estimate young driver exposure. At present there are virtually no data available to indicate how driving exposure for young, novice drivers changes under a GDL system. The one indicator most often used to estimate exposure, the number of licensed drivers, is potentially problematic.

GDL disrupts what is normally an equilibrium or “steady state” of the young licensed driver population, and this disruption can last for several years. There is typically an extended transition period due to the unique nature of GDL; it is an extended process rather than a “law” that applies equally to all drivers immediately on enactment. In North Carolina, for example, prior to GDL there were essentially two types of “license” that a beginner might possess: a permit and a full license. For several years after GDL, young drivers could hold any of five distinct types of license, and the prevalence of each type changed substantially from 1997 through 2000. Table 1 shows this increasing heterogeneity of licenses among 16 year old drivers. A similar effect occurred, beginning one year later, among 17 year old drivers.

From the table it is clear that, until 2000, there is no “licensed driver” count that can adequately represent exposure of 16 year old drivers and that might appropriately be used to compute a driver based, post-GDL crash rate. A further complication is that there is a critical period when the number of drivers holding each license type changes substantially every month. The duration of this period, and the time of onset after GDL, will depend on the particulars of the individual program. During that period, unless driver based crash rates are computed monthly, or even weekly, crash rates per licensed driver will be misleading. The reason for this is that a single licensed driver is assumed to represent exposure for the full period during which crashes are counted. When a licensing system is in a steady state, this assumption is justified regardless of when a licensed driver count is obtained. When the system is disrupted, that assumption is unfounded. Rates based on the number of “licensed drivers” can be highly misleading under such a condition.

WE'VE ONLY JUST BEGUN

Although the general concept of graduated licensing dates back several decades, the GDL era has really only just begun. Prior to 1997 there were only a few GDL programs in place throughout the world; five years later there are several dozen. Because most are so new, relatively few GDL programs have been thoroughly evaluated. Largely as a result of their recency, GDL evaluations have generally used less than ideal study designs. No multi-year follow up studies have yet been possible for GDL systems in the United States. Such studies would help to disentangle effects of altered exposure and other products of the GDL process.

Similarly, no studies have been completed in which the driver's license level is linked to crash data; this would provide another way to incorporate exposure in the analyses. Only the Nova Scotia GDL system and the original 1979 Maryland program have been examined using time-series analyses, wherein the effects of long term crash trends and other possible contaminating factors can be controlled statistically. Finally, studies have focused on a variety of outcomes that are examined in different populations. Studies that analyze crashes among teen drivers (for example, ages 16–19) will detect effects of a combination of factors, in undetermined proportions. Findings from studies that examine a single year age cohort (for example, 16 year old drivers) can be interpreted more easily, but are unable to address broader, longer range effects.

In summary, it is clear that GDL works. At present, that is probably all we can say with confidence. A variety of important questions remain largely unanswered, including why it works, how it works, whether initial effects will erode, and how it might be improved. Fortunately, a sufficient number of well designed GDL programs have been in place long enough that it will be possible to answer some of these questions within the next few years. Certainly, we will be able to learn whether the effects of GDL persist beyond the time during which exposure is reduced by the protective restrictions that distinguish GDL from earlier approaches to driver licensing.

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Graduated driver licensing: what works?

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