Rationale for graduated licensing and the risks it should address

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The increased crash risk of young, beginning drivers has long been cause for concern. Graduated licensing systems, which seek to phase in driving experience gradually over time, have recently been adopted by many states in an effort to reduce these risks. In an attempt to define the basic rationale for graduated licensing, relevant research evidence that describes the conditions under which risk is known to be increased for young drivers was reviewed. Potential changes in licensing laws that best address these known risk factors are described. It was found that certain situations contribute to even greater crash risk, most notably nighttime driving and driving with passengers in the peer group. The underlying premise for graduated licensing is that while crash risk of young drivers is heightened under all situations, some situations are more or less risky than others. If experience can be gained initially under lower risk conditions, both in the learning stage and when first licensed, crash risk will be reduced.

Driving a motor vehicle is a complex task integrating psychomotor, perceptual, and cognitive skills. It takes several years to become proficient at this task, and beginners, especially young beginners, are at heightened crash risk.[1] Sixteen year old drivers are especially prone to crash with rates per mile driven more than four times that of drivers in their 20s. The increased risk is not only for themselves but also for others, and mistakes on the roads can have serious consequences. Nevertheless, on-road practice is an essential step toward becoming an experienced driver.

To try to address the conundrum that on-road driving by beginners is both necessary and risky, many states now have adopted graduated licensing systems. The goal of such systems is to manage exposure to risk, keeping beginners out of higher risk situations while they are learning. Thus, beginners go through stages that vary by amount of crash risk involved, starting with the lowest risk. Learning drivers typically are required to spend an extended period of time, at least six months, practice driving with an adult supervisor so that they gain experience in a wide range of driving situations. When first licensed, unsupervised driving is allowed but restrictions are placed on the higher risk driving activities such as driving at night and with other teen passengers in the car. Only after experience is gained in lower risk settings can beginners graduate to a full unrestricted license that allows them to drive anywhere, anytime, with whoever they choose.

The aim is not to reduce the quantity of driving. In fact, it is important for beginners in a graduated system to drive at least as much as they would have under prior licensing systems. The aim is to reduce the crash risk that results from driving inexperience, moving from low risk driving to somewhat higher risk, and then to full driving privileges as experience is gained over time. Of course, in allowing some types of driving but not others, graduated licensing represents a compromise between safety and mobility.

It makes eminent sense to have an apprenticeship type system for acquiring a complex skill that takes time to develop and during which learning errors can endanger people. It is no different in principle from mastering other skills where performance errors can have serious consequences, such as rock climbing or piloting a plane. People are taught such skills under supervised conditions, and initial experience is limited to lower risk settings. Graduated licensing addresses the crash risks of teenage drivers by delaying higher risk driving until teenagers are both more experienced and more mature. Crash risk is increased for the youngest drivers under all driving conditions; however there is abundant evidence that some driving situations pose a much higher risk than do others. This paper will outline the research evidence that forms the basis for graduated licensing and how it should be structured.

ADDRESSING AGE AND INEXPERIENCE

In countries other than the United States, the provisions of graduated licensing systems apply to novices of all ages. But in all countries including the United States, the provisions apply mainly to young people because most beginners are young. Thus, graduated licensing addresses the risks associated with youthful age: the "immaturity factor". There may be various factors related to adolescent development that make young drivers as a group more crash prone than older drivers, although there is a continuum of risk among young people, with some at more risk than others.[2–5] However, this is the subject of another paper in this issue and will not be elaborated here.

Whatever the causes, the age factor plays out in a more risky driving style among adolescents. Compared with older drivers, younger people are more likely to drive at excessive speeds, follow too closely, violate traffic signs and signals, overtake other vehicles in a risky manner, allow too little time to merge, and fail to yield to pedestrians.[6–9] Driving too fast is particularly associated with youthfulness. Observational studies indicate that young people drive faster than older people, a higher proportion of their traffic violations are for speeding, and excessive speed is cited as a factor in a higher proportion of their crashes.[8–13] In some cases, risky driving reflects deliberate thrill seeking; in other cases, it can merely reflect lack of recognition (because of inexperience) that the behavior is risky. The immaturity and inexperience factors often interact.

Abbreviations: FARS, Fatality Analysis Reporting System; GDL, graduated driver licensing; NASS/GES, National Automotive Sampling System General Estimates System; NPTS, Nationwide Personal Transportation Survey

Risky driving leads young people into hazardous situations, and inexperience makes it more difficult to cope with such situations.

The relative contributions of age and inexperience are difficult to estimate because they are highly correlated. Some studies have found age to be the more important factor; others have reported that inexperience plays the dominant role.[14] Age is a more important influence in countries that typically license early, like the United States and Canada, than in European countries where licensing begins at 17 or 18. Lack of experience appears to be the more influential factor in minor crashes, whereas age related factors are more likely to play a role in serious crashes.[15 16] In addressing the young driver problem, it is clear that risks arising from both inexperience and age need to be taken into account.

By delaying full driving privileges until people are older, and by keeping people out of higher risk driving situations while they learn and accumulate experience, graduated licensing addresses the age/immaturity risk factor as well as inexperience. By the time young people are allowed to drive in all situations, including the most risky ones, they are older and on their way to maturing out of risky driving tendencies.[17] Another possible way graduated licensing could address the age factor is by delaying the onset of driving by postponing the age at which a person decides to apply for a permit. This could happen if, for example, young people are less interested in getting restricted licenses than full-privilege ones.

Raise the licensing age?

The age issue also could be addressed by raising the licensing age from 16 to 17 or 18. This would be effective policy from a safety standpoint, and there is considerable support for it among parents and other adults.[18–20] However, the effect on mobility would be extreme, and the inexperience issue would not be addressed. For example, in New Jersey (the only US state that has had a driving age of 17), 17 year old novices had a somewhat higher crash rate than 17 year olds in neighboring states that were licensed at 16, although overall there was a substantial reduction in crashes in New Jersey among 16–17 year olds.[21]

Extending the low risk supervised learner period

Supervised driving by learners (often with a parent or driving instructor) is a low risk activity, and most jurisdictions traditionally have allowed for a supervised learner period.[22] But there typically has been no required minimum time for this phase, or it was short (usually 14–30 days).[23] The first stage of graduated licensing mandates a minimum learner's period, allowing beginners to build up a foundation of low risk driving. In recent years many states have mandated and extended their learner's permit periods, but they have done this in different ways. There are differences in the length of time required to hold a permit, varying from as little as 2 months to 12 months. Some states allow a younger starting age than in the prior licensing system, with supervised practice beginning at or even before age 15. Other states do not allow practice driving until 15 years 6 months, or even 16 years.

Both the timing and length of practice driving probably influence the age at which initial driver's licenses are sought. For example, in Michigan where permits can first be obtained at age 14 years 9 months and are required to be held for six months, teenage drivers have no difficulty meeting the holding requirements by age 16, when initial licenses first are allowed. North Carolina, on the other hand, allows permits to be obtained at age 15 but requires them to be held for 12 months. This has the effect of delaying licensure beyond the age of 16 because not all teenagers will obtain their permits right away; some evidence indicates this is the case.[24] The requirements in other states, such as Connecticut, Kentucky, Rhode Island, and Virginia, result in licensure delays until after the 16th birthday.

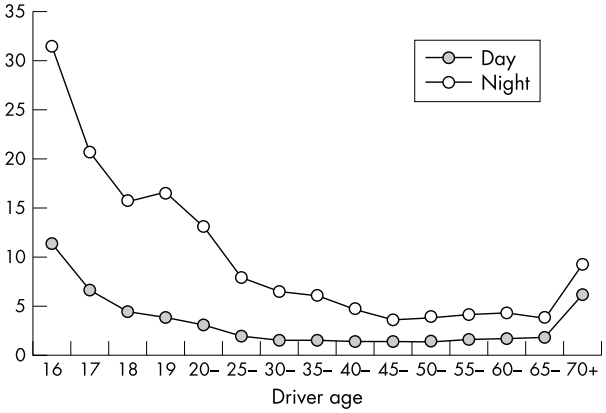

Figure 1 Fatal crashes per 100 million miles, day versus night, by driver age, 1995–96.

What this all means for improved driving safety is unclear. It seems likely that longer periods of practice driving would be beneficial; however, no studies confirm this. It may even be counterproductive from a safety standpoint to allow teenagers to begin earlier if the result is an earlier licensure date.

Limiting high risk driving when initially licensed

The very highest risk for beginners comes immediately on licensure, starting with the first month. For example, data for 16 year old novice drivers in Nova Scotia (prior to graduated licensing) indicate that the crash rate during the first month of licensure was 241 per 10 000 compared with 107 per 10 000 at 9–10 months. Afterwards, the crash rate declined more gradually through 24 months.[22]

The second stage of graduated licensing starts when a beginner passes a driving test and obtains a license. During the first months of licensure, when crash rates are highest, unsupervised driving in situations of highest risk is restricted. The two high risk situations addressed in graduated systems are late night driving and driving with passengers.

ADDRESSING INEXPERIENCE AND HIGH RISK DRIVING CIRCUMSTANCES

Late night driving

Driving at night is associated with increased risk of serious crashes for young drivers. The driving task is more difficult when it is dark, and risky driving, generally associated with recreational activities, is more likely to occur at night.[25] In response to a survey asking teenagers to describe their dangerous driving situations during the past six months ("If a cop had been there you probably would have been stopped"), the teens reported that the majority of such incidents occurred after 10 pm.[26] Fatigue and alcohol also are more likely to contribute to crashes during nighttime hours.

Figure 1 shows the increased fatal crash risk at night, based on US data from the Fatality Analysis Reporting System (FARS) and the 1995 Nationwide Personal Transportation Survey (NPTS), which is the latest mileage data available. The fatal crash risk for 16–17 year olds during the 9 pm to 5 59 am period is about three times the daytime risk. The increased fatal crash risk at night is present for drivers of all ages, and although the nighttime risk is much higher for the youngest drivers compared with older drivers, the differences between nighttime and daytime crash risks are proportionately greater for drivers ages 18–44. For example, for drivers in their 20s, the fatal crash risk at night is more than four times the daytime risk.

When all crashes (not just fatal crashes) are considered, nighttime and daytime crash risk is not much different. For example, for 16–17 year olds the nighttime crash rate per million miles was 28 compared with 27 for daytime crashes, based on mileage data from NPTS and crash data from the National Automotive Sampling System General Estimates System (NASS/GES), which is a probability sample of police reported crashes in the United States.

In 1995 (before most states started to enact night driving restrictions), 32% of all fatal crashes of 16–17 year olds took place between 9 pm and 5 59 am. Most states with late night restrictions do not start them until midnight or 1 am[27] and end them at 5 am, and a few at 6 am. Fourteen percent of all fatal crashes of 16–17 year olds in 1995 occurred between midnight and 5 59 am; thus, the majority of nighttime fatal crashes (58%) occurred prior to midnight. Although the frequency of fatal crashes occurring after midnight is low, the crash risk is higher than earlier in the evening.[28]

Only 14% of 16–17 year olds total mileage in 1995 was between 9 pm and 5 59 am, so the limitations on mobility imposed by nighttime restrictions are not severe. Moreover, within the restricted hours there is not a total ban or curfew; driving is allowed if an adult is in the car, and most states allow exemptions for what is considered essential driving (work, religious activities, medical necessities, school activities, etc, depending on the state). Presumably these are lower risk activities than the recreational driving that is the target of the late night restrictions, although data are not available to verify this. There is also some concern about the risk that may be involved in some types of driving that are exempted in some states, such as to and from school events at night.

Risk of combining drinking and driving

Combining alcohol consumption with driving creates a major risk for drivers of all ages. Teenagers are less likely than adults to drive after drinking, but their crash risks are higher when they do drink, especially at low and moderate blood alcohol concentrations.[29–31] This probably is because of their relative inexperience with drinking and with driving after drinking.

Among drivers of all ages, deaths related to alcohol impaired driving have substantially decreased since the early 1980s, and the declines have been greater for teenagers, particularly 16 and 17 year olds. The larger declines have occurred because of laws aimed specifically at people younger than 21. Such laws raise the minimum alcohol purchase age to 21 and make it illegal to drive with any measurable amount of alcohol in the blood (zero tolerance laws).[32–35] In 1982, 43% of fatally injured 16 and 17 year old drivers had been drinking compared to 18% in 1995–2000. Thirty one percent of fatally injured 16–17 year olds had blood alcohol concentrations of 0.10% or greater in 1982 compared to 12% in 1995–2000. In the last few years, the contribution of alcohol to the fatal crashes of 16–17 year olds has shown negligible changes.

Minimum purchase age and zero tolerance laws are not considered parts of US licensing systems. However, night driving restrictions are determined by licensing laws and, because many of the crashes involving alcohol occur at night, the night driving restrictions potentially influence the alcohol problem. In 1995–2000, 55% of the deaths of 16–17 year olds with blood alcohol concentrations of 0.10% or greater were sustained from midnight to 5 59 am, and 23% occurred between 9 pm and 11 59 pm. Fifty percent of the deaths in which any alcohol was present occurred in the midnight and 5 59 am period, and 22% occurred between 9 pm and 11 59 pm.

Transporting passengers

Most people are well aware of the heightened crash risk when teenagers travel together in a car. The social dynamic in a vehicle occupied by several teenagers can be distracting to beginning drivers, who need to pay close attention to the driving task. Inducements to take risks and show off also may be created. In a survey asking teenagers to describe their dangerous driving situations during the past six months, 85% of the reported incidents involved one or more peers as passengers in the vehicle.[26] Several studies conducted in the 1990s have quantified the excess risk created when teenage drivers transport passengers.[28 36–38] Figure 2 shows typical findings. These data are based on NPTS and NASS/GES. Collectively, the studies indicate the following:

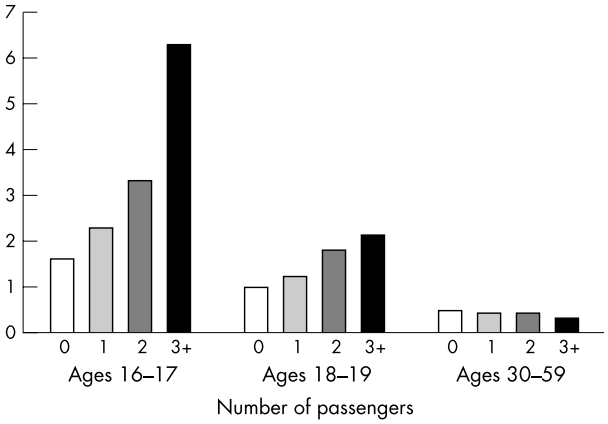

Figure 2 Crash rates by age of driver and number of passengers per 10 000 trips.

(1) The increased risk associated with passengers is present only for teenage drivers; it is more pronounced among the youngest teenagers. For older drivers, passenger presence is associated with decreased risk. This is unlike late night driving, which increases the risk for drivers of all ages.

(2) Crash risk for teenage drivers increases incrementally with one, two, three, or more passengers. With two, three, or more passengers crash risk is 3–5 times greater than when driving alone.[28 36]

(3) The increased crash risk with passengers present exists for both daytime and nighttime hours in about the same proportions, although overall crash risks are much higher at night.[28 36 37] In one study, driver death rates from 10 pm to 6 am were 1.74 times higher with passengers present than without passengers. During the daytime the rates were 1.77 times higher.[28]

(4) Part of the increased injury risk with passengers could be because higher vehicle occupancy by itself increases the opportunity for injury in a crash. However, there is increased risk for young drivers with passengers in studies based on involvement in crashes, including property damage crashes, or deaths to drivers per million trips; in neither of these cases is the influence of high vehicle occupancy on injury a factor.[28 36]

(5) The increased risk when transporting passengers is evident in fatal crashes, nonfatal injury crashes, and property damage only crashes. This is unlike late night driving, which for young people elevates only the risk of a fatal crash.

(6) There is some evidence that when driving with passengers in their 20s, crash risk for teenage drivers is higher than when the passengers are other teenagers[28]; seat belt use by fatally injured teenage drivers is lowest[39]; and alcohol is most likely to be present. In a study of fatally injured drivers, 34% of teenage drivers with passengers in their 20s had blood alcohol concentrations of 0.10% or greater; this compares with 18% in other driving situations. Fortunately, only 7% of all teenage driver deaths occurred when

Table 1 Deaths in crashes of 16–17 year old drivers in 1995 (pre-GDL) without an adult (age 21 or older) supervisor

Situation	Number	Percent of all 3101 deaths
Unsupervised driving 9 pm to 5 am	856	28
Unsupervised transportation of passengers younger than 20	1691	55
9 pm to 5 am	549	18
Daytime	1142	37
Unsupervised driving 9 pm to 5 am (856) or daytime transportation of passengers younger than 20 (1142)	1998	64

they were transporting passengers in their 20s, so this risky behavior occurs infrequently. This points to a potential weakness in many existing passenger restrictions that apply only to transporting passengers younger than 21; most states, in fact, waive the restrictions if there is a passenger present who is 21 (or 25) or older.[39]

(7) Both male and female teenage drivers have increased risk with passengers present, and the risks increase even more given certain combinations of occupants; other combinations do not increase the risk or reduce it. The high risk combination is a male or female driver with male passengers. This has been found in statistical studies based on crash rates per trip and also in a study of on-road driving. In a study based on driver death rates, the presence of one male passenger almost doubled the death rate for both male and female drivers; two or more male passengers more than doubled the death rate.[28] In a study of on-road driving, young drivers with young male passengers drove more dangerously than drivers without passengers; that is, they drove faster and accepted smaller gaps at intersections.[40] The lower risk situation involves a male driver and a female passenger. In the study of on-road driving, males with a female passenger drove slower and did not follow vehicles as closely as did males driving alone.[40] In the study based on driver death rates, there was no increased risk with one female passenger, but there was with two or more.[28] The driver death rates study found some increased risk when young females transported other young females, although the on-road study found no difference in driving risk compared with driving alone.

Contributions of late night driving and transporting passengers

The consequences of high risk, late night driving and transporting passengers are determined by the risk itself and the frequency with which the behaviors occur. In 1995 (before the modern graduated licensing movement began), 3101 deaths occurred in crashes involving 16 and 17 year old passenger vehicle drivers. It can be calculated how many of these deaths potentially would be affected by nighttime and passenger restrictions, separately and in combination. The restrictions are assumed to prohibit driving during specified nighttime hours unless someone 21 or older is in the vehicle, and transporting passengers younger than 20 without someone 21 or older present. Table 1 shows the numbers of deaths that occurred under these conditions. Note that this exercise does not predict the effect of the restrictions because compliance will be nowhere near universal, and alternative types of legal travel to get around the restrictions would not be risk free.

Based on the data in table 1, 28% of the deaths occurred in unsupervised travel between 9 pm and 5 am. Fifty five percent of all deaths involved unsupervised transportation of passengers younger than 20 during the day or at night, and 64% involved either late night travel or daytime transportation of young passengers without adult supervision. Thus, in 1995, almost two thirds of all the deaths in the crashes of 16–17 year old drivers occurred under driving conditions that would be prohibited by the combination of nighttime and passenger restrictions. The data in table 1 highlight the large contribution to fatalities of teenagers traveling with other teenagers and, thus, the potential benefit of passenger restrictions. More than half of the deaths in crashes of 16–17 year old drivers involve multiple occupants under age 21. More than two thirds of these deaths (68%) occur during the daytime (5 am to 9 pm). Note that only 347 (11%) of the total deaths occurred between midnight and 5 am, the most popular time for a night driving restriction.

Seat belt use

On-road observations have indicated that teenage drivers and front seat passengers are less likely than older drivers and passengers to use seat belts.[41–43] Teenage passenger belt use is particularly low.[43] Thus, teenagers not only have higher crash risk but also are less likely to be protected by belts when they do crash; this increases their injury risk. The injury problem is aggravated by the fact that belt use is lower in situations of higher crash risk, such as late at night or when drivers have consumed alcohol.[39]

The most recent information on belt use among teenagers comes from a study conducted in 12 high schools in Connecticut and Massachusetts.[44] It was possible to compare belt use among teenage drivers going to high school, their teenage passengers, and adults dropping teenagers off at school or driving them to football games. Observations recorded when arriving at school in the morning and when arriving at Friday evening football games showed consistent patterns of lower belt use among teenagers. For example, when arriving at football games, adult belt use was 74%, teenage driver belt use was 56%, and belt use by teenage passengers with teenage drivers was 49%.

The problem of low driver belt use can be addressed apart from graduated licensing. Shifting from secondary to primary (standard) enforcement for all motorists would be beneficial. Other possibilities are to change from secondary to primary enforcement for teenagers only and/or apply special penalties to teenagers who do not use belts. For example, in North Carolina (primary enforcement state), there is an enhanced penalty (up to $100 versus $25) for driving with an unrestrained occupant. A driver may not advance to the next licensing level if the violation occurred within the previous six months.

CONCLUSIONS

The excess crash risk of young, beginning drivers is indisputable. The combination of youth and inexperience leads to heightened crash risk in every driving situation, but as this paper outlines, certain situations contribute to even greater risk, most notably nighttime driving and driving with passengers in the peer group. There may be additional driving situations that entail crash risk, but it is doubtful if any other

risk situations occur frequently enough to constitute a major problem that should be addressed in a graduated system.

In contrast with other countries that license at ages 17 or 18, licensure in the United States typically has been allowed at 16. Delaying licensure clearly can reduce crash risk among 16 year olds, although this comes at some cost (whatever the licensure age) because crash risk is higher for beginners no matter what age they get their licenses. The challenge is to manage novice driving so as to allow essential mobility at a young age while reducing associated risks to acceptable levels. It makes sense to mandate an extended period of supervised driving to enable learners to acquire needed skills before being allowed to drive unsupervised, but there is little research to indicate the optimum period. Nor does research indicate whether permitting supervised driving at a younger age will result in the anticipated benefits once a license is obtained, or will it lead to earlier licensure and, thus, increased exposure.

The increased crash risk for beginners comes immediately on licensure and drops very rapidly in the first few months. This finding supports the imposition of significant driving restrictions during the first six months to a year of licensure. Crash data strongly support a nighttime restriction that begins as early as 9 pm and a prohibition on passengers who can be considered peers.

The question of how well graduated systems manage the major risk factors is outside the scope of this paper. Graduated licensing can be expected to reduce crashes, but the risk associated with youth and inexperience cannot be eliminated. There is great variation in how existing graduated licensing systems in the United States and Canada attempt to address the risk factors; some address them more adequately than others.[45] In allowing some driving, the systems are a compromise, and the combination of youth and inexperience would result in increased crash risk even if compliance with the rules were perfect. However, compliance will not be universal or anywhere near it, and young drivers at the highest risk of crashing have characteristics (for example, rebelliousness and less parental influence) that probably will make them less likely to comply.[46 47] An additional problem is that compliance with restrictions on high risk driving probably will lessen when the restrictions are stronger. Nevertheless, there is solid rationale for graduated licensing as a way to reduce the very high crash risks of young beginners.

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DISCUSSION PAPER

Williams and Ferguson have clearly spelled out what is known about the crash risk of young drivers, thereby providing a succinct overview of the epidemiological data. The research findings are quite solid that crash risk is considerably higher for inexperienced drivers, for young drivers, and for drinking drivers. In addition, late night driving and driving with passengers increases the crash risk for young drivers. Further, the injury risk in a crash is higher for young drivers because of their low seat belt use. Many of these risk factors can be appropriately addressed with graduated driver licensing (GDL).

There are, however, some limitations with the available data on which these findings had to be based. For instance, the data used to calculate crashes per mile driven are from the last Nationwide Personal Transportation Survey (NPTS), conducted in 1995. These data are, therefore, quite possibly outdated. In addition, there is some question as to whether teens were adequately represented in the sample. Furthermore, teens are especially unlikely to remember all their trips when asked questions retrospectively, so their mileage may not be accurate. Also, as noted by Williams and Ferguson, problems with the survey questions precluded calculating risk per mile driven for late night driving (midnight to 6 am), a factor of considerable interest. Although the Fatal Analysis Reporting System (FARS) data are quite complete for fatal crashes, when examining all police reported crashes (not solely fatal crashes), one must use the National Automotive Sampling System General Estimates System (NASS/GES). This database provides only a sample of the crashes, and again, may not adequately reflect the crashes of young people. Consistency of these crash data is also a problem due to differences in crash reporting requirements and thoroughness of data among states. At present, these are the best available data, but they do have some limitations that one would hope to see addressed in the future.

WHAT IS NOT YET KNOWN?

Given the available data, what is not yet known and needs further study to deal with the risk factors of young novice drivers? First is the issue of practice to gain driving experience. How much is the optimum amount of practice needed? How should practice be measured—in miles driven, hours behind the wheel, or months on the calendar? A requirement in time to hold a learner's license does not necessarily mean that adequate practice is taking place. Should certain driving conditions be required or recommended in the practice? What is the best age at which to start practice driving? There is some evidence supporting a younger age to begin practice, providing more time before a license to drive independently is obtained.[1] Second is the issue of the appropriate age for licensure to drive. What is the ideal age at which a young person can drive without supervision? Third is the issue of trip purpose. Does trip purpose make a difference in crash risk? Is the night driving crash risk higher because of some of the reasons teens are driving at that time (for example, to/from a party or school sports event)? Fourth, the issue of increased risk with passengers raises additional questions. What is the social context in which these crashes take place, that is, what is going on? What are the separate and combined effects of passenger age, passenger gender, and alcohol use?

Turning to GDL, several questions are not yet answered and require research. First, as Williams and Ferguson point out, how well does GDL manage the major risk factors for teen crashes? Second, how good is compliance with GDL and how much compliance is necessary to achieve crash reductions? In this area, parents literally may hold the keys, but teens must comply with the GDL restrictions. Third, to what extent are the GDL restrictions enforced by police? And fourth, to what extent are GDL requirements thoroughly implemented? Are licensing officials following through on such requirements as the need to be violation free for a specified time period before advancing to the next licensure level?

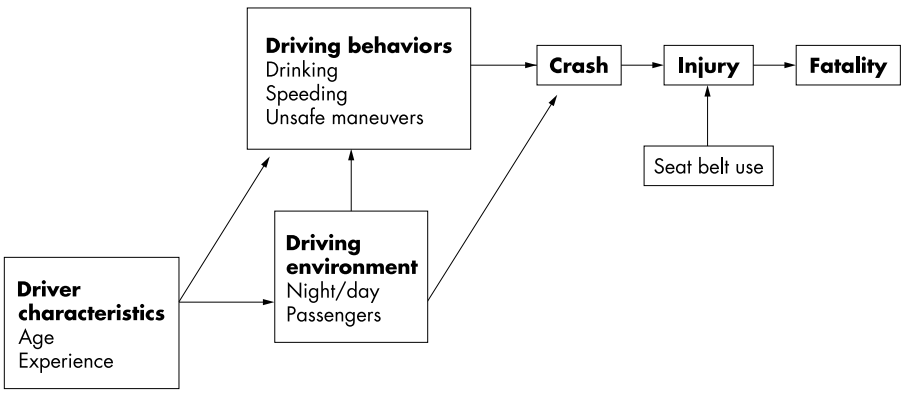

Figure 1 Conceptual framework of young driver crash risks, based on Williams and Ferguson.

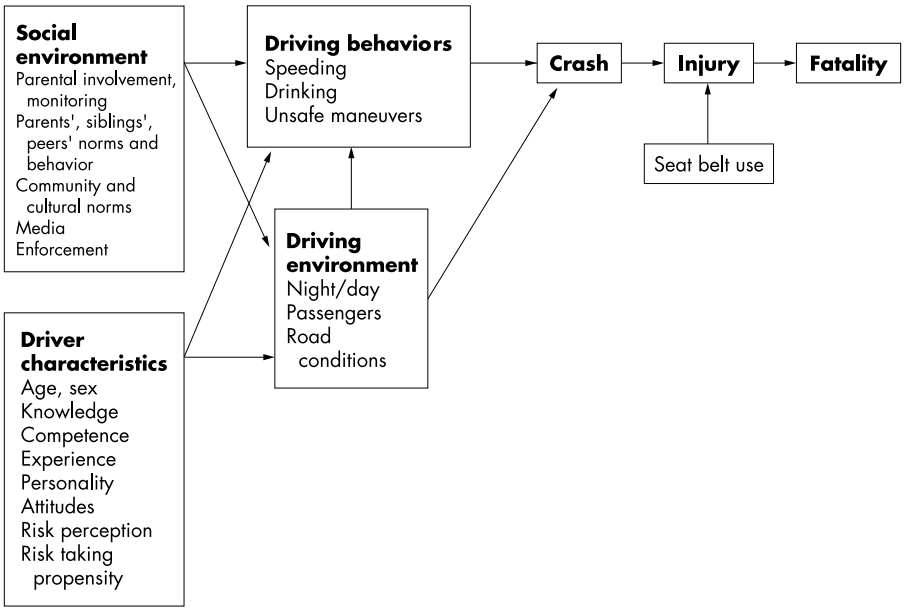

Figure 2 Expanded conceptual framework of young driver crash risks, based on additional research.

WHAT ISSUES WERE NOT ADDRESSED?

From the paper by Williams and Ferguson, we can see what the crash risks are, who is at risk, when they are at risk, and what GDL might do for those risks. But we need to step back and look at a bigger picture in order to understand better how GDL will address the crash risks, and how we might do even more in terms of interventions to reduce these risks. Doing so will help answer such questions as: Why are these risks so high? What else is going on?

Using the Haddon matrix[2] to broaden our perspective, we can focus on the pre-event phase of crashes, desiring to prevent them from happening. The public health risk factors involved that might suggest potential intervention opportunities include the individual's behavior, the agent involved, and the physical and socioeconomic environment. Behavioral science recommends that interventions be grounded in theory.[3] Theories such as social learning theory[3] and problem behavior theory[4] can certainly be applied to youthful driving, but we have not yet specified a theoretical basis for GDL. Rather, this administrative intervention seems roughly to be based on an environmental change approach (reducing exposure to high risk situations), some learning principles (rewarding good behavior rather than punishing bad behavior; incorporating practice and experience), and effectively raising the age at which young people can drive alone.

It seems essential that we identify a conceptual framework, if not a theory, to guide our research in understanding young people's crash risk and in developing interventions to reduce that risk. Such a framework would also help us to understand and intervene appropriately with the excess crash risk that some young drivers exhibit, above and beyond the risk for this group as a whole. Figure 1 depicts graphically the risk factors highlighted in the Williams and Ferguson paper that may lead to crashes, and subsequently injuries and fatalities. They noted young age and inexperience as risk factors or *characteristics of drivers* that might lead to crash prone *driving behaviors* (drinking, speeding, unsafe driving maneuvers) and *driving environments* (at night, or with passengers). One successful intervention they mentioned was the use of seat belts to prevent injury in case of a crash.

Other factors from existing and future research could be added to this framework that also affect the risk of crash and could be considered as opportunities for intervention (fig 2). A *social environment* category has been added, including parental involvement and monitoring; the norms and behaviors of parents, siblings, and peers; community and cultural norms; the media; and enforcement. Under driver characteristics, sex, knowledge, competence, personality, attitudes, risk perception and risk taking propensity have been added as additional risk factors that affect driving and the driving environment. Road conditions have been added to the driving environment as another potential risk factor. Figure 2 is suggested as a starting point on which others can build, testing and adding factors to enhance our understanding.

A conceptual framework such as that in fig 2 can be used to identify which risk factors will be addressed by various interventions. Knowing why and how one factor leads to another helps to clarify the intended purpose of an intervention, and how it may work. GDL may increase parent involvement, and eventually community norms regarding readiness for driving. It can influence driver age and experience, and driving environment (night restrictions). But the framework also draws attention to other risk factors that GDL is not addressing, and for which interventions are needed. The framework can also be used to identify intermediate or mediating factors that an intervention may be designed to address, and that intervention evaluations must assess. Crash reductions may not result if the intermediate effect is not achieved. Such a framework can thus guide research, suggest interventions, and inform evaluation efforts.

WHAT ARE THE IMPLICATIONS FOR FUTURE RESEARCH AND POLICY?

A conceptual framework such as that presented here is an essential component of future research and policy development. Ongoing research can add to and refine the framework, as a continuing effort. Gaps in our knowledge base can be filled in as new findings are shared with others. Interventions will have a sound basis in research findings, and be more likely to succeed in producing the desired outcomes. Evaluations of interventions to reduce crash risk will be more complete, having clarified their desired outcomes as well as remaining vigilant for unanticipated outcomes. As Williams and Ferguson have detailed, there is an excellent rationale for graduated driver licensing, and it should be able to address at least some of the identified crash risks. But the risk factors for youthful motor vehicle crashes are many and complex, and merit thorough study.

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