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Keeping Young Drivers Safe During Early Licensure

Dr Bruce Simons-Morton
National Institute of Child Health and Human Development
September 2019

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About the Author

Dr Bruce Simons-Morton is Senior Investigator in the intramural program of the Eunice Kennedy Shriver National Institute of Child Health and Human Development. His research on the teenage driving risk and prevention have included a wide range of research methods, including simulation, test track, and on road experimental; naturalistic observational; interventional; and survey, accounting for many of his 321 publications. He has been a visiting scholar at the University of Michigan, University of Iowa, Ohio State University, and the University of North Carolina, and adjunct professor at the University of South Wales. He was the 2007 American Academy of Health Behavior Research Laurette and in 2019 received the National Institutes of Health Director's Award for *"…exceptional contributions to research on adolescent driving and reducing teenage crash risk."*

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Disclaimer

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Contents

1 Learning to Drive Safely 1

2 Individual Variability in Safe and Risky Driving 4

3 Application to Prevention Programmes 8

3.1 Graduated driver licensing policy 9

3.2 Driver training and education programmes 11

3.3 Parental management 14

3.4 Technology 14

4 Conclusion: Improving Prevention Programmes 16

References 19

Summary

The safety of young drivers is an issue that transcends national and political boundaries. Notably, the extremely high crash rate immediately after licensure and the prolonged period of risk, particularly among young novices, are problems of international concern.

Analyses comparing crash rates of novices with those of experienced adults have invariably demonstrated extreme disparities, with rates among novices that are higher and more variable, and which maintain for years after licensure. Young age at licensure seems to exacerbate the problem, but inexperience, regardless of age, is a fundamental factor. Not surprisingly, the amount of experience needed by novices to develop safe driving skills and good judgement is substantial; added to this, some novices require more experience than others, which is consistent with the way that carrying out any complex psychomotor task is learnt.

According to every available measure, including crashes, risky driving and driving errors, improvements in driving performance occur gradually and unevenly over time. This has been described as the 'young driver problem': novices require substantial independent driving experience to become safe drivers, but the more they drive as novices the greater the associated risk. In most Western countries, at least, considerable attention is being paid to this problem, giving rise to initiatives in the spheres of education, training, testing, licensing, supervision and monitoring of novice young drivers. Despite their considerable potential, the protective benefits of these policies and programmes have not been well demonstrated, with the possible exception of graduated driver licensing. Despite improvements in their vehicle management skills after professional training, supervised practice and road testing, novices do not suddenly become safe drivers overnight.

While there is already a wide range of available programmes, activities and policies in existence, and even though these measures are administered by highly motivated professionals, the effectiveness of driving safety programmes could still be improved by gaining a greater understanding of, and attention to, the mechanisms by which novices learn to drive safely.

1. Learning to Drive Safely

People in the initial stages of learning a complex psychomotor task, such as driving, riding a bicycle, playing a sport, dancing, or cooking, are termed 'novices' because they lack the experience and expertise that would allow them to perform the task capably. With minimal instruction and practice, novice drivers quickly learn to manage the vehicle in the car park or local neighbourhood (Durso & Dattel, 2006). But even after a period of instruction and supervision, newly licensed drivers are still novices when they first start driving on their own, and without supervision must manage the vehicle while constantly monitoring and adapting to dynamic road conditions. This is because expertise develops only over time with real-life, independent on-road experience, as skills are fully incorporated and judgement improves (Fitts & Posner, 1967).

Unsurprisingly, newly licensed young drivers make many mistakes and engage in behaviours inconsistent with safety (Curry et al., 2011; Horrey et al., 2015; McKnight & McKnight, 2003). Even after mastering basic driving skills, the full development of the complex skills and judgement required for safe driving can take place only with practice over time. By way of analogy, consider the frustrating experience of the typical coach of a youth sports team watching young athletes fail to employ, under real-world game conditions, the skills they learnt in practice. Despite skill improvements acquired from extensive practice, in a game with actual opponents, when everything speeds up and the

dynamics require split-second decision-making, self-control and creative playmaking, it can be difficult for inexperienced players to perform as they have practised, no matter how well coached they are and how hard they have trained. Gradually, as they gain experience, their skills solidify and become second nature; young players are eventually able to exercise the judgement that enables them to perform capably under game conditions.

Similarly, when novices start riding two-wheeled bicycles, they must learn how to mount, move off, maintain balance, shift gears, steer, stop and dismount – skills that are second nature to experienced cyclists, but which constitute complicated actions for a novice. But these are simply the basic skills required to ride without losing control. Ultimately, these skills are essential, but they are not sufficient for ensuring safety. Cycling safely requires the exercise of good judgement, including constantly paying attention to the road ahead, anticipating hazards, signalling one's intentions, and discerning and anticipating the behaviour of other road users. Of course, as skills improve so does confidence and also the acceptance of more complex conditions – graduating from cycling or driving around the block, to around the neighbourhood, and finally across town. As with sport, cycling and other complex activities, safe driving performance is not so much about mastering basic vehicle management skill as about exercising good judgement in complex real-world conditions – something that comes mainly with experience.

A great deal of learning occurs by way of meaningful feedback from experience. This information can then be applied to future situations in anticipation of similar consequences (Kazdin, 2001). A large part of learning is thus the result of making mistakes, experiencing the result (which often means suffering the consequences), and adjusting performance to minimise the likelihood of negative consequences and maximise the likelihood of positive ones. Accordingly, novice drivers quickly learn from the feedback they get from their performance errors (for example crossing the lane marker, jerking the vehicle, stopping abruptly or hitting the kerb), and from their supervisors' feedback, guidance and instruction. Practice that is deliberative – done correctly according to instruction – hastens the learning process (Ericsson et al., 2006). However, instruction and supervised practice are no substitute for the many hours of independent practice under actual road conditions that are required for the attaining of safe driving competence (Ericsson et al. 1993). Indeed, mastery of a complex task (getting as good as you are going to get) is estimated to take at least 10,000 hours of practice (Ericsson et al., 2006). It is thus not surprising that crash rates decline with experience (Chapman et al., 2014; Curry et al., 2017a).

Driving has been conceptualised as a balancing act between task demand and capabilities (Fuller, 2011). Most experienced drivers, most of the time, maintain a dynamic homeostasis between competing task demands – for example, attending to traffic conditions, vehicle speed and kinematics, other road users, and tasks secondary to driving (such as using a phone or eating) – so that they do not exceed their personal and situational capabilities, thereby minimising their risk of making errors, losing control and crashing. Novices, however, are not good judges either of the complexity of tasks or of their own skill level, because they have little experience upon which to base these judgements. Given their lack of experience, novices are less able to appropriately manage task demand, such as speed or route selection. Indeed, they may be inclined to overestimate their capabilities and consequentially

accept or seek overly demanding tasks. Indeed, to learn what their capabilities are, they increase task demand partly in order to determine their capabilities.

Hence, learning to drive safely is complex, requiring frequent complex calculations, constant attention, good judgement and self-control. While much of the essential learning occurs during training and supervised practice, substantial practice and real-world driving experience is required before these skills can be fully accommodated and automatically accessible to assist as safe driving judgement demands. Substantial evidence documents the variability in driving performance and risk among novice drivers, and their tendency both to make more errors and to engage in more risky driving than older drivers, all of which is consistent with an improper balance between task demand and capabilities. Therefore, it is to be expected that most young novice drivers will make many mistakes as they experience unique and complicated driving environments while exploring their capabilities and testing their own limits.

2. Individual Variability in Safe and Risky Driving

Considering the complexity, prevalence and volume of modern transport, it is surprising that crash rates among experienced adults in the US and UK are actually fairly low (Feleke et al., 2018; IIHS, 2016). However, crash rates are high among the youngest and least experienced drivers relative to older, more experienced drivers (Feleke et al., 2018). Novice drivers have high crash rates mainly because they are inexperienced, but also to an extent simply because they are young. On the basis of roadside interviews, Twisk and Stacy (2007) reported that crash rates were highest immediately upon licensure, and thereafter declined rapidly for a period of time, then more gradually over a period of years. This was the case regardless of the age at licensure. The resulting pattern of declining crashes over time resembles a classic learning curve in which errors are extremely high initially and decline steeply at first and then more gradually with experience. However, this pattern was more pronounced the younger the age at licensure, with higher initial crash rates and slower declines in crash rates among those licensed as teenagers than those licensed in their twenties. Accordingly, inexperience was seen to be the single most important factor, but young age itself was also an important factor.

Evidence about the individual variability in novice young driver risk has accumulated from naturalistic driving studies in which the vehicles of volunteer drivers have been fitted with a range of sensors, including accelerometers and cameras. The great advantages of this method include:

1. the same participants are followed for a period of months or years;
2. an objective assessment of exposure (miles driven), crashes, and driving behaviours such as speeding and abrupt manoeuvring is gained; and
3. constant video is gathered, allowing an assessment of factors contributing to crashes.

By intensively collecting data on many aspects of driving performance among the same individuals, it is possible to determine the factors associated with the variability in risk over time.

One unique benefit of naturalistic driving studies is the ability to assess the miles driven. The strong association between experience and safe driving performance is well recognised in the transport professions, and is taken into account for certification and operator responsibility (Durso & Dattel, 2006). Like novice pilots, novice drivers should not be expected to perform safely until they have gained substantial experience. This paradoxical situation is the 'young driver problem': novices need to drive to develop competence and reduce their riskiness, but because they are not good drivers the more they drive the greater their risk of crashing. To illustrate, Gershon et al. (2017) found that crash rates per mile among higher- and lower-mileage novice drivers were similar, but the higher-mileage teenagers had many more crashes – similar rates but greater number of crashes among higher-mileage drivers.

Naturalistic driving studies have consistently shown that crash rates per mile are higher among novices, particularly young novices than among older drivers. Notably, young novices have higher crash rates than older, more experienced drivers (Gershon et al., 2018; Simons-Morton et al., 2011). Crash rates decline significantly over the first year or so of licensure among some novices, but not others (Guo et al., 2013). During supervised practice driving when novices must be accompanied by an adult, CNC (crash and near-crash) rates are low, but upon licensure, when novices are allowed to drive on their own without supervision, these rates increase dramatically and remain elevated for at least one year (Gershon et al., 2018).

Accelerometers can identify abrupt manoeuvring, measured by the rate of elevated gravitational force events, which increase crash likelihood (Simons-Morton et al., 2012; Simons-Morton et al., 2013b). The rate of abrupt manoeuvring is substantially higher and more variable among young novices than adults (Simons-Morton et al., 2019). When newly-licensed teenagers drive with their parents as passengers their rates of such incidents are low, being similar to those of experienced adults (Gershon et al., 2018; Simons-Morton et al., 2011). Apparently, then, novice teenagers are *able* to drive in a less risky manner, but *elect* not to do so.

Distraction is particularly risky for novice drivers (Klauer et al., 2014). Distraction occurs most commonly when attention is diverted to 'secondary tasks' that compete with the driving task (Patten et al., 2006). Of course, learning a new skill or set of skills, such as driving, is highly demanding, requiring much of a novice's available cognitive capacity; it demands conscious

attention and leaves little in reserve to attend to other important tasks. Klauer et al. (2014) reported that novice teenage drivers, when compared with adults, had a higher CNC risk when engaging in secondary tasks, particularly calling, texting, and even reaching for a phone or other object. Crash risk doubles when drivers' eyes are off the road ahead for just two seconds (Simons-Morton et al., 2014). Presumably, a driver who is not looking cannot respond to an unexpected road hazard, but also longer glances away from the driving task may reflect greater cognitive demand and imply the need for a longer period of attention recovery. The tendency of novices to be easily distracted by mobile phone-related tasks has been demonstrated experimentally (Ehsani et al., 2016; Lee et al., 2008). These findings demonstrate that without looking one cannot see, identify and mitigate hazard. Certain secondary tasks, particularly those that take the driver's eyes off the road ahead, greatly increase crash risk, particularly among novice teenage drivers who may lack the intuition or automaticity of systematically looking at the road ahead even when engaging in a secondary task.

While inexperience and young age largely explain the elevated crash risk of novice drivers compared to older drivers, these factors do not fully explain the variability in crash rates from one novice young driver to another. Some novices have more crashes and engage in more risky driving than others, which could be due in part to cognitive immaturity consistent with incomplete adolescent brain development (Lambert et al., 2014), personality traits (Ehsani et al., 2015a; Sita et al., 2019), and attitudes and perceptions (Hatakka et al., 2002). For now, however, the overwhelming evidence suggests that the most promising prevention programmes address the average elevated risk of novice drivers due to their inexperience and young age.

Table 3.1: Crash risk factors and their implications for novice driver safety

Risk factors	Relationship to increased risk
1. Age/inexperience	Expertise comes only with experience.
2. Exposure(miles/time driving)	The more novices drive, the greater their crash risk, because they are young and inexperienced.
3. Error proneness	Novices make many errors of judgement, increasing crash risk.
4. Risky driving behaviour	Elevated G-force rates (kinematic risky driving) are high over the first two years of driving.
5. Susceptibility to distraction	Distracting secondary task engagement increases risk more among novices than in experienced adults.
6. Personal characteristics	Individual characteristics such as personality and attitudes do not provide a consistent or strong explanation of young driver risk relative to inexperience, exposure (miles driven) and risky driving behaviour.

Source: Adapted from Simons-Morton et al. (2019)

A summary of this discussion about learning to drive safely is included in Table 3.1, which indicates the following:

1. **Age** and inexperience are risk factors because expertise consistent with safety comes only with substantial independent driving experience.
2. **Exposure**: Novices must drive to gain the sort of real-world experience necessary to develop safe driving capabilities, but the more they drive the greater their crash risk, particularly during the year or so after licensure when they are effectively still just learning. Because not all driving is equally risky, it is useful to set limits on driving conditions such as proscribing driving late at night, with teenage passengers, and while using a phone.
3. Novice drivers make many **errors** of skill and judgement, as is generally the case for novices learning any complex psychomotor skill.
4. The high rate of kinematic **risky driving** is a unique characteristic of young drivers.
5. **Distraction** due to secondary task engagement greatly increases crash risk among novices, more so than for other drivers.
6. **Personal Characteristics**: Personality and attitudes appear to contribute to risk variability only modestly and unpredictably.

On the whole, the evidence supports population approaches that seek to limit risk among all novices, rather than individual approaches that seek to target those novices deemed to be at highest risk.

3. Application to Prevention Programmes

The previous section emphasised that driving competence requires the development of safe driving judgement, which comes only with experience. Training and supervised practice are important, primarily to the extent that they provide a solid basis for safe driving experience. Unlike most other common complex psychomotor activities, driving is potentially highly dangerous, and novices are allowed to drive mainly because driving is an important aspect of mobility, one which is itself related to other societal values such as employment and education. Society therefore attempts to balance safety and mobility. Of course, general traffic safety measures, safe road designs, clear signage and vehicle safety devices provide the greatest benefit to drivers with the highest crash rates, such as novices. So, to make novice driving safer, it is important to make driving safer overall.

Recognising the high risks associated with novice driving, most countries have in place a range of requirements and prevention programmes to assure safety as much as possible, while enabling mobility. Notably, licensing requirements generally include a minimum age, together with a test of awareness of the rules of the road, and of on-road performance. Over the past several decades, a

new approach to licensing young novices, graduated driver licensing (GDL), described below, has been adopted in many Western countries. A plethora of pre-drive education programmes and a few post-licensure programmes are available in many countries, but generally lack evidence for their effectiveness. The effectiveness of these programmes might be established or improved if they were more firmly based on a modern understanding of how novices eventually learn to drive safely, and the variability inherent in learning complex tasks. Best practices are here described for four important prevention approaches, including:

- GDL policy;
- driver education and training;
- parent supervision and management; and
- technology.

These are shown in Table 4.1; suggestions as to how their effectiveness might be improved by applying what is known about how novices learn to drive safely are indicated in Table 5.1.

Table 4.1: Young driver prevention programmes, primary objectives, and evaluation of the evidence of their effects on safety

Safety programme	Primary objective	Safety evidence
GDL policy	Reduce exposure (total miles driven) to risk	Strong
Driver education and training	Train for licensure	Weak
Parent supervision and management	Manage early driving risk	Promising
Technology	Feedback about risk	Promising

Source: Adapted from Simons-Morton et al. (2019)

3.1 Graduated driver licensing policy

The concept of GDL evolved out of an appreciation of the dilemma that novices need driving experience to develop skills and safe driving judgement, but at the same time the more they drive, the greater the associated risk. A partial solution to this dilemma is to allow driving, for a period after licensure, primarily under less risky driving conditions. GDL policy is typified by a flexible, three-stage process, including:

1. a protracted period (at least several months in duration) of supervised practice driving, often with requirements for a minimum number and type of supervised practice driving hours;
2. the preliminary or intermediate stage, allowing unsupervised driving with certain restrictions such as not driving late at night, with multiple teenage passengers, while alcohol or drug impaired, and while using a mobile phone; and
3. full, unrestricted licensure after a period of time or from a particular age (Williams et al., 2012).

GDL has gained wide acceptance in the United States, where all 50 states have adopted it in some form, and also in Canada, Australia, New Zealand and Israel. Most of these are countries with vast lands and agrarian traditions, with a history of allowing licensure at young ages, typically 16 or 17.

Innovations that provide relative advantages over existing practice tend to diffuse rapidly (Rogers, 2003) and GDL is a remarkable example of this kind of rapid diffusion. The relative advantages of GDL are manifold. It is:

1. compatible with existing licensing policies;
2. easy to explain and understand;
3. adaptable;
4. modifiable; and
5. observable.

In essence, adding an intermediate stage has proven to be compatible with existing policy, and easy for policymakers and parents to understand. A range of possible GDL provisions can be adopted, allowing unique adaptations based on jurisdictional considerations. Over time, GDL policies can be – and have been – modified to meet particular needs and objectives. Notably, some US states are now in their third generation of GDL. Perhaps most importantly of all, its safety benefits have been well established.

While there have been few, if any, objective evaluations of GDL in other countries, numerous evaluations have been conducted in the United States. Summaries of this research conclude that GDL provides modest improvements in crash rates, generally assessed by examination of state crash reports before and after adoption (Williams, 2017). A meta-analysis of 14 studies indicated an overall reduction in total crashes of 16% for 16-year-old and 11% for 17-year-old drivers (Masten et al., 2015). Some research has indicated greater mitigating effects arising from GDL policies with more strict provisions (Chen et al., 2006; Masten et al., 2013). Williams (2017) concluded that the evidence for these stricter versions indicates strong crash reductions for 16-year-old novices, but modest and inconsistent effects for 17-year-old novices. However, it is difficult to attribute these benefits to any particular aspect of GDL. Presumably, 16-year-old novices benefit most because their crash risk is greatest and they are exposed to GDL for the longest period, given that most policies are in place for 12 months following licensure, or until age 18. GDL may delay licensure somewhat, but expert evaluations of GDL have concluded that it works as planned, and that its effectiveness is generally due to reduced exposure to the high-risk driving contexts that it is designed to limit, such as late at night and with multiple teenage passengers on board (Williams, 2017).

Surprisingly, GDL has worked largely without an emphasis on enforcement, at least in the USA (Williams et al., 2010). Evaluations have found that large majorities of both parents and teenagers have positive attitudes to GDL, and self-reported adherence is high, suggesting little need for strict enforcement (Curry et al., 2017a). GDL may also shape norms about what constitutes safe driving behaviour, and the role of parents in monitoring novice driver behaviour, but there is as yet little research on this. While GDL appears to be generally effective, it is probably not as effective as it could be under ideal conditions (Foss, 2007).

There is general interest in extending GDL to older novice drivers. The limited research on the benefits of GDL among older novices indicates that benefits would be likely, but less so than for the youngest novices (Curry et al., 2017b; Kinnear et al., 2014). For example, a study in New Jersey found a reduction of 10% overall crashes and 17% late-night crashes among drivers aged 18 after GDL introduction (Williams et al., 2010). Kinnear et al. (2014) estimated potential annual reductions of over 4,400 casualties and £200 million in the United Kingdom from GDL with relatively strict night and passenger restrictions, applying only to 17- to 19-year-old novices, with additional possible savings if it were extended to older novices. GDL seems to strike a fair and acceptable balance between safety and mobility when applied to the youngest novices. When applied to the older novice, probable benefits would occur from limits on late-night driving, but passenger restrictions and a protracted period of supervised practice might not be as relevant or important as for younger novice drivers, given the key role of parental involvement and management in GDL systems for those younger novices. However, there would be benefits to the extent that older novices accept the safety premises of the policies and find the limitations not unduly restrictive.

Given the lack of research on the topic, it is difficult to conclude with confidence the extent of possible benefits of GDL policies for novices beyond teenagers.

3.2 Driver training and education programmes

Formal driver education and training programmes are generally available and mandated at some level in most Western countries. While there is considerable variability in their composition, in general they include classroom training focused on the rules of the road and a minimum number of hours, but rarely more than six hours, of on-road supervised training with a qualified instructor. In the United States, driver education is generally a requirement for teenagers applying for licensure, provided as part of the high school curriculum in some jurisdictions, and more generally as a private service. Unequivocally, these programmes are successful in preparing novices for the driving test, leading to licensure, but they have not consistently been shown to provide safety benefits, with most evaluations in fact showing no safety benefits (Lonero & Mayhew, 2010). This overall lack of safety benefits is to be expected given the discussion above about how novices learn. In defence of these programmes, they are limited in scope and are designed simply to teach novices how to drive well enough to past the licensing test, and do not deal extensively with eventual independent, licensed driving. While there are substantial differences in driver training programmes, there is little research on innovations that might improve their effectiveness. Peck (2011) estimated that formal driver training could theoretically, under ideal conditions, reduce crash rates by up to 5%. However, substantial innovation and improvements in practice would be needed.

One of the most important recent innovations in driver training is hazard anticipation training; its potential is founded on an understanding that attention to and identification of hazards are essential precursors to mitigation. Evidence is amassing from simulation and on-road studies (Fisher et al., 2007) that hazard skills can be taught and learnt, and one

large study reported that crashes were lower among males exposed to a brief period of computer-based hazard skills training (Thomas et al., 2016). In another innovative approach, expert instructors viewed video footage of their on-road training and identified examples of higher-level instruction (hazard identification, for example), which they subsequently used to train other instructors (Scott-Parker et al., 2014). The idea in this programme, still in the evaluation stage, was to improve overall instructional competence, with a greater focus on higher-order driving skills. More such innovation is needed.

Apart from formal driver education and training programmes, a wide range of pre- and post-drive programmes are popular. Beanland and colleagues (2013) nicely categorised pre-drive programmes as professional driving instruction, education, and simulator training, and described the focus of post-licence training as vehicle and risk management skills training. The authors concluded that some evidence suggests that some forms of pre-drive and post-license training may improve technical driving skills, but that there is no evidence of safety benefits. Kinnear et al. (2017) conducted a survey of pre-drive programmes in Scotland and found that about two out of three local authorities supported some pre-drive programme, including demonstrations, exhibitions and off-road activities. Many of these programmes were popular with the public, and the motivation of programme professionals was deemed high. However, most of these efforts were deemed not to be systematic, many consisting of a single event of only a few hour's duration. There was a notable lack of the standardisation that would be necessary for a broader application. Overall, the researchers noted a lamentable lack of evidence of actual effectiveness (Kinnear et al., 2017). There was, however, a decided emphasis on driving knowledge, attitudes and skills, which are logically linked to driving behaviour, and are necessary – but not sufficient – to assure safe driving. Notably, the Goals for Driver Education (GDE) matrix has been influential in guiding the development of driver training programmes in Europe (Hatakka et al, 2002). GDE proposes a four-level hierarchical model for driver training:

1. basic knowledge and vehicle-handling skills;
2. translation of skills to dynamic roadway contexts;
3. journey-level factors (e.g. trip purpose, driving conditions, social context); and
4. driver life goals and purpose.

In this sense, the GDE framework is unique in recognising the importance of motivation as an essential element of training. Despite its relatively widespread adoption in Europe, little evidence for the effectiveness of GDE-based training exists, at least conceptually. Indeed, motivation (generally measured by attitude scales) is difficult to change and to maintain once changed, and motivation alone is insufficient for bringing about changes in behaviour (McKenna, 2010; Tronsmoen, 2010).

The lack of evaluation of pre-drive programmes in the USA, UK, and Europe has long been lamented (Beanland et al., 2013; Foss et al., 2009; Kinnear et al., 2017). This lack is in part understandable, given the paucity of funding dedicated to such evaluations. However, it is concerning that little information is collected at the programme level about the objectives of the programmes, curriculum specifics, participation rates, fidelity of delivery (how well was the program implemented as designed), immediate learning outcomes (knowledge and

skills), and other basic information that could contribute to the evidence of implementation. Indeed, evaluations of these programs generally have not provided evidence of efficacy (under ideal conditions can the programme be implemented as designed and achieve its learning objectives) or effectiveness (in the real world as actually practiced does the program meet its learning objectives and safety goals). Of course, it is a lot to ask of training programmes that occur prior to licensure to expect them to have much effect on independent driving, but future support for such programmes may depend on demonstrated effectiveness. Kinnear et al. (2017) argued that programme effectiveness could be improved with greater emphases on established behaviour-change methods. Evaluations should be consistent with realistic expectations that are related to the nature of the programme objectives and to the extent of the programme. The lack of evaluation does not mean that pre-drive programmes provide no benefits, but without better evaluation it is impossible to know which programmes work, how they work, in which context they may work, the extent and quality of their delivery, or how they could be improved. This is a problem for funders inasmuch as they cannot know how best to devote resources to this important problem.

In a rare evaluation of a pre-drive programme, Senserrick et al. (2009) described a multiple-community programme that focused on a systematic approach to road safety. Each community adopted a range of activities designed to encourage safe driving behaviour along with safe vehicles and safe roads. Overall, there was evidence of lower subsequent crash rates in the participating vs. comparison communities. However, given the wide variability in activities in each community, it would be difficult to know how to expand or generalise this programme.

Advanced vehicle management skills training – sometimes described as procedural, defensive driving, or skid training – remains popular with the public, but the limited evaluations provide no evidence that they provide safety benefits and suggest they may even increase risk (Beanland et al., 2013). These programmes (often taught and promoted in the USA by off-duty police) provide instruction and practice in 'advanced' manoeuvring skills, such as how to get out of a skid (Isler et al., 2011; Washington et al., 2011). Often young drivers in a relatively safe environment are encouraged to drive fast and turn sharply, learning about how to get into and out of imminent danger. While there are few evaluations, one study found that those exposed to this training actually drove in a more reckless manner than before, presumably because the participants gained confidence (unwarrantedly) in their ability to get out of a skid and therefore could be more unconcerned about getting into one (Katila et al., 2004). Notably, success in skid recovery and other last-moment manoeuvring to avoid a crash is uncertain, which is why near misses are a useful measure of risk in transport generally. Therefore, the effectiveness of such programmes might be improved by emphasising how to avoid getting into such situations.

3.3 Parental management

Parents have many possible areas of responsibility for novice teenager driving safety, including supervising pre-licence practice, and then monitoring and managing the early independent driving experience. Unfortunately, much of this potential remains unrealised. In the USA, according to GDL policies, parents are required to supervise practice driving for an average of about 50 hours, protecting novices as they learn, providing instruction, and establishing safety norms. However, the few evaluations of supervised practice driving indicate that parents are largely passive observers, providing little instruction and paying little attention to higher-order skills (Ehsani et al, 2015b; Goodwin et al., 2014). Mirman et al. (2014) report that a web-based intervention called the 'Teen Driving Plan' conducted in Pennsylvania increased the quantity and diversity of parent-supervised practice. Logically, providing novices with progressively more complex practice could provide safety benefits during the very high-risk period directly after licensure.

In recognition of the high crash rate during the early licence period, a number of studies have examined parenting practices, while other studies have evaluated programmes designed to increase parental involvement. Regrettably, the available research suggests that parents do not carefully manage their newly licensed teenagers' early driving experience (Hartos et al., 2004; Simons-Morton & Hartos, 2003). The research evaluating programmes that have been designed to encourage parents to actively manage the early licensure period by limiting driving to less risky driving conditions is encouraging, if limited. Peek-Asa et al. (2014) conducted a school-based randomised trial testing the Steering Teens Safe programme in Iowa, designed to improve parental communication with teenagers about safe driving. The evaluation found improved parent-teenager communication and lower scores on reported risky driving. Randomised trials conducted in various US states (e.g., New Jersey, Connecticut, Maryland, Michigan) evaluating the Checkpoints™ Program have demonstrated that it is possible to deliver interventions directed at parents in a variety of settings, including driver education (Simons-Morton & Ouimet, 2006; Zakrajsek et al., 2013), adolescent medicine practice (Shope et al., 2016), and online (Zakrajsek et al., 2013), with significant increases in parental management, including adoption of a parent–teenager driving agreement and more strict limits on independent driving, resulting in lower rates of risky driving and crashes. However, participation rates have been low and effect sizes modest. Researchers and practice professionals alike have recognised the need for new methods, possibly utilising technology. However, even given the assistance of technology, parents need to be more involved by establishing expectations and serving as active managers of novice teenagers' early independent driving.

3.4 Technology

A range of technologies, including standard and aftermarket vehicle equipment, are available for monitoring and protecting novice young drivers. Notably, phone blocking technology is now available that can prevent phone use or notify parents that the teenager has used a phone while driving, but participation has been poor and many logistical problems will

have to be overcome before this technology can become widely available (Creaser et al., 2015). Abrupt manoeuvring can be assessed with accelerometers. DriveCam devices, which include an accelerometer and cameras mounted near the rear-view mirror, are employed by truck and vehicle fleet operators as a means of managing driver behaviour. This technology was also employed in Teen Safe Driver Program, operated by American Family Insurance until 2016. The device as part of the program or in some cases separately has been well evaluated with respect to its potential for limiting teenage risky driving by informing parents about their teenager's driving behaviour, including abrupt manoeuvring and distraction. When an abrupt manoeuvre that exceeds a specified gravitational force occurs, a blinking light informs the driver. Video footage of the seconds before and after the event is recorded for later viewing by the teenager and parents, along with a summary of the teenager's weekly driving performance. Several studies have demonstrated significant reduction in kinematic events, which is consistent with less risky driving (Carney et al., 2010).

In one study, DriveCams were installed in the vehicles of a sample of teenagers. For several months the devices operated in stealth mode, with no signal to the driver, to provide a baseline. Then, in one group the devices were adjusted so the driver received feedback about elevated G-force events; in the other group the devices were adjusted so as to inform the driver of the event, and in addition the video footage was saved and shared online with the teenagers and their parents, who also got a weekly report of their teenagers' driving behaviour. The group that received feedback to the driver and nothing more did not evidence a change in their event rate, while rates in the group that received feedback to the teenagers and parents declined significantly (Simons-Morton et al., 2013a). The authors concluded that feedback to the teen driver not linked to external consequences was not effective, but feedback to parents that increased the likelihood of parent-imposed consequences reduced risky driving behaviour, although weekly viewing of the video and reports of teenage driving behaviour was uncommon.

It seems fair to conclude that technology has the potential to 'place the parent in the vehicle' to the extent that young drivers appreciate that the parent can access objective information about their driving behaviour, thereby improving the potential effectiveness of parental management practices. However, even with insurance discounts provided as an inducement for families to employ DriveCam, participation has been very limited (Carney et al., 2010). As with phone blockers, low levels of participation by parents in the form of their willingness to monitor their teenage driver, and the actual monitoring rates of parents in these studies, suggests that the technology is ahead of parent norms of the sort that would motivate parents to adopt and employ it.

4. Conclusion: Improving Prevention Programmes

A substantial and growing body of literature has documented that novice drivers, particularly the youngest novices, have very high crash rates during early independent driving, regardless of the type of training and the amount of supervised practice that they have undergone. While there is considerable variability in their crash rates between these novices, it has been determined that inexperience, young age, exposure (in terms of total miles driven), errors of judgement, abrupt manoeuvring, distraction and possibly some psychosocial factors are important determinants. All of this is consistent with the known understanding that novices develop driving expertise consistent with safety mainly as they gain experience in real-world driving conditions. This process of learning varies within and between individuals over time, but it is presently not possible to identify higher- and lower-risk novice drivers with satisfactory precision. Thus, the greatest need is for population-based rather than individual-level prevention efforts. While a range of prevention programmes that have substantial potential are available, they have not generally been based on the known characteristics of risk, which has resulted in uncertain and unsatisfactory evidence as to their effectiveness.

Fortunately, there are a number of important strengths of efforts to reduce novice teenager crash risk. In general, modern societies recognise that novice teenagers are at high risk for crashes and devote resources to prevention programmes. Of course, as a high-risk group, novices benefit disproportionately from general transport safety measures such as appropriate speed limits, road designs and enforcement of traffic laws. In addition, all Western societies establish a minimum age for licensure and encourage pre-licence professional training and supervised practice. Graduated driver licensing (GDL) provides an advanced and effective approach to licensing that yields substantial safety benefits. Significantly, there is an abundance of dedicated professionals passionate about teenage driving, and professional organisations have established standards for practice; moreover, many thoughtful and creative pre-drive programmes have been developed. However, the state of practice has not reached the point where it is possible to emphasize, encourage, adopt, and support only those programmes based on the principles of best practices. Without a sufficient evidence base, the key facts about what novices are learning, the extent to which learning matters when it comes to driving performance, how to improve existing programmes, or which programmes merit sponsorship cannot be known.

Numerous reports have encouraged greater emphases on best practices for teenage driving risk prevention programmes within the context of broader road safety (Beanland et al., 2013; Foss et al., 2009; Kinnear et al., 2017). These recommendations include:

1. the setting of clear programme objectives consistent with programmatic effort and extent;
2. the development of systematic curricula that focus on appropriate risk factors and employ established behavioural methods;
3. the extensive training of programme professionals;
4. evaluation of participation, implementation extent and quality, and immediate learning outcomes; and
5. evaluation of the impact of the programme on driving outcomes.

Table 5.1: Improving effectiveness of young driver prevention programmes

Safety programme	Possible modifications
GDL	Adopt, add or extend provisions Increase parental involvement
Driver education and training	Evaluate and improve formal driver education, and pre- and post-drive programmes Extend focus to higher-order skills and independent driving Increase parental involvement
Parent supervision and management	Increase parental involvement Link to technology
Technology feedback and consequences	Apply broadly Increase parental involvement

Source: Adapted from Simons-Morton et al. (2019)

Of available prevention programmes (see Table 5.1), GDL would seem to have the greatest potential for reducing novice driver crash risk, given the strong evidence base and the

fact that GDL represents a modest shift in how licensing of new drivers is done in most countries. However, GDL could be improved and its effects extended by greater parental involvement and by general adoption of technology that can improve parents' ability to manage teenage driving. Neither driver education and training, nor the range of pre-drive programmes developed so far, have lived up to their considerable promise, although there would seem to be great potential for improving this training to focus more on higher-order skills such as hazard anticipation and mitigation, with greater application to independent driving. The potential of the many pre-drive programmes popular in the UK, USA, Australia and other parts of the world remains to be determined – this could be achieved through systematic formative evaluation that would enable improvements and eventual standardisation, and outcome evaluation of the impact on driving performance that would determine programme utility. Parenting programmes have generally been shown to be effective, but participation in them has proved to be low. Such programmes might benefit from technology such as phone blockers and G-force feedback systems, because they provide objective information to young drivers and their parents.

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