STATE OF CALIFORNIA
DMV
DEPARTMENT OF MOTOR VEHICLES

Teenage Driver Risks and Interventions

January 2004

Author: Scott V. Masten
Research and Development Branch
Licensing Operations Division

© California Department of Motor Vehicles, 2004

RSS-04-207

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503.

1. AGENCY USE ONLY (Leave blank)	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	January 2004	Final Report

4. TITLE AND SUBTITLE

Teenage Driver Risks and Interventions

5. FUNDING NUMBERS

6. AUTHOR(S)

Scott V. Masten

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)

California Department of Motor Vehicles
Research and Development Branch
P.O. Box 932382
Sacramento, CA 94232-3820

8. PERFORMING ORGANIZATION REPORT NUMBER

CAL-DMV-RSS-04-207

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES

12a. DISTRIBUTION/AVAILABILITY STATEMENT

12b. DISTRIBUTION CODE

13. ABSTRACT (Maximum 200 words)

California teenage drivers aged 16-19-years-old have extremely high per capita and mileage-adjusted crash and traffic violation rates. This report summarizes the literature regarding the risk factors involved in their high crash rates, as well as the countermeasures that have been used in California and elsewhere to reduce their high crash risk. Although some portion of teenage crash involvements can be accounted for by poorer basic vehicle handling skills, the research suggests that it is young drivers' immaturity and inexperience, and the resultant risk-taking, that contribute most to their increased crash risk. Certain driving conditions, such as nighttime driving and transporting young passengers, are particularly high risk for teen drivers. The higher crash rates for teens associated with the use of alcohol and drugs may mostly be the result of a general pattern of risky behavior. The countermeasures used to reduce the crash risk of teen drivers that are discussed in this report include driver improvement programs, driver education and training, special licensing programs for teens (provisional and graduated licensing), BAC limits, and curfew laws.

14. SUBJECT TERMS

Young Drivers, Teenage Drivers, Crash Risk, Countermeasures, Risk Factors, Literature Review

15. NUMBER OF PAGES

56

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
Unclassified	Unclassified	Unclassified	None

PREFACE

This literature review was prepared by the Research and Development Branch of the California Department of Motor Vehicles under the administration of Cliff Helander, Chief. The opinions, findings, and conclusions expressed in this publication are those of the author and not necessarily those of the State of California or the California Department of Motor Vehicles.

ACKNOWLEDGMENTS

This literature review was conducted under the supervision of Robert Hagge, Research Manager II. Debbie McKenzie, Associate Governmental Program Analyst, helped format the final report. Sarah Breitenbach and Dianne Thompson, student research assistants, helped identify studies for the review, checked the references, and also helped edit the report.

EXECUTIVE SUMMARY

Risk Factors

California teens aged 16-19 have higher average annual crash and violation rates than any other age group (Janke, Masten, McKenzie, Gebers, & Kelsey, 2003). Although some portion of their crash involvements can be accounted for by poorer basic vehicle handling skills, the research suggests that it is young drivers' immaturity and inexperience, and the resultant risk-taking, that contribute most to their increased crash risk. Research specific to teen risk perception indicates that teens are worse at perceiving hazards both in time and frequency than are drivers with more experience. Teens also tend to view the driving environment in more of a piecemeal manner and fail to respond to hazards within the context of the entire driving situation. They overestimate their own driving ability and perceive hazardous behaviors, situations, and road conditions as less risky than do drivers with more experience. As a result of immaturity and inexperience teens, particularly men, take more risks while driving as shown by their higher involvement in crashes and traffic violations associated with riskier driving (e.g., head-on and roll-over crashes). Ample evidence suggests that the risky driving of teens may be part of a general risk-taking lifestyle.

Certain driving conditions, such as nighttime driving and transporting young passengers, are particularly high risk for teen drivers. Whereas having passengers is associated with lower crash risk for most drivers, the risk for teens is much higher even when they are transporting one young passenger, and it increases even higher as the number of passengers increases. The evidence suggests that the higher nighttime crash

rates for teens result from the facts that teens are less experienced driving at night, and that nighttime driving is typically recreational, includes other young passengers, and often involves alcohol. The highest crash rates for teens have been found to be when they drive at night and have other young passengers in the vehicle.

The higher crash rates for teens associated with the use of alcohol and drugs may mostly be the result of a general pattern of risky behavior. Although teens are less likely to drive after drinking alcohol, those who do have a higher likelihood of being involved in a severe crash than older drivers who have the same concentrations of alcohol in their blood as do the teenage drivers. Furthermore, teen crash risk increases faster as BAC levels increase than is the case for older drivers.

Countermeasures

Countermeasures used to reduce the crash risk of teen drivers included driver improvement programs, driver education and training, special licensing programs for teens (provisional and graduated licensing), BAC limits, and curfew laws.

The literature suggests that driver education and driver training are not effective for reducing the crash and violation rates for teens who are trained. Experts suggest that driver education and training be integrated into graduated licensing programs as multi-level courses and that the programs be more geared towards teaching teens how to make good driving decisions and be aware of risk behaviors and driving conditions.

Both provisional licensing and graduated licensing programs attempt to reduce the crash risk of teens by requiring them to gain experience under less-risky conditions before being allowed to drive unsupervised. Evaluations of these programs in California and elsewhere suggest that they are indeed effective at reducing teen crash risk when they delay licensure or reduce unsupervised teen driving under high-risk conditions (i.e., with teen passengers and at nighttime).

General nighttime curfews, zero-tolerance laws, and lowered legal BAC levels for teens have also been shown to be associated with reductions in teen crash rates. The effectiveness of standard driver improvement countermeasures in reducing crashes, however, is not as clear. The California teen driver improvement program, in which they are subject to sanctions and penalties at lower point thresholds than for adults, has been found to contribute to reduced crash and violation rates. However, some research suggests that teens respond differently to standard countermeasures than do older drivers. More research is needed to determine the optimal system for teen post-license control, particularly given that accelerated-sanctioning programs are important components of other countermeasures (e.g., graduated licensing).

TABLE OF CONTENTS

PAGE

PREFACE i

ACKNOWLEDGMENTS i

EXECUTIVE SUMMARY i
- Risk Factors i
- Countermeasures ii

INTRODUCTION 1

FACTORS INVOLVED IN YOUNG DRIVERS' HIGH CRASH AND VIOLATION RATES 1
- Poor Risk Perception 1
  - Hazard Perception Detection/Identification 1
  - Subjective Perception of Risks 2
- Excessive Risk Taking 3
  - Risky Driving as a Result of a General Pattern of Risky Behavior 4
  - Gender Differences in Risk Taking 5
- Immaturity and Driving Inexperience 6
- Passengers, Nighttime, and Weekends 9
  - Passengers 9
  - Nighttime and Weekends 10
- Personality Characteristics 11
- Alcohol and Drug Use 12
  - Alcohol 12
  - Drugs 13

COUNTERMEASURES FOR YOUNG DRIVERS 14
- Driver Education and Driver Training 14
- Provisional Driver Licensing 17
- Graduated Driver Licensing 19
- General Nighttime Curfews 21
- Driver Improvement Programs 22
- Zero-Tolerance and Lowered BAC 23

REFERENCES 24

INTRODUCTION

For both men and women, California teenagers aged 16- to 19-years-old have the highest average annual crash and traffic violation rates per 100 drivers. Their high crash rates per 100,000 miles driven are matched only by drivers age 85+. Teenage driver violation rates per 10,000 miles driven, particularly for men, are completely unparalleled (Janke, Masten, McKenzie, Gebers, & Kelsey, 2003). The overinvolvement of teenagers in crashes is not unique to California; it is a problem nationwide (Foss & Goodwin, 2003; Massie, Campbell, & Williams, 1995; Williams, 1996ab, 2003) and worldwide (Twisk, 1996; Williams, 1996ab). In fact, traffic crashes are the leading cause of death for teenagers across the United States (Foss & Goodwin, 2003; Jonah, 1986; Mayhew & Simpson, 1999; Shope & Molnar, 2003). High teen crash risk is due to a number of factors, including (obviously) a fundamental lack of driving skill. However, contrary to what one might think, the evidence suggests that poor vehicle control skills account for only 10% of novice driver crashes; the remaining 90% is accounted for by factors such as inexperience, immaturity, inaccurate risk perception, overestimation of driving skills, and risk taking (Edwards, 2001). There are also certain psychological characteristics, such as sensation seeking, and driving situations, such as nighttime driving or carrying passengers, that put teens at higher crash risk. Finally, although drivers of all ages drive under the influence of drugs and alcohol, teens have had much less experience doing so, which further contributes to their higher crash rates. A summary of the research regarding the major factors that increase teen crash risk are described in the first section of this report, which is followed in the second section by research regarding the effectiveness of different countermeasures used to reduce their risk before and after they are licensed.

FACTORS INVOLVED IN YOUNG DRIVERS' HIGH CRASH AND VIOLATION RATES

Poor Risk Perception

Although teens quickly gain the basic vehicle handling skills and knowledge needed to operate a motor vehicle, it takes them longer to develop the higher-level perceptual and cognitive skills necessary to drive safely, such as risk perception (Arnett, 2002; Brown, 1982; Deery, 1999; Hall & West, 1996; Mayhew & Simpson, 1999; Williams & Ferguson, 2002). Risk perception while driving involves identifying a potential hazard in the driving environment (hazard perception) and assessing the likelihood that the hazard can be mitigated based on prior experience and a subjective evaluation of one's skill level (Deery, 1999). Risk perception is related to age/developmental factors, as expressed in teenagers' willingness to tolerate a higher amount of risk while driving (risk acceptance), and also to inexperience, as in their poorer ability to correctly identify dangerous driving situations they may not have previously encountered. Similarly, their beliefs about whether they can mitigate a hazard are affected both by developmental factors (e.g., immaturity) and inexperience (Arnett, 2002; Deery, 1999).

Hazard Perception/Detection/Identification

To be able to respond to potentially hazardous situations, a driver must first be able to identify it. There is evidence that young novice drivers are actually less able to perceive driving hazards than are older more experienced drivers. For example, in a review of

the literature on the perceptual skills of young novice drivers, Mayhew and Simpson (1995) found that young novices were more likely than older more experienced drivers to scan a smaller range of the roadway, including both their forward view and side-to-side peripheral field. When they do scan, novices are likely to use their mirrors less, glance at objects less often and fixate for a shorter time period, and are more likely to fixate on stationary objects than on moving ones. Novice drivers are also less likely to view the driving environment holistically, in that they tend to focus on single characteristics in the driving environment and react similarly to those single characteristics, independent of other contextual factors (Benda & Hoyos, 1983; Deery, 1999; Milech, Glencross, & Hartley, 1989). For example, they may choose to always drive the speed limit as a rule, regardless of whether the road and weather conditions make it safe to do so. Although young drivers have the fastest simple reaction and choice reaction times of all drivers (Quimby & Watts, 1981), they respond to filmed traffic hazards more slowly than do older drivers. The study authors attributed this to the frequent failure by young drivers to recognize potentially hazardous situations. The idea that young drivers are worse at detecting hazards was also supported by later studies (Egberink, Lourens, & van der Molden, 1986; McKenna & Crick, 1991; Summala, 1987). Even when teen drivers do identify potentially dangerous driving situations, they may not actually perceive them to be risky, as is discussed in the next section.

Subjective Perception of Risks

The high risk-taking of young drivers appears to be related to their failure to perceive dangerous situations as being of high crash risk (Finn & Bragg, 1986). This is evidenced by the fact that they tend to underestimate the risk of crashes in hazardous situations and overestimate their ability to avoid threats they identify (Arnett, 2002; Deery, 1999). Others have similarly concluded that younger drivers' higher incidence of fault in crashes could be due to their being overly optimistic about their driving ability or their actual accident risk (DeJoy, 1992). Young drivers tend to view their risk and vulnerability to crashes differently than do older people, and this often unrealistic subjective perception of their risk is a likely factor included in their high crash rates (Finn & Bragg, 1986; Gregersen, 1996a; Peck, 1985, 1993).

Matthews and Moran (1986) found that young men (ages 18 to 25) tend to underestimate the danger in high-risk driving situations that require fast reflexes or skilled vehicle handling skills. However, they tend to overestimate the danger in low-to-medium-risk situations. Trankle, Gelau, and Metker (1990) documented changes in risk perception that come with age and experience, finding that young men drivers rate certain traffic situations—especially situations involving darkness, graded or curved roadways, and rural environments—as less risky than do older men drivers. In the same study, young women drivers rate only situations involving darkness and intersections as less dangerous than do older women drivers. Young men have also been found to rate dangerous driving situations such as tailgating, driving at night, speeding, driving on snow-covered roads, and driving after drinking, as less risky than do older drivers (Finn & Bragg, 1986).

Mathews and Moran (1986) also found that young men drivers consider themselves to be more skilled than other young drivers or older drivers. Men drivers aged 18 to 24 have also been shown to perceive themselves as being less likely than other drivers their age to be involved in a crash, while older men drivers perceive their crash risk to

be similar to that of their age peers (Finn & Bragg, 1986). However, younger drivers in general consider their driving ability to be superior to that of other drivers and overestimate their own driving skill (Gregersen, 1996a; McGormick, Walkey, & Green, 1986). These findings suggest a difference between young drivers' subjective perceptions about their driving ability and their actual ability levels. This overconfidence of teens in their driving abilities may result from the fact that they develop basic vehicle control skills quickly and efficiently, and therefore conclude that they are highly skilled drivers (Brown, 1982).

The overconfidence of young drivers is also exhibited in their reasons for obeying the traffic laws. Specifically, older drivers are more likely to obey traffic laws because of perceived danger to themselves and others, whereas younger drivers tend to obey the law because of a sense of obligation to obey the law and fear of punishment (Yagil, 1998). That is, young drivers obey laws because of possible familial, financial, or mobility concerns rather than the potentially life-threatening consequences.

The evidence reviewed in this section regarding risk perception for young drivers suggests that teen drivers in general are worse at perceiving potential risks in their driving environment, are less likely to perceive themselves as vulnerable to risks, and are overconfident in their driving abilities (Irwin, 1996; Mayhew & Simpson, 1999). Hence, their poor risk perception is both a result of a failure to perceive hazards in the first place, and also a failure to view these hazards as dangerous. Their higher crash rates may result because their higher-level skills, such as risk perception and responses to risk, are not adequately developed, yet their overconfidence results in them placing inappropriate demands on their abilities (such as high-speed driving) given their inexperience (Brown, 1982; Deery, 1999).

Excessive Risk Taking

Most evidence suggests that risk taking is the most important major factor underlying the high crash rates among teens (Finn & Bragg, 1986; Jonah, 1986; Williams, 2001). The tendency for young drivers to engage in high-risk driving activities has been well documented (e.g., Cooper, 1987; Evans & Wasielewski, 1983; Jonah, 1986, 1990). For example, risk-taking behavior in young drivers has even been identified as a major factor in young drivers' basic motivations not to use seatbelts, which is one of the reasons that their fatal crash rates are higher than those of older age groups (Begg & Langley, 2000; Chliaoutakis, Gnardellis, Drakou, Darviri, & Sboukis, 2000; Hodgdon, Bragg, & Finn, 1981; Jonah, 1986; Mayhew & Simpson, 1999; Williams & Shabanova, 2002).

Teens are more likely to engage in risky driving behavior than are adults. For example, young drivers in general are more likely to drive too fast, tailgate, run red lights, violate traffic signs and signals, make illegal turns, pass dangerously, fail to yield to pedestrians, not wear seat belts, drive after heavy drinking or marijuana use, and engage in other driving behaviors that increase their crash risk (Evans & Wasielewski, 1983; Hingson, Howland, Schiavone, & Damiata, 1991; Irwin, 1996; Jonah, 1986; Williams, 2001; Williams & Ferguson, 2002; Wasielewski, 1984). Other researchers have similarly found that young drivers are more likely to speed, drive through yellow lights, and accept shorter gaps when entering traffic, all of which are further evidence of

risk-taking (Finn & Bragg, 1986; Hodgdon, Bragg, & Finn, 1981). Speeding, in particular, is strongly associated with young drivers (Willams & Ferguson, 2002).

Additional evidence for the higher risk-taking of young drivers is shown in relation to one of the most risky driving behaviors, running red lights. Retting, Ulmer, and Williams (1999) found that drivers involved in red-light-running crashes were more likely to be younger than age 30, male, have invalid driver licenses, and been driving while under the influence of alcohol. Although red-light-running crashes at all times were more likely to involve young men drivers, the relationship was found to be particularly pronounced during nighttime. Consistent with these findings, Porter and Berry (2001) found that younger drivers of both sexes were more likely to run red lights overall than were older drivers.

The types of crashes involving young drivers are those that tend to result from risky driving. Crashes involving young drivers are more likely to involve a single vehicle, driver error, intersections, speeding, following too closely (rear-end collisions), disobeying a traffic control, and passing dangerously (Kirk & Stamatiadis, 2001; McGwin & Brown, 1999; Ulmer, Williams, & Preusser, 1997; Williams, 1997, 2000; Williams, Preusser, Ulmer, & Weinstein, 1995). Young drivers are more likely to be at fault for serious head-on, rollover, and rear-end crashes, which are crashes that likely result from poor judgment or reckless behavior (Richardson, Kim, Li, & Nitz, 1996). In addition, they are up to three times more likely to be found at-fault in a crash, particularly if they are driving a pickup truck (Kim, Li, Richardson, & Nitz, 1998). It has been suggested that younger drivers' higher incidence of fault in crashes could be due to their being ignorant about the consequences of their risky behavior (Malfetti, 1993), possibly because of poor risk perception and inexperience.

Teen drivers in general perceive greater rewards for risky driving, are more subject to negative peer influences, and are less likely to perceive that preventative actions, such as wearing seatbelts, have benefits (Irwin, 1996; Mayhew & Simpson, 1999). Their predisposition towards risk-taking also appears to be related to their higher willingness to take more risks than older drivers (Finn & Bragg, 1986). Simpson (1996) makes the point that the concept of risk taking is independent from that of risky driving. Risk taking does not necessarily result in risky driving, and risky driving may not result from risk taking. For example, a driver may engage in tire squealing as a result of risk-taking behavior, even though the behavior is not necessarily risky. On the other hand, some young drivers may engage in such risky driving behaviors as following too closely, because their inexperience makes them less aware of the risks of doing so. That is, their risk-taking does not necessarily imply that they are aware of the riskiness of their actions (Jonah, 1986).

Risky Driving as a Result of a General Pattern of Risky Behavior

Although risk-taking is a part of adolescence in general, not all adolescents are risky drivers (Williams, 2001). This suggests that the risk level for any given teen driver falls somewhere along a risk continuum (Willams & Ferguson, 2002) and that there are subgroups of teens who engage in more risky behavior than others, and for whom risky driving is only one expression of a pattern of risk-taking behavior (Donovan, 1993; Elliot, 1987; Irwin, 1996; Jessor, 1987ab; Mayhew & Simpson, 1999; Swisher, 1988).

Younger drivers' higher incidence of fault in crashes could be due to having a high-risk lifestyle in general (Gregersen & Berg, 1994). Teens who engage in higher-risk activities outside the driving situation (e.g., smoking, drug use, heavy drinking, and sleeping less) tend to have a higher incidence of traffic crash involvement, whether they are driving the vehicle or riding as a passenger (Beirness, 1993, 1996; Beirness & Simpson, 1988; Beirness, Simpson, & Mayhew, 1992). This suggests that risky driving may be part of a more general syndrome of risk-taking behavior (Swisher, 1988). Lang, Waller, and Shope (1996) documented a significant relationship between single-vehicle crashes and the tendency toward cigarette smoking among young women drivers, and substance availability (cigarettes, smokeless tobacco, alcohol, and marijuana), frequency of driving, alcohol misuse, and a tendency toward marijuana use among young men drivers. Alcohol misuse and having friends who use or talk about using alcohol and marijuana were also found to be significantly related to injury crashes among women. Living arrangements (living with parents or others), substance availability, and a tendency toward marijuana use are related to injury crashes among young men. Early evidence in California also suggests that risky driving was associated with a general pattern of risk taking. Specifically, Harrington (1972) found that high school bad citizenship grades and less socially desirable personal attributes were associated with higher crash and violation rates.

Comparing teenagers in Connecticut, Delaware, New Jersey, and New York to all other drivers, Cammisa, Williams, and Leaf (1999) found that teenagers were more likely to drive older and smaller vehicles, particularly if they were the owners of the vehicles. Teenagers who owned their own vehicle were more likely to participate in risky driving, such as racing and excessive speeding, and in other risky behaviors, such as smoking and drinking alcohol, and were more likely to be involved in a crash. The authors recommend that limiting teens' ownership of an automobile may be a way to decrease their crash involvement (Cammisa, Williams, & Leaf , 1999).

Gender Differences in Risk Taking

Young drivers are more likely to take risks than are older drivers, and young men are at greater risk of crashing then any other group. Young men drivers are more likely to engage in unsafe behaviors than are young women drivers, while driving and in other areas (Elliot, 1987; Evans & Wasielewski, 1983; Forsyth, 1992; Harre, Field, & Kirkwood, 1996; Wasielewski, 1984). For example, they are more likely to excessively speed, illegally pass, and drive under the influence of alcohol than are young women (Arnett, 1996). They also tend to believe risky driving situations and behaviors are less dangerous than do young women (Brown & Copeman, 1975; Dejoy, 1992; Mundt, Ross, & Harrington, 1992; Trankle, Gelau, & Metker, 1990). A study comparing young men and young women drivers involved in fatal loss-of-control crashes found that young men's crashes were more likely to occur at night, because of driving too fast, and to include alcohol, whereas young women's crashes usually took place during slippery road conditions (Laapotti & Keskiner, 1998). Other researchers have confirmed the higher loss-of-control crash involvement of young men aged 15 to 24 years (Tavris, Kuhn, & Layde, 2001).

Although actual risky driving is predominantly a young male activity, there is at least one study that challenges the data showing that young men are higher risk takers than are young women drivers, instead finding that younger men and women drivers are

equal in their risk taking (Boyce & Geller, 2002). Other researchers have suggested that the risky-driving behavior rates of women are starting to catch-up to those for men, particularly in the area of DUI (Finken, Jacobs, & Laguna, 1998; Moore, 1994; Popkin, 1991; Shapiro, Siegel, Scovill, & Hayes, 1998). On a positive note, there is some evidence that even men reduce their risky driving to moderate levels by age 26 (Begg & Langley, 2001).

Immaturity and Driving Inexperience

The most dangerous period of driving for a teenager is immediately after they have been licensed, particularly in the first month (Mayhew, Simpson, & Pak, 2000a; McCartt, Shabanova, & Leaf, 2003). This is when they are the youngest and also the most inexperienced. When researchers refer to the contribution of age to crash rates for teen drivers, they are typically referring to developmental characteristics associated with immaturity per se (Williams & Ferguson, 2002). Both immaturity and inexperience contribute to teen drivers' higher crash risk. As they become more mature and experienced with age, their crash rates tend to decrease (Harrington, 1972; Kirk, & Stamatiadis, 2001; Mayhew, 2003; Mayhew & Simpson, 1990, 1999; Simpson, 1996).

In terms of inexperience, it is known that novice teen drivers are worse compared to experienced drivers in their ability to recognize and mitigate hazards, pay attention to the important things in the driving environment at the right time, quickly shift from one driving skill to another (timesharing), and match their performance with that required by environmental demands (Deery, 1999). They are not as able as more experienced drivers to brake, steer, adjust their speed, or coordinate these skills appropriately (Mayhew & Simpson, 1999). Furthermore, their ability to execute these driving skills is worse under more demanding circumstances.

The crash involvement of 16- to 17-year-old drivers has also been found to decrease dramatically after the first year of driving, which suggests that new drivers face a first-year learning curve regarding vehicle control (Kirk & Stamatiadis, 2001). The fact that teenagers who are learning to drive can only gain experience to lower their crash risk by exposing themselves to crashes (i.e., by driving) has been called the "young driver paradox," because they must be exposed to the very conditions that make them risky in order to reduce their risk (Deery, 1999; Jonah, 1986; Lin & Fearn, 2003; Warren & Simpson, 1976). The purpose of learner permits at all ages is to allow novices to gain experience driving under conditions of reduced risk while under supervision (Evans, 1987; Mayhew, 2003; Waller, 2003; Williams, 1994). As might be expected, teens drive less when they do not have an instruction permit or license, and drive less when they have a learner's permit than when they have a full license (Preusser, 1988).

Because increasing experience and maturity go hand-and-hand for teen drivers, it has been difficult to determine the relative contributions of immaturity versus inexperience level to young driver crash risk. Although teens may intentionally take risks while driving, sometimes their risky driving is the result of not perceiving the amount of risk due to their inexperience (Arnett, 2002; Williams & Ferguson, 2002). That is, young novice drivers are slower and less effective at perceiving risks and hazards while driving because of inexperience, and they also take more risks because of their immaturity (Deery, 1999; Williams & Ferguson, 2002). For example, risky driving such

as speeding sometimes is a result of their deliberate thrill seeking associated with immaturity, whereas at other times their risky driving is a result of not realizing that a behavior or situation is hazardous because of a lack of experience (Williams & Ferguson, 2002).

Complicating the situation even more, teenagers' immaturity and inexperience can interact with each other, such that their risk-taking creates a dangerous situation and their inexperience prevents them from avoiding a negative outcome (Mayhew & Simpson, 1999; Williams & Ferguson, 2002). Hence, their risky driving, dangerous driving errors, violations of laws, and subsequent higher crash and violation rates could be the negative outcome of physical developmental immaturity (e.g., a lack of coordination), driving inexperience (e.g., not knowing how to respond to a high-risk situation), risk-taking due to immaturity (e.g., sensation seeking or peer pressure), risk-taking due to inexperience (e.g., not knowing that a particular situation is dangerous due to not having encountered it before), or a combination of these factors (Blockley & Hartley, 1995; Mayhew & Simpson, 1999; Williams & Ferguson, 2002).

In an early California study that tried to disentangle the effects of inexperience from those for immaturity, Ferdun, Peck, and Coppin (1967) analyzed the records of drivers aged 16 through 19. Inexperience was measured by total miles driven in life and months of licensure. Immaturity was measured indirectly by controlling all available variables which were related to age but not considered to indicate immaturity; any remaining relationship between age and driving record was attributed to immaturity. For men, as experience increased, their violation rate increased but crash rate did not change. As maturity (age) increased, crash rate decreased but violation rate still tended to increase, though not significantly. For women, as experience increased, their violation rate again increased but crash rate decreased, while immaturity (age) was not related to either crashes or violations. The authors suggested that increasing experience may lead to increased confidence and therefore less compliance with traffic laws. Drivers with little experience lack confidence as well as defensive driving skills; they may obey laws better, but lack the skill to avoid crashes as well as more experienced drivers do.

In a follow-up to the Ferdun et al. study, Harrington (1972) found that the average crash rate for men reached its peak in the second year of driving and then declined, while for women it declined from the first year on. Even though mileage increased across years, there was no corresponding increase in crashes. In contrast, the average traffic conviction rate rose for both sexes until the third year of driving, and then declined. Harrington concluded that young drivers learn a great deal about crash avoidance with increasing practice (experience), but seem to show little change in their attitudes toward the traffic laws until the fourth year of driving.

The findings of both Ferdun et al. and Harrington suggest that immaturity is a stronger factor than inexperience in teenagers' violation rates, and inexperience is a stronger factor than immaturity in their crashes. A number of studies conducted since that time support their findings, particularly with regard to the relationship between inexperience and crashes. For example, Gregersen, Berg, Engstrom, Nolen, Nyberg, and Rimmo (2000) evaluated the effect of lowering the age limit for a learner's permit in Sweden from 17 to 16 years (although the actual licensing age remained at 18) in an attempt to give novice drivers more driving experience before they were allowed to

drive on their own. Of the 45% to 50% of the eligible population who used the lowered age opportunity for additional practice, there was a 24% reduction in exposure-adjusted accident risk subsequent to licensure, whereas no benefit at all was realized for those who did not take advantage of the lowered age limit. This effect lasted over a 3-year period for novice drivers who took advantage of the program. Similarly, Maycock, Lockwood, & Lester (1991) found that delaying licensure from age 17 to age 18 only resulted in about a 6% reduction in total crash risk compared to prior levels. Finally, the fact that drivers closer to the age of 16 tend to have more crashes under safer conditions (e.g., during the day, in clear weather, after drinking less) than older young drivers (ages 17 to 21) also suggests a larger effect of inexperience (Ballesteros & Dischinger, 2002).

Other studies have supported the relationship between teen inexperience and crashes, but in the opposite direction. Laberge-Nadeau, Maag, and Bourbeau (1992) found that young drivers with at least 1 year of experience, compared to drivers of the same age who were newly licensed, actually had higher injury crash rates, which has been supported for not-at-fault crashes (but not culpable crashes) by later research (Cooper, Pinili, & Chen, 1995). However, the authors did not adjust the crash rates for the fact that the more experienced drivers likely were driving more and hence were more exposed to conditions leading to crashes, which could explain the surprising findings.

Together, these studies support the conclusion of the early California studies that the high crash risk for young beginner drivers is more strongly related to their inexperience than to their immaturity. This conclusion is consistent with Williams (2001) who, after reviewing the literature, concluded that driving inexperience is the second most important factor, following risk-taking, influencing the higher crash propensity among young drivers. However, immaturity cannot be discounted entirely as a factor in teen crashes. For example, even when crash rates are adjusted for mileage, younger novice drivers (ages 18 to 20) have higher crash rates in the first 6 to 18 months of driving than do older novice drivers, and the risk is even higher for young men drivers (Laapotti, Keskinen, Hatakka, & Katila, 2001). That is, even when experience is held constant, the crash rates for immature (younger) drivers are higher than are those for mature (older) drivers. Levy (1990) similarly found that driving experience was only a minor factor in the over-involvement of 15- to 17-year-old drivers in fatal crashes (unadjusted for mileage). He actually concluded that immaturity was a more important factor in young drivers' crashes than was inexperience, and that raising the driving age would reduce traffic crashes without seriously reducing experience effects. Other studies suggest that driving experience may be a more important factor than increased age in reducing crash risk among novice drivers in general, but for the youngest drivers (15-year-olds) maturity may be more important (Gregersen & Bjurulf, 1996; Mayhew, Simpson, & Pak, 2000b).

The relationship between immaturity, inexperience, and teen crash risk is further complicated by research that suggests immaturity and inexperience may have different impacts on crash risk depending upon the time after licensure. For example, there is evidence that crashes and violations that occur earlier during licensing for novice drivers are due more to inexperience, whereas those that occur later are due to risk-taking (Elliot, Waller, Raghunathan, & Shope, 2001). Young novice drivers aged 16 to 18 have also been found to engage in fewer risky driving behaviors than do novice drivers

who are slightly older (ages 18- to 24-years-old), and reckless driving has been found to increase about 27% between the ages of 14 to 17 (Cooper, 1987; Gerrard, Gibbons, Benthin, & Hessling, 1996; Jonah, 1990). Speeding and alcohol use have been found more likely to be involved in young drivers' crashes as their years of experience increases (Cooper, et al., 1995), which is consistent with findings that younger drivers who are slightly older are more likely to engage in riskier driving behaviors than are those who are just starting to drive (e.g., Laberge-Nadeau et al., 1992). A more recent study supported these findings, showing that 14- and 15-year-olds have less-risky attitudes towards driving than do 16- and 17-years-olds (Harre, Brandt, & Dawe, 2000). These studies imply that the high crash risk of new young drivers is a result of their inexperience, whereas the high crash risk of somewhat more experienced young drivers is the result of risk-taking stemming from their immaturity.

Taken as a whole, the research literature regarding the importance of inexperience and immaturity for teen crash risk clearly indicates that both factors are important and that they often interact with each other to cause high teen rash rates. If any conclusions can be drawn about which is the more important of the two, they are that inexperience appears to be more important for determining teen crash risk in the first year of driving, whereas immaturity is more important later on. The negative effects of greater risk-taking, aggressiveness, and competitiveness characteristic of young drivers, especially men, appears to counterbalance any positive effect of experience after the first year of driving.

Passengers, Nighttime, and Weekends

Young drivers' propensity for risk taking is situation-specific. That is, there are situations under which they drive quite safely such as while learning to drive with their parents (Mayhew, Simpson, & Pak, 2000a; Williams, Preusser, Ferguson, & Ulmer, 1997), and situations under which they are more likely to take risks, such as when driving recreationally, particularly with friends in the vehicle (Preusser, 1996a; Williams & Ferguson, 2002). Although young drivers have crash involvement rates that are higher than most other age groups under most conditions, they are disproportionately high on weekends, at nighttime, and when carrying passengers (Aldridge, Himmler, Aultman-Hall, & Stamatiadis, 1999; Doherty, Andrey, & MacGregor, 1998; Chen, Baker, Braver, & Li, 1999, 2000; Mayhew & Simpson, 1999; McGwinn & Brown, 1999; Williams, 1996ab, 2000, 2003). These situational factors that are associated with high teen crash rates are discussed in this section.

Passengers

The fact that teenage crash risk is higher when teen passengers are in the car has been known at least since 1969 (Foldvary & Lane) and has been supported by other research since that time (Baxter, Manstead, Stradling, Campbell, Reason, & Parker, 1990; Drummond & Triggs, 1991; Farrow, 1987; Vollrath, Meilinger, & Kruger, 2002). Over half of all 16- to 17-year-old drivers' deaths occurred while driving unsupervised with passengers less than 20-years-old (Williams, 2003; Williams & Ferguson, 2002). Teen deaths as passengers are nearly as common as deaths as drivers, and passenger deaths as a percentage of passenger vehicle occupant deaths are nearly twice as high for teenagers (48%) as for older passengers (27%) (Chen et al., 1999; Williams & Wells, 1995). Evidence suggests that this is especially true for 16- to 17-year-old drivers

(Williams, 2000, 2003). Chen et al. (1999, 2000) indicate that the fatality risk of drivers ages 16 to 17 is 3.6 times higher when they were transporting passengers than when they were not, and that the relative risk of a fatal crash increased as the number of passengers increased. When teenagers are driving with three or more passengers, their crash risk is about 4 times greater than without passengers (Williams, 2003).

Others have found culpable crashes for young novices to be related to both years of experience and the presence of passengers. Specifically, as years of experience increased from 1 to 3, the proportion of crashes involving passengers was found to decrease. This suggests that the presence of passengers was more likely to increase the risk of a culpable crash when the young drivers were less rather than more experienced (Cooper et al., 1995). Teenagers also have relatively low levels of seat belt use when transporting peer passengers under the age of 20, which increases their likelihood for a fatal crash (Williams & Shabanova, 2002). Teenage rates of seat belt use as drivers and passengers tends to decrease as the number of passengers under the age of 20 increases, and their rates are the highest when transporting passengers age 30 or older (Williams & Shabanova, 2002).

What is so striking about the increased risk of young drivers (age 24 or younger) with passengers in the vehicle is that for other age groups, passengers are associated with either no increased risk (aged 25 to 29) or decreased risk (age 30 and older; Preusser, Ferguson, & Williams, 1998; Vollrath et al., 2002). In addition, this increased risk exists for teenage drivers traveling with passengers both during the day and night (McKnight, 1996a; Williams, 2000, 2003). Williams, Preusser, and Ferguson (1998) presented evidence that the higher crash involvement for teenagers with teenage passengers may be due to increased risk-taking induced by peers or other distractions such as talking. Aldridge et al. (1999) found that young drivers (ages 16 to 20) have the lowest likelihood of causing a crash when they travel with adults or young children, but a higher likelihood to be involved in single-car crashes when driving with other teenagers, suggesting that teens are more likely to take risks when they are with their peers. Peers may motivate teenage drivers towards increased risk-taking, especially young men with other young men (McKnight, 1996a; Regan & Mitsopoulos, 2001). Additional evidence supporting this contention comes from McKenna, Waylen, and Burkes (1998), who found that young drivers with young men passengers drove more dangerously than they did without passengers, a finding supported by other researchers as well (Baxter et al., 1990). Chen et al. (1999) predicted that restricting 16- to 17-year-old drivers from carrying passengers would reduce the number of crash fatalities for 16- to 17-year-olds anywhere from 9% to 50%. They estimated that even restricting all 16-year-olds only from driving with passengers under age 20 would reduce their crash fatalities by 8% to 47%. Interestingly, there are certain situations where teen passengers do not increase risk for teen drivers. For example, men drivers carrying a women passenger may actually drive safer than when they drive alone (McKenna et al., 1998) and do not have a higher crash risk (Chen et al., 2000).

Nighttime and Weekends

Although crash rates tend to be higher for most age groups on weekends and at nighttime, the effect of passengers in the vehicle resulted in even higher mileage-adjusted crash rates for 16- to-19 year-old drivers in these situations. About 15% of teenage (16- to 17-years-old) driving occurs during the nighttime (9:00 p.m. to 6:00

a.m.), but almost 40% of their fatal crashes occur at night (Lin & Fearn, 2003; Williams & Preusser, 1997). That is, although they do not drive much at night, their per-mile fatal crash risk is very high after 9:00 p.m. Williams and Preusser (1997) found that per-mile crash rates for teenage drivers are 3 times higher after 9:00 p.m. than during the day, likely because nighttime driving for teenagers is generally recreational in nature and often includes teenage passengers (Williams, Preusser, & Ferguson, 1998). Doherty et al. (1998) found that the mileage-adjusted crash rates for 16- to 19-year-old drivers when passengers were in the vehicle were approximately twice as high with passengers compared to without passengers for these younger drivers. In addition, the crash rates are even higher when two or more passengers were in the vehicle compared to only one passenger. The highest overall crash rates for 16- to 19-year-old drivers they observed were when teens carry passengers at nighttime. Cooper et al. (1995) evaluated the crash involvement rates of all novice drivers between the ages of 16 and 55. For drivers aged 16 to 18, crash involvement was found to be higher on weekends (Friday to Sunday) and at nighttime (9:00 p.m. to 3:00 a.m.), particularly if they were in their first year of driving. Late night (midnight to 5:00 a.m.) involvements were found to be more associated with crash risk for young drivers with more experience (2 or 3 years) than for those in their first year of driving. Williams and Wells (1995) similarly found that the deaths of teenage drivers and their passengers are more likely to occur during the nighttime, in smaller-sized vehicles, and in older vehicles. The higher crash risk for teenagers at night may be because the task of driving is more difficult at night, they have had less experience driving at night than during the day, they are sleep-deprived, or teen recreational driving, which often involves alcohol, is more likely to occur at night (Williams, 2003).

Personality Characteristics

Lifestyle factors such as social, psychological, and behavioral characteristics only account for about 20% of the variability in crash involvement and 35% of the variability in risky driving for young drivers (Beirness, 1996). Smith and Heckert (1998) attempted to determine correlates of traffic crash and violation rates in college students and found that lower self-esteem was associated with higher crash rates, but found no relationship between crashes and risk seeking or chronic self-destructiveness. In addition, the results also suggested that lower self-esteem and tendency towards chronic self-destructiveness were associated with higher violation rates, but no relationship was found for risk seeking. Risky driving may reward teen drivers by giving them a sense of power, esteem, independence, and recognition by their peers (Williams, 2001). Increased reckless driving behavior (excessive speeding, racing, dangerous passing, and driving while intoxicated), particularly a problem for young men, has been shown to be associated with sensation-seeking and aggressiveness in teenagers, who tend to be higher in both of these personality characteristics than are adults (Arnett, Offer, & Fine, 1997). Crash-involved teens have also been found to be more thrill and adventure seeking, more tolerant of social deviance, and more risk-taking (Beirness, 1993, 1996; Beirness & Simpson, 1988). The findings that personality characteristics such as sensation seeking, impulsiveness, as well as a risky lifestyle in general, are related to crash risk, and the fact that these characteristics are more prevalent in younger drivers suggests that younger drivers may have a higher level of risk acceptance or risk-seeking than do older drivers (Deery, 1999; Elander, West, & French, 1993; Gegersen, 1996; Mayhew & Simpson, 1995).

Though not strictly due to personality per se, there is evidence that teenage crash and violation rates are related to those of their parents, particularly when the parents were major offenders. Specifically, teens whose parents with three or more crashes on their record are 22% more likely to have been involved in a crash, and those whose parents had three or more violations were 38% more likely to have had a violation themselves in the first years of driving, compared to teens whose parents were not involved in crashes and did not have violations, respectively (Ferguson, Williams, Chapline, Reinfurt, & De Leonardis, 2001).

Alcohol and Drug Use

The consistent theme throughout this literature review has been that young drivers who have a higher crash risk are more likely than others to engage in a general pattern of risky behavior, and this includes using alcohol and drugs (Jessor, 1987ab). Alcohol and drug use are other factors that account for the high crash rates of teens (Mayhew & Simpson, 1999; Shope, Waller, & Lang, 1996). The prevalence of drinking and driving and of alcohol in road crashes decreased dramatically during the 1980s (Mayhew, Brown, & Simpson, 1996, 1998), but only marginal decreases were realized in the 1990s (Simpson, Mayhew, & Beirness, 1996), and a reversal in trends has seen increases in alcohol-related crashes since the late 1990's (Helander, 2002). This section presents a summary of the research findings on the effects of alcohol and drugs on teen crash risk. These factors are of increasing importance, given the recent increases in the incidence of alcohol-impaired driving.

Alcohol

Being below the legal drinking age in all states (including California), teens are less likely than drivers in older age groups to drink and drive, and are less likely to have high Blood Alcohol Content (BAC) levels (Balmforth, 1998; Mayhew, Donelson, Beirness, & Simpson, 1986; Mayhew & Simpson, 1999; Voas, Wells, Lestina, Williams, & Greene, 1998). But those who do drink and drive are at much greater risk of serious collisions than are older drivers who have the same concentrations of alcohol in their blood, and the relative risk increases faster for younger drivers than for older drivers as BAC levels increase (Mayhew, Donelson et al., 1986; Mayhew & Simpson, 1985, 1999; Voas et al., 1998; Zador, 1991; Zador, Krawchuk, & Voas, 2000). One study found that 52% of fatal accidents of young drivers in Canada aged 18 to 25 involved alcohol and that 82% of the drivers had BAC levels that exceeded the legal limit of .08 (Mayhew et al., 1996, 1998). The majority of teenage alcohol-related fatal and injury crashes occur during nighttime hours (9:00 p.m. to 6:00 a.m.) and on weekends (Mayhew & Simpson, 1999).

Older teens are more likely to drink and drive than are younger teens, and teenage men are much more likely to drink and drive than are teenage women (Mayhew & Simpson, 1999). Regarding the onset of drinking alcohol, drivers who started drinking alcohol before age 21 are more likely to be involved in an alcohol related crash compared to those who started drinking at age 21 or older (Hingson, Heeren, Levenson, Jamanka, & Voas, 2002). Recent findings also show that younger drivers convicted of drinking and driving who are involved in crashes are even more likely than other age groups to be

involved in a subsequent drinking and driving crash (Ferrante, Rosman, & Marom, 2001).

The combined effects of young drivers being novices at both driving and consuming alcohol may be the cause of their higher risk, although emerging research suggests that the higher involvement of teens in alcohol-related crashes is due to a subset of teens who engage in a general pattern of risk-taking behavior (Mayhew, Donelson, et al., 1986). For example, Horwood and Fergusson (2000) found that there is a general tendency for young drivers who drink and drive to engage in other high risk or illegal driving behaviors. Even after adjusting crash rates for driver experience level, exposure, and risk-taking behavior, the crash rates for young drivers who drink and drive are higher than those who do not (Horwood & Fergusson, 2000). In another example, young people who drive after drinking have also been found to be more sleep deprived and have slower reaction times than young sober drivers (Corfitsen, 1996).

Some have suggested that young drivers are overinvolved in alcohol-related driving fatalities in part because they are overrepresented among those who drive at night (e.g., Finn & Bragg, 1986), when alcohol-caused crashes are more likely to occur. They are also more socially active than others, especially at night, and have more opportunities to drink and then drive (Carlson, 1972; Jonah, 1986). The more active nighttime social life of teens, and resultant opportunity to drive impaired, suggests that in the long run they do more frequently drive impaired. Alcohol use, however, may just be one more expression of a general tendency in risk-taking for teens (Jonah, 1986).

Drugs

Although persons of all ages who are arrested for drug offenses pose an elevated traffic safety risk up to 2 years after their arrest (Marowitz, 1995), research on specific drugs and their effects on driving is less common than research on alcohol. Furthermore, most of the research that does exist focuses on marijuana use. Young people who use marijuana or other illegal drugs in combination with drinking alcohol are significantly less likely to wear their seatbelts as driver or passengers, more likely to drive after drinking alcohol, and more likely to ride as a passenger with a driver who had been drinking alcohol, which again suggests that at least part of young drivers' alcohol use is attributable to a general pattern of risky behavior (Everett, Lowry, Cohen, & Dellinger, 1999). Fergusson and Horwood (2001) similarly found that although marijuana use was associated with increased crash risk for younger drivers, the relationship is primarily an artifact of a pattern of risky behavior of young people, rather than the effects of marijuana use on their actual driving performance. Similarly, the use of cigarettes, alcohol, and marijuana prior to having a driver license is a significant predictor of higher subsequent crash and violation rates after being licensed for younger men and women (Shope, Waller, Raghunathan, & Patil, 2001). Jessor (1987ab) also found that marijuana use and other delinquent behaviors were associated with higher risk driving. Frighteningly, a recent survey indicates that some teenagers believe that it is more acceptable to drive under the influence of marijuana than to drive under the influence of alcohol (Patton & Brown, 2002).

COUNTERMEASURES FOR YOUNG DRIVERS

Regardless of the cause for the high crash and violation rates of young drivers, it is the responsibility of states and other responsible jurisdictions to attempt to reduce their risk level. Young men and women beginning drivers who receive traffic violations or who are involved in crashes are more likely to violate or crash again than are beginning drivers who are violation and crash free (Elliot, Waller, Raghunathan, Shope, & Little, 2000). Different countermeasures that have been used for teen drivers include driver improvement programs, driver education and training, special licensing procedures for teens (provisional and graduated licensing), BAC limits, and curfew laws. Some countermeasures are preventative programs used for all young drivers based on their risk at the population level, such as graduated licensing programs, while others result from an individual driver having exhibited high-risk behavior, such as driver improvement programs. This section presents a review of evaluations of the various countermeasures.

Driver Education and Driver Training

Driver education, which is the part of learning to drive where facts, skills, and attitudes are taught (usually, but not always, in a classroom), and driver training, which is the actual in-car instruction, exist throughout the world and are common way of teaching new drivers the knowledge, skills, and abilities necessary for passing the behind-the-wheel driving test and subsequently driving safely (Mayhew & Simpson, 1996a, 2002). Although driver education and training are commonly considered to have safety value for reducing teen crash and violation rates, the preponderance of research both in California and throughout the world does not support this view (Peck, 1985; Mayhew & Simpson, 2002).

Most of the early research on driver education and training is quasi-experimental in nature, and tends to show some evidence of safety benefits. For example, Harrington (1972) found that there was some evidence that driver training reduces the rate of fatal/injury crashes for licensed women drivers, but not men (Harrington, 1972). Ferdun et al. (1967) found that subsequent traffic violation rates were lower for teens who completed driver training compared to those who did not, but did not find a difference in their subsequent crash rates. There have even been a handful of recent studies that suggest driver education and training have some safety benefits. For example, a study in Oregon also found that while there is no overall evidence of a significant driver training effect, young women receiving behind-the-wheel driver training showed a trend toward lower crash rates (Jones & McCormac, 1989). In addition, Levy (1990) concluded that mandatory driver education may have been associated with reduced fatal crash rates for 15- to 17-year-olds, but that any reduction may have been offset by contributing to higher licensure rates of teens and the higher total crash rates that result. The tendency for driver training to increase or lead to earlier licensure of teenagers is also documented in earlier studies by Robertson and Zador (1977) and Robertson (1980).

The notion that driver education and training increase licensure and, therefore, have a negative impact on teen crash rates has been studied by a number of researchers. For example, Robertson (1980) found that removing funding for driving education from

high schools in Connecticut may have had a beneficial impact on teen crash rates by reducing their rates of licensure and subsequently resulting in lower teen crash rates. Conversely, delays in licensure resulting from requiring 15-year-old license applicants to complete driver education in Louisiana before licensure was associated with lower 15-year-old fatal and injury crash involvements (Ulmer, Preusser, Ferguson, & Williams, 1999). Not only do teenagers from states that allow earlier licensure report more and riskier driving than do teens in states that do not allow early licensure, but the fatal crash involvement rate of teens is higher in states that permit earlier practice driving and licensure and the fatal and injury crash involvements are higher in states that do not restrict the initial licenses of teen drivers to reduce their exposure, such as by nighttime driving restrictions (Ferguson, Leaf, Williams, & Preusser, 1996; Preusser, 1988, 1996a; Preusser, Ferguson, Williams, Leaf, & Farmer, 1998; Ulmer, Ferguson, Williams, & Preusser, 2001). Even minor changes to licensing requirements that delay licensure such as requiring 16- to 17-year-old applicants to either complete a driver education course or hold a learner's permit for 90 days have been shown to result in more driving practice (Preusser, Ferguson, & Williams, 1999), and increased experience behind-the-wheel has been associated with large reductions in crash rates in England (Forsyth, Maycock, & Sexton, 1995), Canada (Mayhew & Simpson, 1991), Australia (Drummond, 1996), and the United States (Elliot, Raghunathan, & Shope, 2002; McKnight, 1996a). Therefore, there is some logical evidence that supports the idea that anything that results in teens licensing earlier is also likely to result in higher crash rates.

Some researchers studied the idea of lengthening or otherwise making driver education and training more rigorous to determine if these 'improved' courses would result in traffic safety benefits. For example, Dreyer and Janke (1979) studied randomly assigned California high school students given, in addition to standard training components, 8 hours of practice on an off-road driving range (but they had the same total number of training hours). Although there were no differences in licensure rate or time to licensure between the groups, those who received training on the driving range were found to have 33% lower crash rates compared to those who were not given the special range training. Although these findings are compelling, the sophisticated driving range was very costly, and the authors acknowledge that the general use of such facilities might be infeasible. The idea that somehow making driver training longer or more rigorous would result in lower crash rates is also not supported by another California study (Hagge & Marsh, 1988). In this study, young novice drivers who completed a competency-based driver training course, for which they had to demonstrate driving competence to pass the course, were compared to students who completed courses for which the only criterion for passing was having completed 6 hours of behind-the-wheel supervised practice. The results indicated that students who completed the competency-based course had 5.6% and 10.3% higher subsequent total crash and fatal/injury crash rates, respectively, than did those who completed the standard driver training course, even after adjusting for differences in gender and licensing age. The authors do suggest that the findings could partially be explained if those who received competency-based training tended to license earlier and drive more during the criterion period.

Later research on driver education and training that used rigorous experimental methodology did not result in findings consistent with the early literature. In a now

famous well-designed experimental study, Stock, Weaver, Ray, Brink, and Sadof (1983) evaluated two types of high school driver education and training courses in DeKalb Georgia against a no-training condition. One of the courses was quite extensive, including 32 hours of classroom training, 16 hours of driving simulation, 16 hours of driving range instruction, 3 hours of instruction on evasive maneuvers, and 5 hours of on-the-road training. The other course was a 20-hour basic driver education course that included classroom, range and simulation instruction, and practice driving with parents. The results of the study indicated no statistically significant reduction in subsequent crashes for either course compared to the no-training control group. However, some significant (though small) crash and violation reductions for the training courses were found when the analysis was limited to those who actually completed the courses and were licensed during the first 6 months following training. This difference diminished over the next 18 months, resulting in no true long-term impact of the training courses. Similar to other studies, students who completed either of the training courses were found to have become licensed earlier on average than those who did not take a course, which the authors believe may have counteracted any overall traffic safety benefit of training (Stock et al., 1983). Finding that driver training had no long-term impact on crashes in such a rigorous scientific evaluation lead to much controversy and scrutiny, and several authors reanalyzed their data over the years (e.g., Davis, 1990; de Wolf & Smith, 1988; Lund, Williams, & Zador, 1986; Smith, 1987; Smith & Blatt, 1987). The pattern of results from these other studies re-analyzing the DeKalb data lead to the same conclusion: Driver training and education, even when well-designed and rigorous, have not been shown to reliably reduce the crash rates of young drivers (Mayhew & Simpson, 1996a; Peck, 1996).

The conclusions that are based on the DeKalb study have been reinforced by later research as well. For example, a recent literature review of nine evaluations of high school driver education concluded that there is no consistent evidence that high school driver education is associated with lower crash risk for young drivers (Vernick, Li, Ogaitis, MacKenzie, Baker, & Gielen, 1999). These authors also found there to be evidence that the opportunity for earlier licensure afforded by driver education courses may actually lead to higher crash involvement. Another recent evaluation of driver education in Pennsylvania also found no reductions in crashes, violations, or injury severity, no change in seat belt use, and no reduction in risk-taking behavior for teens completing driver education courses (McKenna, Yost, Munzenrider, & Young, 2000).

In a comprehensive review of 30 studies on driver education, behind-the-wheel driver training, motorcycle training and education programs, and advanced training courses for novices, Mayhew and Simpson (1996a) found that there is little evidence in the literature supporting the idea that driver education or driver training lead to reduced violation or crash rates. That is, the majority of the evidence they reviewed did not indicate that students who completed formal training programs had fewer subsequent crashes and violations than did students who did not have such training. Their conclusions have been supported by the findings of four other independent reviews completed since (Christie, 2001; Roberts, Kwan, & Cochrane Injuries Group Driver Education Reviewers, 2002; Vernick et al., 1999; Wooley, 2000). In these reviews the authors have consistently concluded that formal training leads to earlier and increased licensure for young drivers, which tends to cause increases in crashes and violations that outweigh any potential safety benefits gained through knowledge and skills

training (Christie, 2001; Mayhew & Simpson, 1996a, 2002; Roberts et al., 2002; Vernick et al., 1999; Woolley, 2000). However, Anderson, Ford, and Peck (1980) were able to demonstrate a positive impact of two improved motorcycle training courses for novices on motorcycle and automobile convictions, automobile accidents, and total accidents and convictions compared to the standard licensing program. This study is an exception, however, as a review of the total literature concluded that formal motorcycle training has also not been found to reduce subsequent crash rates (Mayhew & Simpson, 1996a). In fact, advanced skills courses for novices, such as those that teach skid training, may actually contribute to higher crash risk, particularly for young men (Christie, 2001; Mayhew & Simpson, 1996a, 2002).

Besides the fact that driver education and training lead to higher and earlier licensure rates, other reasons suggested to explain why diver education and training have failed to result in safety benefits are: (a) the courses fail to teach the knowledge and skills that are critical for safe driving in teens, (b) the students in the courses are not motivated to use the safety skills that they do learn, (c) completing the courses fosters overconfidence in students, (d) the courses fail to adequately address teenage lifestyle issues, and (e) the courses do not tailor the safety content to meet student needs (Mayhew & Simpson, 2002). On the positive side, there is evidence that driver education courses with enough behind-the-wheel practice can be a good way to learn driving skills and gain knowledge, but these increased knowledge and skill levels do not necessarily translate into less-risky behavior and lower crash rates (Mayhew & Simpson, 1996a). Furthermore, evaluations of several off-road approaches to teaching novice drivers hazard and risk perception without exposing them to crashes, such as commentary driving (Gregersen, 1993, 1994; Marek & Sten, 1997; Spolander, 1990), mediated instruction (Regan, Deery, & Triggs, 1998a), risk prediction training (McKenna & Crick, 1991), and attentional control through variable priority training (Regan, Deery, & Triggs, 1998b), have resulted in promising results (Deery, 1999).

If driver education and training are to continue being offered, experts recommend that the courses (a) be redesigned to emphasize safe decision making and reduce risk-taking behavior by teaching teens how to make good decisions and be aware of risks, (b) include increased parental supervised driving practice, (c) be integrated with graduated licensing programs, and (d) be multi-staged with separate courses in the learner and provisional stages of licensing (Edwards, 2001; Gregersen, 1996b; Lonero & Clinton, 1996; Mayhew & Simpson, 1996ab, 2002; Mayhew, Simpson, Williams, & Ferguson, 1998; McKnight, 1986; McKnight & Peck, 2003; National Highway Traffic Safety Administration, 1994; Saunders, 1998; Simons-Morton, 2002; Simons-Morton, Hartos, & Leaf, 2002; Waller, 1986; Williams, 2001; Williams & Mayhew, 2003). Furthermore, until the safety value of driver education and training is demonstrated, experts recommend that jurisdictions not remove restrictions or allow drivers to license earlier based on their having completed the courses (Mayhew & Simpson, 1996b).

Provisional Driver Licensing

Provisional licensing systems are modified approaches to licensing for young drivers. These programs typically subject young drivers to a probationary period where license control actions such as warning letters and suspensions apply earlier than for regularly-licensed drivers, placed restrictions on their driving privileges to reduce their exposure

to high-risk situations, (e.g., night and freeway driving), and require a mandatory instruction permit period during which practice behind-the-wheel can be gained (Mayhew, 1996; Mayhew & Simpson, 1996b; Simpson, 2003). Provisional licensing systems that use accelerated licensing actions rely on the threat of punishment to encourage novice teens to drive safely. Provisional licensing systems have been introduced in several states and other countries (Mayhew, 1996; Mayhew & Simpson, 1996b). Evaluations of some of the systems implemented in the United States are presented in this section.

The Maryland provisional licensing program was inaugurated in January 1979, and included a nighttime driving restriction, parent-supervised driving, quicker actions when teens received traffic violations, and a requirement that teens have 6 months of violation-free driving before being issued an unrestricted license. McKnight, Hyle, and Albrecht (1983) evaluated the program and found that the nighttime driving restriction failed to significantly reduce crashes during curfew hours for 16- to 17-year-olds. However, daytime crashes fell by 5% for 16- to 17-year-olds the first year of the program, although the reduction was only statistically significant for the 17-year-olds. The implementation of the program was also associated with a significant 10% decline in traffic violations for 16-year-olds; although the results showed a 5% decline for the 17-year-olds, the difference was not statistically significant. However, an analysis of second-year driving records for those who had been subject to the provisional licensing requirements did not indicate a longer-term effect of the program after the restrictions were removed (McKnight, Hyle, & Albrecht, 1983). The authors judged that the requirement for 6 months of violation-free driving was primarily responsible for the declines in crashes and violations resulting from the provisional licensing program. A follow-up evaluation of the effects of moving the nighttime restriction from between 1:00 a.m. to 6:00 a.m. to between 12:00 a.m. to 5:00 a.m., and of lengthening the provisional license period during which the teens were subject to the nighttime restriction and accelerated license control actions, found that these changes did not result in decreased day or nighttime crashes (McKnight, Tippetts, & Marques, 1990).

California's provisional licensing program was implemented in October 1983, and included a mandatory 1-month instruction period, a teen-parent practice guide, parent certification of behind-the-wheel practice, waiting periods for written and drive test failures, distinctive licenses, and earlier license control actions for 15- to 17-years-old. Hagge and Marsh (1988) evaluated the program using time series analysis and also an assessment of individual driver records and found that the program as a whole was associated with 5.3% lower crash rates for 15- to 17-year-olds and 23% lower violation rates for 16-year-olds. The program was also found to decrease the percentage of 16- to 17-year-olds licensed to drive, and increase the time that they held their instruction permits. This reduction in driving exposure and the earlier sanctioning of drivers violating traffic laws and causing crashes were judged by the authors to have largely contributed to the program's safety benefits.

Oregon's provisional licensing law was implemented in October 1989, and included an additional knowledge test of safe driving practices that teens had to take before their road test, a 28-day waiting period for drive test failures before being retested and the requirement that teens who fail the test obtain an instruction permit, and tougher driver improvement actions taken at lower violation count levels. Findings from an evaluation

of the program by Jones (1994) indicated that drivers licensed under the program took more time to prepare for the behind-the-wheel test and failed less often. In addition, men licensed under the program had 16% fewer crashes in their first year of driving, although no reduction was found for women. No violation reduction associated with the program was found for men or women.

Graduated Driver Licensing

Given that research on teen drivers has shown that increased driving experience is associated with reduced crash risk (Ferguson, 1996; Mayhew & Simpson, 1990; Simpson & Mayhew, 1992), many states, provinces, and countries have introduced graduated licensing programs for novice drivers that gradually and systematically lift initial licensing restrictions to reduce the exposure of new drivers to the highest risk driving situations (Foss & Goodwin, 2003; Mayhew & Simpson, 1984, 1996b; McKnight, 1996b; Shope & Molnar, 2003; Simpson, 2003). Graduated driver license programs are similar to provisional licensing programs in that they usually involve an instruction permit period, accelerated license control actions, and restrictions to reduce teen crash risk. They differ in that the restrictions used to limit teen's exposure to risky driving situations are gradually and systematically removed in a step-by-step manner; hence the name 'graduated' licensing (Mayhew & Simpson, 1996b; McKnight, 1996b; Preusser & Leaf, 2003; Simpson, 2003). Some programs apply to new drivers of any age (e.g., Nova Scotia and Ontario), while others apply only to novice drivers under certain ages (e.g., under age 25 in New Zealand and under age 18 in most U.S. states, including California).

Graduated licensing programs may include (a) longer mandatory periods of supervised driving instruction, (b) restrictions from driving during certain hours at night, (c) restrictions from carrying passengers under a certain age (usually age 20), (d) accelerated and more severe penalties for drivers who violate traffic laws or cause crashes, (e) the requirement that teens maintain a record with no traffic violations or crashes before advancing to the next stage of licensing, and (f) zero-tolerance or lower BAC restrictions for novice drivers (Mayhew & Simpson, 1996b; McKnight, 1996b; Williams & Mayhew, 2003). Other authors have suggested additional restrictions such as a restriction from allowing novice drivers to drive on freeways and on weekends (Mayhew & Simpson, 1984, 1996b; McKnight, 1996b), but these types of restrictions do not appear to be as common, although they are supported by the findings reviewed earlier in this paper (e.g., Cooper et al., 1995). Restrictions on driving at night and transporting young passengers are considered to be very important features of any GDL program (Lin & Fearn, 2003; Williams & Mayhew, 2003), and both are included in the California program implemented in July 1998. Night driving curfews have been shown to not only reduce driving during the restricted hours, but also discourage early licensure (Williams, Lund, & Preusser, 1985). Nighttime driving restrictions have been found to result in less risky driving, especially when the removal of such restrictions is contingent upon not receiving traffic violations during the restricted stage (McKnight, 1986).

So far, 37 states have adopted multi-stage graduated licensing programs, and 47 states and the District of Columbia have implemented one or more of the major components mentioned above (Shope & Molnar, 2003). States that have adopted even some of the

key components, such as the nighttime restriction, have realized lower teenage crash rates (Ferguson, Leaf, et al., 1996; McKnight, Hyle, & Albrecht, 1983; Preusser, Ferguson, & Williams, 1999). In fact, evaluations of graduated licensing programs or their components outside of California have generally found that they are associated with reductions in crashes, although there is a lot of variation in the observed effect sizes. The variability may be due to the fact that the programs vary in their components, some being more comprehensive than others, and to differences in methodology used in the evaluations (e.g., different crash metric and statistical analyses). A fairly thorough summary of the results of a number of evaluations of GDL programs in jurisdictions other than California can be found in McKnight and Peck (2003). Graduated licensing programs, however, are not above reproach, as they may be viewed as unfair to teens and burdensome to licensing agencies (Foss, 1996).

The California GDL program is quite comprehensive and contains all of the components of an optimal system (Williams & Mayhew, 2003). Implemented in July 1998, the California program extended the mandatory instruction permit period for drivers under the age of 18 from 1 month to 6 months, required parent certification of 50 hours of behind-the-wheel practice (including 10 hours at night), and added after licensure a 12-month restriction from driving between 12:00 a.m. and 5:00 a.m. and a 6-month restriction from driving with passengers under the age of 20. As stated earlier, California already had a provisional licensing program in effect before 1998 that included accelerated license controls, a mandatory 1-month instruction period, and waiting periods for teens who failed written or drive tests, among other things. Hence, any impact of the additional graduated licensing provisions would at best be reflected as only an incremental decrease in crash rates beyond that resulting from the preexisting provisional licensing components. Past efforts to show incremental reductions in teen crashes associated with strengthening existing licensing laws have not always been successful (e.g., McKnight et al., 1990).

California's GDL program was formally evaluated using interrupted time series analysis by Masten and Hagge in 2003. This study analyzed several different crash types and age-groups, various intervention models, and flexible intervention start points to determine whether the enhancements made to the California teen licensing program in July 1998 resulted in crash reductions for teen drivers. The results found no overall reduction in total crashes or fatal/injury crashes immediately following program implementation or beginning 6 months later. This outcome was the same even when transition components were added to the models to adjust for the influence of the influx of teen licensees before the implementation date, when the adult series was included as a control variable, when only 16-year-old driver crashes were analyzed, and when the rates were calculated as crash involvements rather than being based on the youngest involved driver. However the program was found to be associated with a 19.45% gradual-permanent increase in total crashes for 18- to 19-year-olds 6 months after the program was implemented (about 9,464 additional crashes per year). No significant effect was found in the 18- to 19-year-olds fatal/injury crash rates.

In the Masten and Hagge (2003) study, the 12-month nighttime restriction was associated with a sudden-permanent 0.44% reduction in total crashes occurring during the hours of midnight to 5:00 a.m. for 15- to 17-year-olds starting 1-year subsequent to the implementation of the nighttime restriction. The results also suggested a marginally

significant sudden-permanent 0.45% reduction in their nighttime fatal/injury crashes starting 1-year subsequent to the program implementation. These effects translate into savings of 153 total crashes and 68 fatal/injury crashes annually for 15- to 17-year-olds. These crash savings estimates are based on an assumption that the GDL night driving restriction did not influence daytime crashes.

The same study found that the 6-month passenger restriction was associated with a marginally significant sudden-permanent 2.52% reduction in 15- to 17-year-old total teen passenger crashes, and a significant gradual-permanent reduction stabilizing at -6.43% in fatal/injury passenger crashes when using an intervention date 1-year subsequent to the program start date. These effects equate to savings of 878 total crashes and 975 fatal/injury crashes annually for 15- to 17-year-olds. These crash savings estimates are based on an assumption that the GDL passenger restriction did not influence non-passenger crashes for the 15- to 17-year-old age group.

General Nighttime Curfews

Although nighttime curfews have been found to be effective as a component of graduated licensing programs (e.g., Begg, Stephenson, Alsop, & Langley, 2001; Foss, Feaganes, & Rodgman, 2001; Shope, Molnar, Elliot, & Waller, 2001; Ulmer, Preusser, Williams, Ferguson, & Farmer, 2000), several other studies have evaluated the effects of general state and city curfews on teen crash rates. Results of these evaluations are presented in this section.

Analyzing data from three large cities with curfew ordinances limiting late-night activities in public places by persons under age 18, Preusser, Williams, Lund, and Zador (1990) found a 23% reduction in fatal and non-fatal motor vehicle injuries for 13- to 17-year-olds as passengers, drivers, pedestrians, and bicyclists during the curfew hours. This finding was replicated exactly in a study by Preusser, Zador, and Willams (1993) who also found a 23% reduction in fatal motor-vehicle injuries for 13- to 17-year-olds during curfew hours when they compared cities with and without general curfews. Further evidence for the effectiveness of nighttime driving restrictions for younger drivers was provided by Ferguson, Leaf, et al. (1996), who found that states with restrictions on the unsupervised driving of 16-year-old drivers had lower teenage crash rates than did states without such restrictions. Levy (1988), studying data from 47 states over a 10-year period, found that curfews for 15- to 17-year-olds were associated with a 28% reduction in multiple-vehicle fatal crashes and a 25% reduction in single-vehicle crashes. In their study of four states with driving curfews, Preusser, Williams, Zador, and Blomberg (1984) found that crashes during curfew hours involving 16-year-old drivers dropped 69% in Pennsylvania, 62% in New York, 40% in Maryland, and 25% in Louisiana. This study also showed that longer curfew hours produce greater reductions in crashes involving young drivers and presented evidence that curfew laws also reduce the rate of early licensure of teens, which could explain why general curfew laws are associated with lower teen crash rates. However, Levy (1990) concluded that curfew laws reduce fatal crash risk beyond any effects related to reducing licensure rates of teenagers. Incidentally, the Louisiana nighttime restriction was found to be even more effective after a law change that required 15-year-old license applicants to complete 36-hours of driver education before being licensed (Ulmer et al., 1999).

The starting time of nighttime restrictions on teens also appears to make a difference in how effective it is. For example, Foss and Evenson (1999) reviewed the literature on general and driving-specific nighttime restrictions and found evidence of a consistent 23% to 25% reduction in nighttime crash injury and fatality rates for jurisdictions with curfews that begin before midnight, but no effect on crashes for when the restriction began after this time. The latter finding is consistent with at least one study suggesting that increased crash risk for first-year novice teens is actually higher in the early evenings than after 12:00 a.m., whereas risk is higher after 12:00 a.m. for second- and third-year young novices (Cooper et al., 1995). Other researchers have concluded that for a nighttime curfew to be effective, it should start by at least 11:00 p.m. (McKnight, 1986).

Driver Improvement Programs

Post-licensing control countermeasures, such as warning letters, group driver improvement meetings, individual hearings, and license suspension and revocation, have been shown to be effective interventions for licensing agencies to use for reducing the subsequent crash and violation rates of licensed drivers in general (Masten & Peck, 2003). Although one of the critical elements of graduated licensing is accelerated intervention for teens involved in crashes or who receive violations (point counts), there is actually very little research on the effectiveness of these standard countermeasures on young drivers specifically (McKnight & Peck, 2003). Studies that address the effectiveness of standard countermeasures on young drivers, whether delivered at an accelerated rate or not, are presented in this section.

An early study conducted in California evaluated the effectiveness of two different driver improvement courses (a 10-hour Defensive Driving Course or a 10-hour Trigger Response Group) for drivers younger than age 27 convicted of traffic violations. Compared to drivers of the same age who received only the conventional court sentencing, those who completed either course had fewer 1-year subsequent crashes (Brown, 1975). The drivers who attended the Defensive Driving Course were also found to have lower subsequent traffic violation rates, but no difference was found for the Trigger Response Group. A Michigan study of young drivers on their probationary license who were randomly assigned to attend a group safety education course or to receive no treatment for 1 year based on certain convictions or lowered point count criteria found significant reductions in 6-month subsequent crashes and both 6-month and 1-year subsequent traffic violations for those young drivers who were assigned to the group meeting (Eavy, Edwards, & Lee-Gosselin, 1987; McKnight, 1986). McKnight and Edwards (1987) evaluated the effectiveness of threatening a short-term (14 day) license suspension and the effectiveness of the actual suspension itself on the 2-year subsequent crash and violation rates of young traffic violation offenders in Michigan during their probationary license period. Control drivers were threatened with a group interview or had to actually attend the group interview. Interestingly, the threat of the suspension was effective for reducing subsequent crashes and violations for women, but not for men. On the other hand, the actual suspension reduced the subsequent crash and violation rates for young men, but did not have a significant effect on the women (McKnight, 1986). That is, women were affected by the threat of the suspension, whereas the men had to actually experience the suspension for it to be effective. In a different study, Harrington (1972) found that suspending and revoking young drivers'

licenses in California was not very effective at actually making risky teen drivers stop driving.

There is some additional evidence that the traditional countermeasures used for adults are not as effective when used with younger drivers. For example, an early California study evaluating the effectiveness of group driver improvement meetings found that, although the meetings resulted in fewer subsequent traffic violations in general, they appeared to have less of an effect on the younger traffic violators than on those who were older (Coppin, 1962). A study comparing the effectiveness of standard and soft-sell warning letters found that while both letters were effective for reducing accident risk for drivers over age 25, they were both less effective for drivers younger than 25 (Jones, 1997).

Other studies have evaluated the effect of accelerated driver improvement programs for young drivers using teens who receive driver improvement actions at the slower rate applied to all other drivers as a comparison group. One such study, the evaluation of Oregon's provisional licensing program by Jones (1994) that was discussed earlier, found no additional benefit compared to the adult driver improvement program of the accelerated driver improvement component for teens, which included warning letters, individual meetings, and license suspension, in order, for successive traffic violations (Jones, 1994). California's provisional licensing law also included accelerated license control actions for novice drivers 16- to 17-years-old. Under this accelerated program, teens received a warning letter after their first traffic violation or responsible crash, a 1 month restriction allowing only supervised driving after their second violation or crash in a 12-month period, a 6-month license suspension and 1-year probation after a third offense in 12 months, and license suspension or revocation after a fourth offense or violation of probation. Hagge and Marsh (1988) conducted an evaluation of the accelerated program as part of their assessment of the entire provisional licensing program. Compared to the adult program, the accelerated post-licensing control program was found to be superior for reducing subsequent 2-year total accident and violation rates for teens, and increasingly more effective at higher point counts. The findings also suggested that the accelerated program was more effective than the adult program at reducing teen fatal/injury crash rates (Hagge & Marsh, 1988). Although a similar accelerated driver improvement program was part of the provisional licensing system implemented in Maryland in 1979 and evaluated by McKnight et al. (1983), problems that slowed the implementation of the program made it impossible to evaluate its effectiveness.

Zero-Tolerance and Lowered BAC

All states have implemented lower allowable BAC limits or zero-tolerance laws for teenagers, which usually result in a license suspension or extension of the age at which a teenager can apply for a license if he or she is caught anywhere with any measurable BAC (Preusser, 1996b). The majority of evidence suggests that zero-tolerance laws and lower BAC levels for teens are effective for reducing alcohol-related teenage crashes, as discussed in this section (Hingson, Heeren, & Winter, 1995; Mann, Macdonald, Stoduto, Bondy, Jonah, & Shaikh, 2001; Mayhew & Simpson, 1990; Preusser, 1996b).

The National Highway Traffic Safety Administration (NHTSA) evaluated a zero-tolerance law in Maryland that made it illegal for drivers under age 21 (i.e., below the legal drinking age) to operate a motor vehicle at a BAC level of 0.02% or higher (Kedjidjian, 1993). (The standard was set at .02% rather than zero because of practical measurement limitations.) NHTSA reported that there was an 11% reduction in crashes involving drivers under 21 who had been drinking after the zero-tolerance law went into effect. Additionally, NHTSA reported that in six Maryland test counties implementing public awareness campaigns, the number of alcohol-related traffic crashes involving younger drivers dropped an additional 30% beyond the statewide reduction.

A meta-analysis of six low BAC studies for younger drivers from different states and countries found that all six studies showed reductions in crashes associated with the implementation of the lowered BAC laws (Zwerling & Jones, 1999). Estimates of the reductions in crashes or injuries ranged from 10% to 33%, with an average effect size reduction of 20%. In general, the results suggested that tougher BAC laws were associated with larger crash reductions for younger drivers. States in the study with zero tolerance BAC levels for younger drivers (such as California) were associated with a 22% average reduction for nighttime, single vehicle fatal crashes. States with .02% BAC laws showed an average reduction of 17%, and those with .04% to .06% BAC laws had reductions of 7%.

Similarly, Hingson, Heeren, Howland, and Winter (1991) found that lowering BAC limits for teen drivers in Maine, New Mexico, North Carolina, and Wisconsin was associated with reduced nighttime fatal collisions among adolescents in these states. The National Safety Council estimates that the fact that the minimum drinking age in all states was 21 years of age as of July 1998 saves about 1,000 lives each year (Graham, 2002). At least one jurisdiction (Ontario, Canada) has implemented as part of its graduated licensing law that the adult supervisor of a learning driver may not be under the influence of alcohol during the supervision. However, the effectiveness of this provision has not yet been determined.

REFERENCES

Aldridge, B., Himmler, M., Aultman-Hall, L., & Stamatiadis, N. (1999). Impact of passengers on driver safety. *Transportation Research Record, 1693*, 25-30. Washington, DC: Transportation Research Board.

Anderson, J., Ford, J. L., & Peck, R. C. (1980). *Improved motorcyclist licensing and testing project (volume I*). Sacramento: California Department of Motor Vehicles.

Arnett, J. J. (1996). Sensation seeking, aggressiveness and adolescent reckless behavior. *Personality and Individual Differences, 20*, 693-702.

Arnett, J. J. (2002). Developmental sources of crash risk in young drivers. *Injury Prevention, 8*(Suppl. II), ii17-ii23.

Arnett, J. J., Offer, D., & Fine, M A. (1997). Reckless driving in adolescence: ‘State’ and ‘trait’ factors. *Accident Analysis and Prevention, 29*, 57-63.

Ballesteros, M. F., & Dischinger, P. C. (2002). Characteristics of traffic crashes in Maryland (1996-1998): Differences among the youngest drivers. *Accident Analysis and Prevention, 34*, 279-284.

Balmforth, D. (1998). *National Survey of Drinking and Driving Attitudes and Behavior: 1997*. DOT HS 808 844. Washington, DC: U.S. Department of Transportation, National Highway Traffic Safety Administration.

Baxter, J. S., Manstead, A. S. R., Stradling, S. G., Campbell, K. A., Reason, J. T., & Parker, D. (1990). Social facilitation and driver behavior. *British Journal of Psychology, 81*, 351-360.

Begg, D. J., & Langley, J. D. (2000). Seat-belt use and related behaviors among young adults. *Journal of Safety Research, 31*, 211-220.

Begg, D. J. & Langley, J. D. (2001). Changes in risky driving behavior from age 21 to 26 years. *Journal of Safety Research, 32*, 491-499.

Begg, D. J., Stephenson, S., Alsop, J., & Langley, J. (2001). Impact of graduated driver licensing restriction on crashes involving young drivers in New Zealand. *Injury Prevention, 7*(4), 292-296.

Beirness, D. J. (1993). Do we really drive as we live? The role of personality factors in road crashes. *Alcohol, Drugs and Driving, 9*, 129-143.

Beirness, D. J. (1996). The relationship between lifestyle factors and collisions involving young drivers. In H. Simpson (Ed.), *New to the road: Reducing the risks for young motorists.* Proceedings of the First Annual International Symposium of the Youth Enhancement Service (pp. 71-77). Los Angeles: University of California.

Beirness, D. J., & Simpson, H. M. (1988). Lifestyle correlates of risky driving and accident involvement among youth. *Alcohol, Drugs and Driving, 4*(3-4), 193-204.

Beirness, D. J., Simpson, H. M., & Mayhew, D. R. (1992). *Diagnostic assessment of problem drivers: I. Review of factors associated with risky and problem driving (*Report No. TP-11549). Ottawa, Ontario: The Traffic Injury Research Foundation of Canada.

Benda, H. V., & Hoyos, C. G. (1983). Estimating hazards in traffic situations. *Accident Analysis and Prevention, 15*, 1-10.

Blockley, P., & Hartley, L. (1995). Aberrant driving behavior: Errors and violations. *Ergonomics, 38*(9), 1759-1771.

Boyce, T. E., & Geller, E. S. (2002). An instrumented vehicle assessment of problem behavior and driving style: Do younger males really take more risks? *Accident Analysis and Prevention, 34*, 51-64.

Brown, K. B. (1975). *Traffic court school countermeasure*. Sacramento, CA: Sacramento Safety Council, A Chapter of the National Safety Council.

Brown, I. D. (1982). Exposure and experience are a confounded nuisance in research on driver behavior. *Accident Analysis and Prevention, 14*, 345-352.

Brown, I. D., & Copeman, A. K. (1975). Drivers' attitudes to the seriousness of road traffic offences considered in relation to the design of the sanctions. *Accident Analysis and Prevention, 7*, 15-26.

Cammisa, M. X., Williams, A. F., & Leaf, W. A. (1999). Vehicles driven by teenagers in four states. *Journal of Safety Research, 30*, 25-30.

Carlson, W. L. (1972). Alcohol usage of the nighttime driver. *Journal of Safety Researc*h, 4, 12-25.

Chen, L., Baker, S. P., Braver, E. R., & Li, G. (1999). *The potential benefits of restrictions on the transport of teenage passengers by teenage drivers*. Arlington, VA: Insurance Institute for Highway Safety.

Chen, L., Baker, S. P., Braver, E. R., Li, G. (2000). Carrying passengers as a risk factor for crashes fatal to 16- and 17-year-old drivers. *Journal of the American Medical Association, 283*, 1578-1582.

Chliaoutakis, J. E., Gnardellis, I. D., Drakou, I., Darviri, C., & Sboukis, V. (2000). Modeling the factors related to seatbelt use by the young drivers of Athens. *Accident Analysis and Prevention, 32*, 815-825.

Christie, R. (2001). *The effectiveness of driver training as a road safety measure: A review of the literature.* Noble Park, Victoria, Australia: Royal Automobile Club of Victoria.

Cooper, P. J. (1987). Young drivers as represented in the accident data. In J. P. Rothe (Ed.), *Rethinking Young Drivers* (pp. 253-280). New Brunswick, NJ: Transaction.

Cooper, P. J., Pinili, M., & Chen, W. (1995). An examination of the crash involvement rates of novice drivers aged 16 to 55. *Accident Analysis and Prevention, 27*, 89-104.

Coppin, R. S. (1962). A controlled evaluation of group driver improvement meetings. *Traffic Safety Research Review, 6*(3), 17-23.

Corfitsen, M. T. (1996). Enhanced tiredness among young impaired male nighttime drivers. *Accident Analysis and Prevention, 28*, 155-162.

Davis, C. S. (1990). *The DeKalb County, Georgia, driver education demonstration project: Analysis of its long-term effect*. Draft Final Report. Iowa City: University of Iowa, Department of Preventative Medicine.

De Wolf, V. A., & Smith, M. F. (1988). *Re-evaluating a federally-funded driver education experiment*. Post session presentation, American Statistical Association Annual Meeting, New Orleans, LA.

Deery, H. A. (1999). Hazard and risk perception among young novice drivers. *Journal of Safety Research, 30*, 225-236.

DeJoy, D. (1992). An examination of gender differences in traffic accident risk perception. *Accident Analysis and Prevention, 24*, 237-246.

Doherty, S. T., Andrey, J. C., & MacGregor, C. (1998). The situational risks of young drivers: The influence of passengers, time of day and day of week on accident rates. *Accident Analysis and Prevention, 30*, 45-52.

Donovan, J. E. (1993). Young adult drinking-driving: Behavioral and psychosocial correlates. *Journal of Studies on Alcohol, 54*(5), 600-613.

Dreyer, D. R., & Janke, M. K. (1979). The effects of range vs. non-range driver training on the accident and conviction frequencies of young drivers. *Accident Analysis and Prevention, 11*, 179-198.

Drummond, A. E. (1996). The role of experience in improving young driver safety. In H. Simpson (Ed.), *New to the road: Reducing the risks for young motorists.* Proceedings of the First Annual International Symposium of the Youth Enhancement Service (pp. 41-49). Los Angeles: University of California.

Drummond, A. E., & Triggs, T. J. (1991). *Driving as a Skilled Performance: A Perspective for Improving Young Driver Safety*. Melbourne, Australia: Monash University, Accident Research Center.

Eavy, P. W., Edwards, M. L., & Lee-Gosselin, M. H. (1987). *Group interviews for probationary drivers with low violation levels: An evaluation of the traffic safety impact*. Lansing: Michigan Department of State.

Edwards, M. (2001). Standards for novice driver education and licensing. In *Driver Education at the Crossroads.* Proceedings from the Committee on Operator Education and Regulation (Report No. E-C024), *Transportation Research Circular*. Washington, DC: Transportation Research Board.

Egberink, H. O., Lourens, P. F., & van der Molden, H. H. (1986). Driving strategies among younger and older drivers when encountering children. *Accident Analysis and Prevention, 18,* 315-324.

Elander, J., West, R., & French, D. (1993). Behavioral correlates of individual differences in road-traffic crash risk: An examination of methods and findings. *Psychological Bulletin, 113,* 279-294.

Elliot, D. (1987). Self-reported driving while under the influence of alcohol/drugs and the risk of alcohol/drug-related accidents. *Alcohol, Drugs, and Driving, 3,* 31-43.

Elliot, M. R., Raghunathan, T. E., & Shope, J. T. (2002). The effect of duration and delay of licensure on risk of crash: A Bayesian analysis of repeated time-to-event measures, *Journal of the American Statistical Association, 97,* 420-431.

Elliot, M. R., Waller, P. F., Raghunathan, T. E., & Shope, J. T. (2001). Predicting offenses and crashes from young drivers' offense and crash histories. *Crash Prevention and Injury Control, 2,* 167-178.

Elliot, M. R., Waller, P. F., Raghunathan, T. E., Shope, J. T., & Little, R. J. A. (2000). Persistence of violation and crash behavior over time. *Journal of Safety Research, 31,* 229-242.

Evans, L. (1987). Young driver involvement in severe car crashes. *Alcohol, Drugs, and Driving, 3,* 63-78.

Evans, L., & Wasielewski, P. (1983). Risky driving related to driver and vehicle characteristics. *Accident Analysis and Prevention, 15,* 121-136.

Everett, S. A., Lowry, R., Cohen, L. R., & Dellinger, A. M. (1999). Unsafe motor vehicle practices among substance-using college students. *Accident Analysis and Prevention, 31,* 667-673.

Farrow, J. A. (1987). Young driver risk-taking: A description of dangerous driving situations among 16- to 19-year-old drivers. *The International Journal of Addictions, 22,* 1255-1267.

Ferdun, G. S, Peck, R. C., & Coppin, R. S. (1967). The teen-aged driver: An evaluation of age, experience, driving exposure and driver training as they related to driving record. *Highway Research Record, 163,* 31-53.

Ferguson, S. A. (1996). How we license in the United States—Paths to licensure. In *Graduated Licensing: Past Experiences and Future Status.* Proceedings from the Committee on Operator Education and Regulation (Report No. 458), Transportation Research Circular. Washington, DC: Transportation Research Board.

Ferguson, S. A., Leaf, W. A., Williams, A. F., & Preusser, D. F. (1996). Differences in young driver crash involvement in states with varying licensure practices. *Accident Analysis and Prevention, 28,* 171-180.

Fergusson, D. M., & Horwood, L. J. (2001). Cannabis use and traffic accidents in a birth cohort of young adults. *Accident Analysis and Prevention, 33,* 703-711.

Ferguson, S. A., Williams, A. F., Chapline, J. F., Reinfurt, D. W., & De Leonardis, D. M. (2001). Relationship of parent driving records to the driving records of their children. *Accident Analysis and Prevention, 33,* 229-234.

Ferrante, A. M., Rosman, D. L., & Marom, Y. (2001). Novice drink drivers, recidivism and crash involvement. *Accident Analysis and Prevention, 33,* 221-227.

Finken, L. L., Jacobs, J. E., & Laguna, K. (1998). Risky drinking and driving decisions: The role of previous experience. *Journal of Youth and Adolescence, 27,* 493-511.

Finn, P., & Bragg, B. W. E. (1986). Perception of the risk of an accident by young and older drivers. *Accident Analysis and Prevention, 18,* 289-298.

Foldvary, L. A., & Lane, J. C. (1969). *Car crash injuries by seating position and miles traveled.* Proceedings of the 13th Annual Conference of the American Association for Automotive Medicine. Minneapolis, MN: American Association for Automotive Medicine.

Forsyth, E. (1992). *Cohort study of learner and novice drivers, part 2: Attitudes, opinions and the development of driving skills in the first 2 years* (TRL Report No. RR372). Crowthorne, UK: Department of Transport.

Forsyth, E., Maycock, G., & Sexton, B. (1995). *Cohort study of learner and novice drivers. Part 3. Accidents, offenses and driving experience in the first three years of driving.* (Project Report 111). Crowthorne, England: Transport Research Laboratory.

Foss, R. D. (1996). An assessment of graduated driver licensing: Pros and cons. In *Graduated Licensing: Past Experiences and Future Status.* Proceedings from the Committee on Operator Education and Regulation (Report No. 458), Transportation Research Circular. Washington, DC: Transportation Research Board.

Foss, R. D., & Evenson, K. R. (1999). Effectiveness of graduated driver licensing in reducing motor vehicle crashes. *American Journal of Preventative Medicine, 16,* 47-56.

Foss, R. D., Feaganes, J. R., & Rodgman, E. A. (2001). Initial effects of graduated driver licensing on 16-year-old driver crashes in North Carolina. *Journal of the American Medical Association, 286*(13), 1588-1592.

Foss, R. & Goodwin, A. (2003). Enhancing the effectiveness of graduated driver licensing legislation. *Journal of Safety Research, 34,* 79-84.

Gerrard, M., Gibbons, F. X., Benthin, A. C., & Hessling, R. M. (1996). A longitudinal study of the reciprocal nature of risk behaviors and cognitions in adolescence: What you do shapes what you think and vice versa. *Health Psychology, 15,* 344-354.

Graham, S. (2002). Kids behind the wheel part III: Young drivers and drinking don't mix. *Traffic Safety, 2,* 8-11.

Gregersen, N. P. (1993). *Integrated driver education: An experiment with systematic cooperation between traffic schools and private teachers* (VTI Report 376). Linkoping: Swedish Road and Transport Research Institute.

Gregersen, N. P. (1994). Systematic Cooperation between driving schools and parents in driver education: An experiment. *Accident Analysis and Prevention, 26,* 453-461.

Gregersen, N. P. (1996a). Young drivers' overestimation of their own skill—An experiment on the relation between training strategy and skill. *Accident Analysis and Prevention, 28,* 243-250.

Gregersen, N. P. (1996b). What should be taught? Basic vehicle control skills or higher order skills. In H. Simpson (Ed.), *New to the road: Reducing the risks for young motorists.* Proceedings of the First Annual International Symposium of the Youth Enhancement Service (pp. 103-114). Los Angeles: University of California.

Gregersen, N. P., & Berg, H. Y. (1994). Lifestyle and accidents among young drivers. *Accident Analysis and Prevention, 26,* 297-303.

Gregersen, N. P., Berg, H. Y., Engstrom, I., Nolen, S., Nyberg, A., & Rimmo, P. A. (2000). Sixteen years age limit for learner drivers in Sweden—An evaluation of safety effects. *Accident Analysis and Prevention, 32*, 25-35.

Gregersen, N. P., & Bjurulf, P. (1996). Young novice drivers: Toward a model of their accident involvement. *Accident Analysis and Prevention, 28*, 229-241.

Hagge, R. A., & Marsh, W. C. (1988). *The traffic safety impact of provisional licensing* (Report No. 116). Sacramento: California Department of Motor Vehicles.

Hall, J., & West, R. (1996). The role of formal instruction and informal practice in learning to drive. *Ergonomics, 39*, 693-706.

Harre, N., Brandt, T., & Dawe, M. (2000). The development of risky driving in adolescence. *Journal of Safety Research, 31*, 185-194.

Harre, N., Field, J., & Kirkwood, B. (1996). Gender differences and areas of common concern in the driving behaviours and attitudes of adolescents. *Journal of Safety Research, 27*, 163-173.

Harrington, D. M. (1972). The young driver follow-up study: An evaluation of the role of human factors in the first four years of driving. *Accident Analysis and Prevention, 4*, 191-240.

Helander, C. J. (2002). *DUI countermeasures in California: What works and what doesn't, with recommendations for legislative reform* (Report No. 197). Sacramento: California Department of Motor Vehicles.

Hingson, R., Heeren, T., Howland, J., & Winter, M. (1991). Reduced BAC limits for young people (impact on night fatal crashes). *Alcohol, Drugs and Driving, 7*(2), 117-127.

Hingson, R., Heeren, T., Levenson, S., Jamanka, A., & Voas, R. (2002). Age of drinking onset, driving after drinking, and involvement in alcohol related motor-vehicle crashes. *Accident Analysis and Prevention, 34*, 85-92.

Hingson, R., Heeren, T., & Winter, M. (1995). Lower legal blood alcohol limits for young drivers. *Public Health Report, 109*, 738-744.

Hingson, R., Howland, J., Schiavone, T., & Damiata, M. (1991). The Massachusetts saving lives program: Six cities widening the focus from drunk driving to speeding, reckless driving and failure to wear seat belts. *Journal of Traffic Medicine, 18*, 123-132.

Hodgdon, J., Bragg, B. W. E, & Finn, P. (1981). *Young driver risk-taking research: The state of the art*. Report to the National Highway Traffic Safety Administration. Springfield, VA: National Technical Information Service.

Horwood, L. J., & Fergusson, D. M. (2000). Drink driving and traffic accidents in young people. *Accident Analysis and Prevention, 32*, 805-814.

Irwin, C. (1996). Adolescent development and driving: Does driving differ from other health damaging behaviors. In H. Simpson (Ed.), *New to the road: Reducing the risks for young motorists.* Proceedings of the First Annual International Symposium of the Youth Enhancement Service (pp. 51-70). Los Angeles: University of California.

Janke M. K., Masten S. V., McKenzie D. M., Gebers M. A., & Kelsey S. L. (2003). *Teen and senior drivers* (Report No. 194). Sacramento: California Department of Motor Vehicles.

Jessor, R. (1987a). Risky driving and adolescent problem behavior: Theoretical and empirical linkage. In T. Benjamin (Ed.), *Young drivers impaired by alcohol and other drugs.* Royal Society of Medicine International Congress and Symposium Series No. 116 (pp. 97-110). London, UK: Royal Society of Medicine Services.

Jessor, R. (1987b). Risky driving and adolescent problem behaviour: An extension of problem-behaviour theory. *Alcohol, Drugs, and Driving, 3*, 1-11.

Jonah, B. A. (1986). Accident Risk and risk-taking behaviour among young drivers. *Accident Analysis and Prevention, 18*, 255-271.

Jonah, B. A. (1990). Age differences in risky driving. *Health Education Research, 5*, 139-149.

Jones, B. (1994). The effectiveness of provisional licensing in Oregon: An analysis of traffic safety benefits. *Journal of Safety Research, 25*, 33-46.

Jones, B. (1997). Age differences in response to high and low-threat driver improvement warning letters. *Journal of Safety Research, 28*, 15-28.

Jones, B., & McCormac, K. (1989). *Effectiveness of Student Driver Training in Oregon: Driver Record Comparisons After One Year*. Salem: Oregon Motor Vehicles Division.

Kedjidjian, C. B. (1993). Get young drivers BAC to zero. *Traffic Safety, 93*(5), 16-18.

Kim, K., Li, L., Richardson, J., & Nitz, L. (1998). Driver at fault: Influences of age, sex, and vehicle type. *Journal of Safety Research, 29*, 171-179.

Kirk, A., & Stamatiadis, N. (2001). Crash rates and traffic maneuvers of younger drivers. *Transportation Research Record, 1779*, 68-74.

Laapotti, S., & Keskinen. (1998). Differences in fatal loss-of-control accidents between young male and female drivers. *Accident Analysis and Prevention, 30*, 435-442.

Laapotti, S., Keskinen, E., Hatakka, M., & Katila, A. (2001). Novice drivers accidents and violations—A failure on higher or lower hierarchical levels of driving behavior. *Accident Analysis and Prevention, 33*, 759-769.

Laberge-Nadeau, C., Maag, U., & Bourbeau, R. (1992). The effects of age and experience on accidents with injuries: Should the licensing age be raised? *Accident Analysis and Prevention, 24*, 107-116.

Lang, S. W., Waller, P. F., & Shope, J. T. (1996). Adolescent driving: Characteristics associated with single-vehicle and injury crashes. *Journal of Safety Research, 27*, 241-257.

Levy, D. T. (1988). The effects of driving age, driver education, and curfew laws on traffic fatalities of 15-17 year olds. *Risk Analysis, 8*(4), 565-570.

Levy, D. T. (1990). Youth and traffic safety: The effects of driving age, experience, and education. *Accident Analysis and Prevention, 22*, 327-334.

Lin, M. L., & Fearn, K. T. (2003). The provisional license: Nighttime and passenger restrictions—a literature review. *Journal of Safety Research, 34*, 51-61.

Lonero, L. P., & Clinton, K. M. (1996). Driver education and graduated licensing: How should they fit together? In *Graduated licensing: Past experiences and future status.* Proceedings from the Committee on Operator Education and Regulation (Report No. 458), Transportation Research Circular. Washington, DC: Transportation Research Board.

Lund, A. K., Williams, A. F., & Zador, P. (1986). High school driver education: Further evaluation of the DeKalb county study. *Accident Analysis and Prevention, 18*, 349-357.

Malfetti, J. (1993). *A study of younger driver insurance records: Opportunities for automotive insurers*. Washington, DC: AAA Foundation for Traffic Safety.

Mann, R. E., Macdonald, S., Stoduto, G., Bondy, S., Jonah, B., & Shaikh, A. (2001). The effects of introducing or lowering legal per se blood alcohol limits for driving: An international review. *Accident Analysis and Prevention, 33*, 569-583.

Marek, J., & Sten, T. (1997). *Traffic environment and the driver. Driver behavior and training in international perspective.* Springfield, IL: Charles C. Thomas.

Marowitz, L. A. (1995). The relationship between drug arrests and driving risk. *Alcohol, Drugs and Driving, 11*(1), 1-22.

Massie, D. L., Campbell, K. L., & Williams, A. F. (1995). Traffic accident involvement rates by driver age and gender. *Accident Analysis and Prevention, 27*, 73-87.

Masten, S. V., & Hagge, R. A. (2003). *Evaluation of California's graduated driver licensing program* (Report No. 205). Sacramento: California Department of Motor Vehicles.

Masten, S. V., & Peck, R. C. (2003). *Problem driver remediation: A meta-analysis of the driver improvement literature.* Arlington, VA: Insurance Institute for Highway Safety.

Matthews, M. L., & Moran, A. R. (1986). Age differences in male drivers' perception of accident risk: The role of perceived driving ability. *Accident Analysis and Prevention, 18*, 299-314.

Maycock, G., Lockwood, C., & Lester, F. (1991). *The accident liability of car drivers* (Report No. TRRL RR 315. UMTRI-82404, pp. 36) Crowthorne, England: Transport and Road Research Laboratory.

Mayhew, D. R. (1996). Licensing systems for controlling the risks of young motorists. In H. Simpson (Ed.), *New to the road: Reducing the risks for young motorists.* Proceedings of the First Annual International Symposium of the Youth Enhancement Service (pp. 79-85). Los Angeles: University of California.

Mayhew, D. R. (2003). The learner's permit. *Journal of Safety Research, 34*, 35-43.

Mayhew, D. R., Brown, S. W., & Simpson, H. M. (1996). *Alcohol use among drivers and pedestrians fatally injured in motor vehicle accidents: Canada, 1994.* Ottawa: Traffic Injury Research Foundation of Canada, Transport Canada: Road Safety and Motor Vehicle Regulation.

Mayhew, D. R., Brown, S. W., & Simpson, H. M. (1998). *Alcohol use among drivers and pedestrians fatally injured in motor vehicle accidents: Canada, 1996.* Ottawa, Ontario: Traffic Injury Research Foundation of Canada, Transport Canada: Road Safety and Motor Vehicle Regulation.

Mayhew, D. R., Donelson, A. C., Beirness, D. J., & Simpson, H. M. (1986). Youth, alcohol and relative risk of crash involvement. *Accident Analysis and Prevention, 18*, 273-287.

Mayhew, D. R., & Simpson, H. M. (1984). *Graduated licensing: State of knowledge and current practices.* Prepared for the Canadian Conference of Motor Vehicle Transport Administrators. Ottawa, Ontario: Traffic Injury Research Foundation of Canada.

Mayhew, D. R. & Simpson, H. M. (1985). Alcohol, age and risk of road accident involvement. In *Proceedings of the 9th International Conference on Alcohol, Drugs and Traffic Safety* (pp. 937-947), San Juan, Puerto Rico.

Mayhew, D. R., & Simpson, H. M. (1990). *New to the road. Young drivers and novice drivers: Similar problems and solutions?* Ottawa, Ontario: Traffic Injury Research Foundation of Canada.

Mayhew, D. R., & Simpson, H. M. (1991). *New to the road. Prevention measures for young drivers or novice drivers.* Ottawa, Ontario: Traffic Injury Research Foundation of Canada.

Mayhew, D. R., & Simpson, H. M. (1995). *The role of driving experience: Implications for training and licensing of new drivers.* Ottawa, Ontario: Traffic Injury Research Foundation of Canada.

Mayhew, D. R., & Simpson, H. M. (1996a). *Effectiveness and role of driver education and training in a graduated licensing system*. Ottawa, Ontario: Traffic Injury Research Foundation of Canada.

Mayhew, D. R., & Simpson, H. M. (1996b). Types of licensing systems. In *Graduated licensing: Past experiences and future status.* Proceedings from the Committee on Operator Education and Regulation (Report No. 458), Transportation Research Circular. Washington, DC: Transportation Research Board.

Mayhew, D. R., & Simpson, H. M. (1999). *Youth and road crashes: Reducing the risks from inexperience, immaturity and alcohol.* Ottawa, Ontario: Traffic Injury Research Foundation of Canada.

Mayhew, D. R., & Simpson, H. M. (2002). The safety value of driver education and training. *Injury Prevention, 8*(Supp.II), ii3-ii8.

Mayhew, D. R., Simpson, H. M., & Pak, A. (2000a). *Changes in collision rates among novice drivers during the first months of driving*. Arlington, VA: Insurance Institute for Highway Safety.

Mayhew, D. R., Simpson, H. M., & Pak, A. (2000b). *Age and experience in young driver crashes*. Arlington, VA: Insurance Institute for Highway Safety.

Mayhew, D. R., Simpson, H. M., Williams, A. F., & Ferguson, S. A. (1998). Effectiveness and role of driver education and training in a graduated licensing system. *Journal of Public Health Policy, 19*, 51-67.

McCartt, A. T., Shabanova, V. I., & Leaf, W. A. (2003). Driving experience, crashes, and traffic citations of teenage beginning drivers. *Accident Analysis and Prevention, 35*, 311-320.

McGormick, I. A., Walkey, F. H., & Green, D. E. (1986). Comparative perceptions of driver ability—A confirmation and expansion. *Accident Analysis and Prevention, 18*, 205-208.

McGwin, G. Jr., & Brown, D. B. (1999). Characteristics of traffic crashes among young, middle-aged, and older drivers. *Accident Analysis and Prevention, 31*, 181-198.

McKenna, F. P, & Crick, J. (1991). Experience and expertise in hazard perception. In G. B. Grayson & J. F. Lester (Eds.), *Behavioral Research in Road Safety* (pp. 39-45). Crowthorne, UK: Transport and Road Research Laboratory.

McKenna, A. P., Waylen, A. E., & Burkes, M. E. (1998). *Male and Female Drivers: How Different are they?* Berkshire, United Kingdom: The University of Reading, Foundation for Road Safety Research.

McKenna, C. K., Yost, B., Munzenrider, R. F., & Young, M. L. (2000). *An evaluation of driver education in Pennsylvania*. University Park: Pennsylvania State University, Pennsylvania Transportation Institute.

McKnight, A. J. (1986). Safety effects of provisional driver licensing programs. *Provisional licensing programs for young drivers: Topical papers by licensing experts*, Washington, DC: U.S. Department of Transportation.

McKnight, A. J. (1996a). Causes of the problem: The role of experience-related factors in the collisions of young drivers. In H. Simpson (Ed.), *New to the road: Reducing the risks for young motorists.* Proceedings of the First Annual International Symposium of the Youth Enhancement Service (pp. 35-40). Los Angeles, CA: University of California.

McKnight, A. J. (1996b). Elements of graduated licensing. In *Graduated licensing: Past experiences and future status.* Proceedings from the Committee on Operator Education

and Regulation (Report No. 458), Transportation Research Circular. Washington, DC: Transportation Research Board.

McKnight, A. J., & Edward, M. L. (1987). *A taste of suspension: The preventative and deterrent value of limited license suspension*. Landover, MD: National Public Services Research Institute.

McKnight, A. J., Hyle, P., & Albrecht, L. (1983). *Youth license control demonstration project*. (HS-806-616). Washington, DC: National Highway Traffic Safety Administration.

McKnight, A. J., & Peck, R. C. (2003). Graduated driver licensing and safer driving. *Journal of Safety Research, 34*, 85-89.

McKnight, A. J., Tippetts, A. S., & Marques, P. R. (1990). *Provisional driver license system for follow-up evaluation of Maryland youth license control demonstration project*. (Contract No. DTNH 22-88-P-05102). Springfield, VA: National Technical Information Service.

Milech, D., Glencross, D., & Hartley, L. (1989). *Skill acquisition by young drivers: Perceiving, interpreting and responding to the driving environment* (Report No. MR4). Canberra, Australia: Federal Office of Road Safety.

Moore, R. H. (1994). Underage female DUI offenders: Personality characteristics, psychosocial stressors, alcohol and other drug use, and driving risk. *Psychological Reports, 74*, 435-445.

Mundt, J. C., Ross, L. E., & Harrington, H. L. (1992). A modeling analysis of young drivers' judgments of accident risk due to alcohol use and other driving conditions. *Journal of Studies on Alcohol, 53*(3), 239-248.

National Highway Traffic Safety Administration. (1994). *Research agenda for an improved novice driver education program*. Report to Congress. Washington, DC: U.S. Department of Transportation.

Patton, D., & Brown, D. (2002). Driving drink, driving high: A comparison of student attitudes towards driving while drunk versus driving while high on cannabis. Poster Session. *Proceedings of the 16th Annual Conference on Alcohol, Drugs, and Traffic Safety*, T-2002. Montreal, Canada.

Peck, R. C. (1985). The role of youth in traffic accidents: A review of past and current California data. *Alcohol, Drugs, and Driving, 1*, 45-61.

Peck, R. C. (1993). The identification of multiple accident correlates in high risk drivers with specific emphasis on the role of age, experience, and prior traffic violation frequency. *Alcohol, Drugs, and Driving, 9*, 145-166.

Peck, R. C. (1996). *Effectiveness of novice driver education.* Paper presented at the Transportation Research Board Conference, Washington, D.C., January 8-11, 1996. Sacramento: California Department of Motor Vehicles.

Popkin, C. L. (1991). Drinking and driving by young females. *Accident Analysis and Prevention, 23*, 37-44.

Porter, B. E., & Berry, T. D. (2001). A nationwide survey of self-reported red light running: Measuring prevalence, predictors, and perceived consequences. *Accident Analysis and Prevention, 33*, 735-741.

Preusser, D. F. (1988). Delaying teenage licensure. *Alcohol, Drugs, and Driving, 4*, 283-295.

Preusser, D. F. (1996a). Licensing practices and crash risk in the United States. In H. Simpson (Ed.) *New to the road: Reducing the risks for young motorists.* Proceedings for the First Annual International Symposium of the Youth Enhancement Service (pp. 87-94). Los Angeles: University of California.

Preusser, D. F.. (1996b). Initial licenses for young drivers. In *Graduated Licensing: Past Experiences and Future Status.* Proceedings from the Committee on Operator Education and Regulation (Report No. 458), Transportation Research Circular. Washington, DC: Transportation Research Board.

Preusser, D. F., Ferguson, S. A., & Williams, A. F. (1998). The effect of teenage passengers on the fatal crash risk of teenage drivers. *Accident Analysis and Prevention, 30,* 217-222.

Preusser, D. F., Ferguson, S. A., & Williams, A. F. (1999). The effect of Learner's permit requirements in Tennessee. *Journal of Safety Research, 30,* 211-217.

Preusser, D. F., Ferguson, S. A., Williams, A. F., Leaf, W. A., & Farmer, C. M. (1998). Teenage driver licensure rates in four states. *Journal of Safety Research, 29,* 97-105.

Preusser, D. F., & Leaf, W. A. (2003). Provisional license. *Journal of Safety Research, 34,* 45-49.

Preusser, D. F., Williams, A. F., Lund, A. K., & Zador, P. L. (1990). City curfew ordinances and teenage motor vehicle injury. *Accident Analysis and Prevention, 22*(4), 391-397.

Preusser, D. F., Williams, A. F., Zador, P. L., & Blomberg, R. D. (1984). The effect of curfew laws on motor vehicle crashes. *Law and Policy, 6*(1), 115-128.

Preusser, D. F., Zador, P. L., & Williams, A. F. (1993). The effect of city curfew ordinances on teenage motor vehicle fatalities. *Accident Analysis and Prevention, 25,* 641-645.

Quimby, A. R., & Watts, G. R. (1981). *Human factors and driving performance.* TRRL Laboratory (Report No. 1004). Berkshire, England: Road Research Laboratory.

Regan, M., Deery, H. A., & Triggs, T. J. (1998a). *A technique for enhancing risk perception in novice car drivers.* Presented at the Road Safety Research, Policing, Education Conference, Wellington, November 16-17.

Regan, M., Deery, H. A., & Triggs, T. J. (1998b). Training for attentional control in novice drivers: A simulator study. *Proceedings of the 42nd Annual Meeting of the Human Factors and Ergonomics Society* (pp. 1408-1413). Chicago, IL.

Regan, M. A., & Mitsopoulos, E. (2001). *Understanding Passenger Influences on Driver Behaviour: Implications for Road Safety and Recommendations for Countermeasure Development* (Report No. 180). Clayton, Victoria, Australia: Monash University Accident Research Centre.

Retting, R. A., Ulmer, R. G., & Williams, A. F. (1999). Prevalence and characteristics of red light running crashes in the United States. *Accident Analysis and Prevention, 31,* 687-694.

Richardson, J., Kim, K., Li, L., & Nitz, L. (1996). Patterns of motor vehicle crash involvement by driver age and sex in Hawaii. *Journal of Safety Research, 27,* 117-125.

Roberts, I., & Kwan, I., & The Cochrane Injuries Group Driver Education Reviewers. (2002). School based driver education for the prevention of traffic crashes (Cochrane Review). In *Cochrane Library, 1.* Oxford: Update Software.

Robertson, L. S. (1980). Crash involvement of teenaged drivers when driver education is eliminated from high school. *American Journal of Public Health, 70,* 599-603.

Robertson, L. S., & Zador, P. L. (1977). *Driver Education and Fatal Crash Involvement of Teenaged Drivers.* Washington, DC: Insurance Institute for Highway Safety.

Saunders, C. (1998). Can driver education be saved? *Traffic Safety, 98,* 18-19.

Shapiro, R., Siegel, A. W., Scovill, L. C., & Hayes, J. (1998). Risk-taking patterns of female adolescents: What they do and why. *Journal of Adolescence, 21*, 143-159.

Shope, J. T., & Molnar, L. J. (2003). Graduated driver licensing in the United States: Evaluation results from the early programs. *Journal of Safety Research, 34*, 63-69.

Shope, J. T., Molnar, L. J., Elliot, M. R., & Waller, P. F. (2001). Graduated driver licensing in Michigan: Early impact on motor vehicle crashes among 16-year-old drivers. *Journal of the American Medical Association, 286*(13), 1598-1599.

Shope, J. T., Waller, P. F., & Lang, S. W. (1996). Driving behavior among high school seniors by gender: Implications for the prevention of crashes and offenses. *Accident Analysis and Prevention, 28*, 755-764.

Shope, J. T., Waller, P. F., Raghunathan, T. E., & Patil, S. M. (2001). Adolescent antecedents of high-risk driving behavior into young adulthood: Substance use and parental influences. *Accident Analysis and Prevention, 33*, 649-658.

Simons-Morton, B. G. (2002). Reducing young driver crash risk. *Injury Prevention, 8* (Suppl. II), ii1-ii2.

Simons-Morton, B. G., Hartos, J. L., & Leaf, W. A. (2002). Promoting parental management of teen driving. *Injury Prevention, 8* (Suppl. II), ii24-ii31.

Simpson, H. M. (1996). Summary of key findings: Research and information needs, program and policy priorities. In H. Simpson (Ed.), *New to the road: Reducing risks for young motorists*. Proceedings of the First Annual International Symposium of the Youth Enhancement Service (pp. 1-17). Los Angeles, CA: Youth Enhancement Service, Brain Information Service, UCLA.

Simpson, H. M. (2003). The evolution and effectiveness of graduated licensing. *Journal of Safety Research, 34*, 25-34.

Simpson, H. M., & Mayhew, D. R. (1992). *Reducing the risk for new drivers: A graduated licensing system for British Columbia*. Ottawa, Ontario: Traffic Injury Research Foundation.

Simpson, H. M., & Mayhew, D. R., & Beirness, D. J. (1996). *Dealing with the hard core drinking driver*. Ottawa, Ontario: Traffic Injury Research Foundation of Canada.

Smith, M. F. (1987). Follow-up evaluation-safe performance curriculum driver education project. *Provisional Licensing Programs for Young Drivers, Topical Papers by Licensing Experts*, Washington, DC: U.S. Department of Transportation.

Smith, M. F., & Blatt, J. (1987). *Follow-up evaluation: Safe performance curriculum driver education project: Summary of preliminary results*. Paper presented at the American Driver and Traffic Safety Education Association, Research Division Annual Conference. Spokane, WA.

Smith, D. L., & Heckert, T. M. (1998). Personality characteristics and traffic accidents of college students. *Journal of Safety Research, 29*, 163-169.

Spolander, K. (1990). *Effects of commentary driving—A study on young male drivers* (VTI Rapport 359). Linkoping: Swedish Road and Transport Research Institute.

Stock, J. R., Weaver, J. K., Ray, H. W., Brink, J. R., & Sadof, M. G. (1983). *Evaluation of Safe Performance Secondary School Driver Education Curriculum Demonstration Project, Final Report*. (DOT HS-806-568). Washington, DC: U.S. Department of Transportation.

Summala, H. (1987). Young driver accidents: Risk taking or failure of skill. *Alcohol, Drugs and Driving, 3*(3-4), 79-91.

Swisher, J. D. (1988). Problem-behavior theory and driving risk. *Alcohol, Drugs, and Driving, 4*, 205-219.

Tavris, D. R., Kuhn, E. M., & Layde, P. M. (2001). Age and gender patterns in motor vehicle crash injuries: Importance of type of crash and occupant role. *Accident Analysis and Prevention, 33*, 167-172.

Trankle, U., Gelau, C., & Metker, T. (1990). Risk perception and age-specific accidents of young drivers. *Accident Analysis and Prevention, 22*, 119-125.

Twisk, D. (1996). Magnitude and characteristics of the problem of young driver crashes in Europe. In H. Simpson (Ed.), *New to the road: Reducing the risks for young motorists.* Proceedings of the First Annual International Symposium of the Youth Enhancement Service (pp. 27-33). Los Angeles: University of California.

Ulmer, R. G., Ferguson, S. A., Williams, A. F., & Preusser, D. F. (2001). Teenage crash reduction associated with delayed licensure in Connecticut. *Journal of Safety Research, 32*, 31-41.

Ulmer, R. G., Preusser, D. F., Ferguson, S. A., & Williams, A. F. (1999). Teenage crash reduction associated with delayed licensure in Louisiana. *Journal of Safety Research, 30*, 31-38.

Ulmer, R. G., Preusser, D. F., Williams, A. F., Ferguson, S. A., & Farmer, C. M. (2000). Effect of Florida's graduated licensing program on the crash rate of teenage drivers. *Accident Analysis and Prevention, 32*, 527-532.

Ulmer, R. G., Williams, A. F, & Preusser, D. F. (1997). Crash involvements of 16-year-old drivers. *Journal of Safety Research, 28*, 97-103.

Vernick, J. S., Li, G., Ogaitis, S., MacKenzie, E. J., Baker, S. P., & Gielen, A. C. (1999). Effects of high school driver education on motor vehicle crashes, violations, and licensure. *American Journal of Preventative Medicine, 16*, 40-46.

Voas, R. B., Wells, J. K., Lestina, D. C., Williams, A. F., & Greene, M. A. (1998). Drinking and driving in the United States: The 1996 national roadside survey. *Accident Analysis and Prevention, 30*, 267-275.

Vollrath, M., Meilinger, T., & Kruger H. P. (2002). How the presence of passengers influences the risk of collision with another vehicle. *Accident Analysis and Prevention, 34*, 649-654.

Waller, P. F. (1986). *A graduated licensing system for beginning drivers*. Chapel Hill: University of North Carolina, Highway Safety Research Center.

Waller, P. F. (2003). The genesis of GDL. *Journal of Safety Research, 34*, 17-23.

Warren, R. A., & Simpson, H. M. (1976). *The young driver paradox*. Ottawa, Ontario: Traffic Injury Research Foundation of Canada.

Wasielewski, P. (1984). Speed as a measure of driver risk: Observed speeds versus driver and vehicle characteristics. *Accident Analysis and Prevention, 16*, 89-103.

Williams, A. F. (1994). Youthful drivers and motor vehicle crash risk. *Alcohol, Drugs, and Driving, 10*, 85-92.

Williams, A. F. (1996a). Magnitude and characteristics of the young driver crash problem in the United States. In H. Simpson (Ed.), *New to the road: reducing the risk of Young Motorists.* Proceedings of the First Annual International Symposium of the Youth Enhancement Service (pp. 19-25). Los Angeles: University of California.

Williams, A. F. (1996b). Overview of the young driver problem in the United States. In *Graduated licensing: Past experiences and future status.* Proceedings from the

Committee on Operator Education and Regulation (Report No. 458), Transportation Research Circular. Washington, DC: Transportation Research Board.

Williams, A. F. (1997). Earning a driver's license. *Public Health Reports, 112*, 453-461.

Williams, A. F. (2000). *Teenage Passengers in Motor Vehicle Crashes: A Summary of Current Research.* Arlington, VA: Insurance Institute for Highway Safety.

Williams, A. F. (2001). Safety needs of drivers: Lifestyle factors. In *Driver Education at the Crossroads.* Proceedings from the Committee on Operator Education and Regulation (Report No. E-C024), Transportation Research Circular. Washington, DC: Transportation Research Board.

Williams, A. F. (2003). Teenage drivers: Patterns of risk. *Journal of Safety Research, 34*, 5-15.

Williams, A. F., & Ferguson, S. A. (2002). Rationale for graduated licensing and risks it should address. *Injury Prevention, 8(Supplement II)*, ii9-ii16.

Willams, A. F., Lund, A. K., & Preusser, D. F. (1985). Teenage driver licensing in relation to state laws. *Accident Analysis and Prevention, 17*(2), 135-145.

Williams, A. F., & Mayhew, D. R. (2003). *Graduated licensing: A blueprint for North America.* Arlington, VA: Insurance Institute for Highway Safety.

Williams, A. F., & Preusser, D. F. (1997). Night driving restrictions for youthful drivers: A literature review and commentary. *Journal of Public Health Policy, 18*(3), 334-345.

Williams, A. F., Preusser, D. F., & Ferguson, S. A. (1998). Fatal crashes involving 16-year-old drivers: Narrative descriptions. *Journal of Traffic Medicine, 26*, 11-17.

Williams, A. F., Preusser, D. F., Ferguson, S. A., & Ulmer, R. G. (1997). Analysis of the fatal crash involvements of 15-year-old drivers. *Journal of Safety Research, 28*, 49-54.

Williams, A. F., Preusser, D. F., Ulmer, R. G., & Weinstein, H. B. (1995). Characteristics of fatal crashes of 16-year-old drivers: Implications for licensure policies. *Journal of Public Health Policy, 16*, 347-360.

Williams, A. F., & Shabanova, V. L. (2002). Situational factors in seat belt use by teenage drivers and passengers. *Traffic Injury Prevention, 3*(3), 201-204.

Williams, A. F., & Wells, J. K. (1995). Deaths of teenagers as motor vehicle passengers. *Journal of Safety Research, 26*, 161-167.

Woolley, J. (2000). *In-car driver training at high schools: A literature review*. Walkerville, South Australia: Safety Strategy, Transport SA.

Yagil, D. (1998) Instrumental and normative motives for compliance with traffic laws among young and older drivers. *Accident Analysis and Prevention, 30*, 417-424.

Zador, P. L. (1991). Alcohol-related relative risk of fatal driver injuries in relation to driver age and sex. *Journal of Studies on Alcohol, 52*, 302-310.

Zador, P. L., Krawchuk, S. A., & Voas, R. B. (2000). Alcohol-related risk of driver fatalities and driver involvement in fatal crashes in relation to driver age and gender: An update using 1996 data. *Journal of Studies on Alcohol, 60*, 387-395.

Zwerling, C., & Jones, M. P. (1999). Evaluation of the effectiveness of low blood alcohol concentration laws for younger drivers. *American Journal of Preventative Medicine, 16*, 76-80.