what factors predicted safe driving at follow-up. The second aim was to examine the readiness to cease driving and what factors are important to understanding older driver's readiness to transition to a non-driver.

Important messages for older drivers are that older drivers have fewer crashes as a result of infringements (speeding, alcohol etc) and more as result of errors. More than 50% of older driver crashes occur at intersections or while merging. Many older drivers adjust their driving patterns to avoid difficult conditions e.g. peak hour traffic, low light and wet weather. Age related changes in visual and physical functioning and cognitive abilities can be contributing factors and driver screening and relicensing requirements take these factors into account.

The follow up study found that participants reported increased difficulty with driving at night, reversing when parking and freeway driving. The follow up study also examined readiness to cease driving. Driving cessation can be associated with social issues such as isolation and depression, functional impairment and transition into care. Professor Anstey said that "There is potential to avoid these negative consequences if older drivers are prepared for the transition from driving".

New Guide to safe vehicle travel for wheelchair users

A new resource for wheelchair users and carers, *Wheels within wheels*, has been produced with funding support from the NRMA-ACT Road Safety Trust. The guide includes advice on a range of issues relating to safe travel in vehicles such as choosing a wheelchair, wheelchair restraint systems, transfer equipment such as hoists and ramps, safe parking, legal and insurance issues, and contact details for suppliers and service providers.

Wheels within wheels is available online at www.roadsafetytrust.org.au/wheels, or the printed version of the booklet may be obtained free of charge from ACRS National Office at faa@acrs.org.au or phone 02 6290 2509. Alternatively, contact the Trust Secretary/Manager, NRMA-ACT Road Safety Trust, Linda.Cooke@act.gov.au or phone 02 6207 7151.

Peer-reviewed papers

Making progress in reducing teenagers' crashes: Can technology help teenagers be safer drivers?

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Introduction

In 2010, 3,115 teenagers (ages 13-19) died in the United States from crash injuries [1]. Such injuries are by far the leading cause of death for this age group [2]. Per mile driven, the crash rate among drivers ages 16-19 in the United States is 3 times the rate for adult drivers for both police-reported crashes of all severities and fatal crashes (Figures 1-2) [3]. Fatal crash rates are particularly high for male teenagers. Teenagers' crash rates are elevated even though they drive less than all but the oldest people.

This presentation summarises the risk factors for teenage crashes, reviews key countermeasures shown to be effective in reducing their crash risk, and discusses how various technologies may be used to keep teenage drivers safer. These technologies, some widely available and some still emerging in the marketplace, have the potential to reinforce some of the countermeasures proven to be effective in reducing teenagers' crash risks.

Teenage crash risks

The crash risk among novice drivers is particularly high during the first months of unsupervised driving [4-6]. The effect of driving inexperience is shown clearly in Figure 3, which shows elevated crash rates among Canadian novice drivers in the first few months after licensure and relatively low rates throughout the learner stage [4]. This research also found an effect of age; young novices (ages 16-19) had higher crash rates than older novices (age 20 and older) at each month of driving experience.

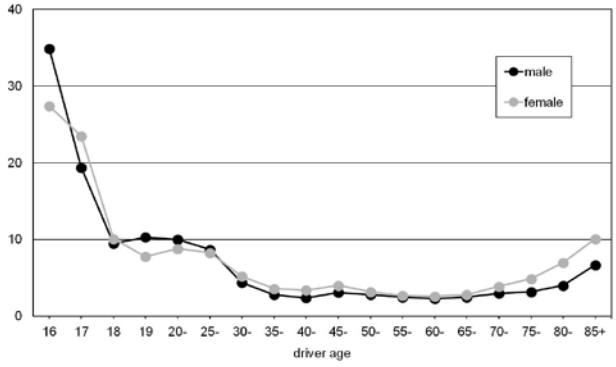

Figure 1. Rates of passenger vehicle driver involvements in police-reported crashes per 100 million miles in the United States by driver age, 2008 [3]

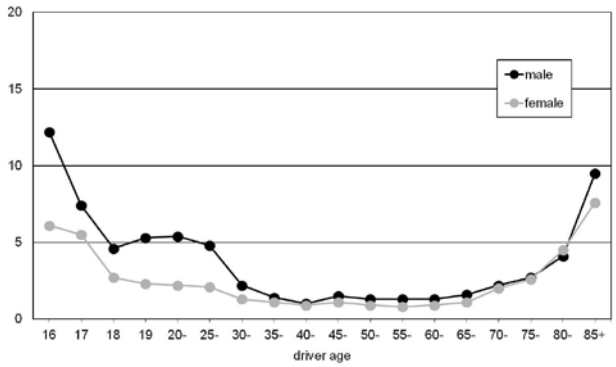

Figure 2. Rates of passenger vehicle driver involvements in fatal crashes per 100 million miles in the United States by driver age, 2008 [3]

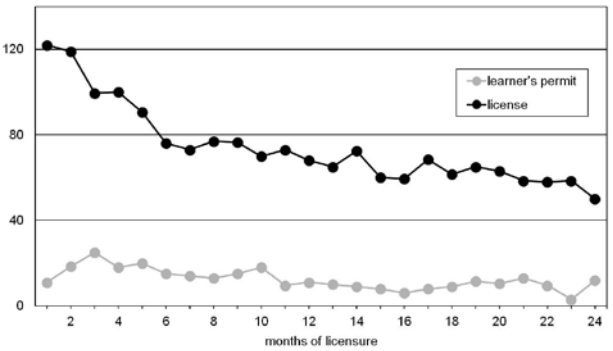

Figure 3. Crashes per 10,000 learner/license drivers by licence status and months of licensure [4]

A number of important crash risks have been identified for U.S. teenagers when they began to drive independently. Per mile driven, fatal crash rates are higher at night for drivers of all ages, but especially for young drivers (Figure 4) [1].

Transporting teenage passengers also is a risk factor (Figure 5) [7]. Compared with having no passengers, the risk of 16-17 year-old driver deaths per mile travelled increases incrementally with one, two, or three or more passengers younger than 21 and no older passengers. In contrast, the presence of at least one adult passenger has a protective effect.

Based on passenger vehicle driver involvements in fatal crashes in the United States in 2010, teenagers were more likely than adults to have been speeding, and male teenagers had higher rates of speeding than female teenagers [1]. Teenagers also were more likely than adults to have driver errors (e.g., following too closely) coded by the police. A study of novice teenage drivers in Connecticut involved in nonfatal crashes found that three factors contributed about equally to their crashes: failing to detect another vehicle or traffic control, speeding, and losing control [8]. Slippery roads also were an important factor. Most failures to detect another vehicle or traffic control involved not looking thoroughly, distraction, or inattention.

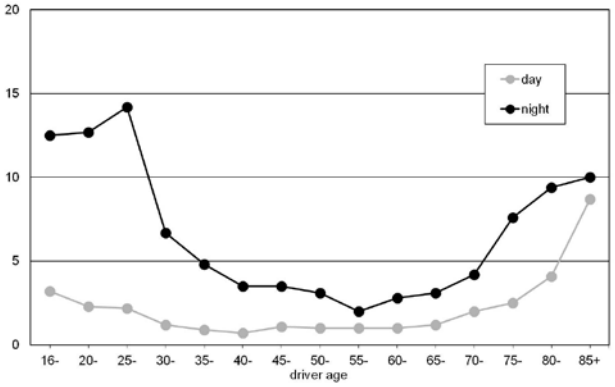

Figure 4. Rates of passenger vehicle driver involvements in nighttime and daytime fatal crashes per 100 million miles in the United States by driver age, 2008 [3]

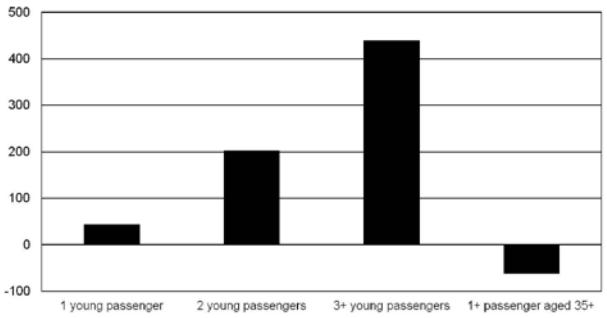

Figure 5. Percentage change in the risk of 16-17 year-old driver crash death per mile travelled with passengers vs. no passengers in the United States, 2008 [7]

In the United States, young drivers are less likely than adults to drive after drinking alcohol, but their crash risk is substantially higher when they do [9]. Among fatally injured 16-17 year-old passenger vehicle drivers in 2010, 16% of males and 13% of females had blood alcohol concentrations (BACs) at or above 0.08% [1]. Among fatally injured passenger vehicle drivers ages 18-19, 31% of males and 22% of females had BACs at or above 0.08%.

Non-belt use persists as a risk factor for injury and death among crash-involved teenage vehicle occupants. Among fatally injured drivers ages 16-19 in 2010, 44% were wearing seat belts; the percentage declined with age, from 49% among 16 year-olds to 39% among 19 year-olds [1]. The rate of belt use was even lower (29%) among fatally injured passengers ages 16-19.

Distractions of any type are likely to be more problematic for teenage drivers than for adult drivers. In the United States, as elsewhere, much attention has focused on the risks of using mobile phones while driving. There are no reliable estimates for the crash risk associated with mobile phone use among teenage drivers, or for the proportion of their crashes involving mobile phone use as a contributing factor. However, teenage drivers' reported phone use is high. A recent survey found that 43% of 18-20 year-olds said they make or receive phone calls during at least some trips, and 17% send text message or emails [10]. Fifty-two percent of 16-17 year-olds with mobile phones reported talking while driving; 34% said they have texted while driving [11].

Proven strategies to keep teenagers safer

Proven strategies to reduce teenagers' crashes and the associated injuries and deaths include countermeasures tailored to address the specific risks of teenage drivers and countermeasures directed at the total driver population.

Graduated driver licensing

Graduated driver licensing (GDL) is a system to phase in young beginners to full driving privileges. Beginning with Florida in 1996, graduated licensing in some form has been adopted in all U.S. states and the District of Columbia. In the United States, graduated licensing laws apply only to young novice drivers, usually people younger than 18. Although not explicitly part of graduated licensing, minimum permit and licence ages are fundamental to all licensing systems. Compared with other jurisdictions around the world, U.S. states license relatively early. Minimum intermediate licence ages range from 14 years, 3 months, in South Dakota to 17 in New Jersey; most states allow a licence at age 16. The minimum learner's permit age ranges from age 14 (6 states) to age 16 (8 states and the District of Columbia).

From 1996 to 2010, per capita teenage driver fatal crash rates have declined dramatically and at a faster rate than the rates among drivers ages 35-59 (Figure 6) [1]. The fatal crash rate declined by 68% for 16 year-olds and by 59% for 17 year-olds; these are the ages most directly affected by GDL in most states. Smaller but still large declines occurred among 18- and 19 year-olds. All the declines for teenagers were larger than the 35% decline among drivers ages 35-59. These data suggest that graduated licensing laws have been effective in reducing teenagers' fatal crashes. GDL's effectiveness in reducing teenagers' crashes has been shown directly in numerous evaluations of these systems in U.S. states and in jurisdictions in other countries [e.g., 12-14].

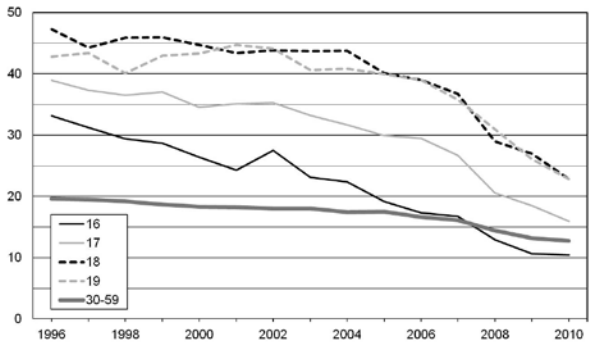

Figure 6. Rates of passenger vehicle driver involvements in fatal crashes per 100,000 people in the United States for ages 16, 17, 18, 19, and 30-59, 1996-2010 [1]

The strengths of states' GDL systems vary widely. In a pair of national studies by the Insurance Institute for Highway Safety (IIHS) and Highway Loss Data Institute (HLDI), strong GDLs were shown to reduce significantly the rates of fatal crashes and insurance collision claims among teenage drivers [15-16]. Based on a rating system developed by IIHS, laws rated good were associated with a 30% lower per capita rate of fatal crashes of 15-17 year-olds, compared with licensing laws are rated poor, and a 20% reduction in the filings of insurance collision claim rates per insured vehicle year among 16 year-old drivers (Figure 7).

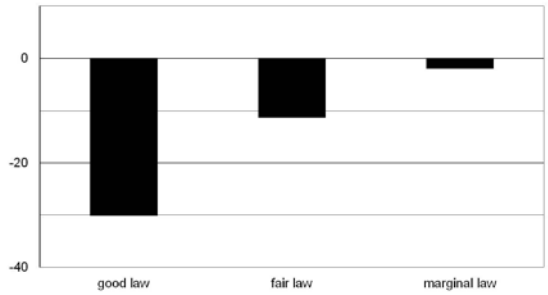

Figure 7. Percentage reduction in per capita fatal crash rates of 15-17 year-olds by IIHS graduated licensing law rating, compared with states that had laws rated poor, 1996-2007 [15]

The studies also found that significant reductions in the rates of fatal crashes and/or insurance collision claims were associated with the relative strength of the following specific graduated licensing components: minimum learner's permit and intermediate licence ages, number of required practice hours, and night and passenger restrictions during the intermediate licence phase [15-16]. These results are summarised in Figure 8.

Figure 8. Percentage reductions in teenagers' crash rates associated with stronger graduated licensing components [15-16]

This research forms the basis of an online calculator that shows in individual states the reductions in the rates of fatal crashes or collision claims that would be expected to result from adopting specific changes in their current teenage licensing laws [17-19]. In contrast to a ratings system, the calculator identifies opportunities for improvement in every state, even those with the strongest laws. A "match the best state" feature allows states to see the estimated crash reductions that could be achieved from adopting the strongest current state provisions.

Crashworthy vehicles with important safety features

Safer vehicles have been instrumental in reducing crash deaths and injuries among vehicle occupants of all ages [20]. Driving a safe vehicle is especially important for newly licensed teenagers, given their elevated crash rates. However, a 2006 IIHS survey of parents of newly licensed teenagers in three U.S. states indicated that many parents were not choosing the safest vehicles for their teenagers and were unaware of the most important vehicle safety features [21]. For example, teenagers tended to drive older model vehicles, which were less likely to have important safety features; 43% were driving vehicles 5-9 years old and 32% were driving vehicles more than 9 years old. In choosing a safe vehicle for their teenager, parents should be encouraged to consider midsize or larger vehicles with good safety ratings and with some of the most important safety features. These features include electronic stability control (ESC), shown to be highly effective in reducing single-vehicle crashes and severe multiple-vehicle crashes [22-23], and head-protecting side airbags, which substantially reduce the risk of car and SUV driver death in driver-side collisions [24]. So that speeding is not encouraged, parents also should avoid high-powered or sporty vehicles.

Proven and emerging crash avoidance technologies

New vehicles increasingly offer advanced technologies that assist the driver with warnings or automatic braking to avoid or mitigate a crash. These technologies have the potential to prevent or mitigate crashes due to any distraction, inattention, fatigue, sleepiness, or driver error. IIHS research estimated that about 1 in 3 fatal crashes and 1 in 5 injury crashes could potentially be prevented or mitigated if all passenger vehicles were equipped with forward collision warning, lane departure warning, blind spot detection, and adaptive headlights [25]. These estimates assume the best-case scenario for the systems, presuming they perform as advertised and drivers respond to them appropriately. The estimates also reflect the known limitations of the systems available at the time of the study.

Most crash avoidance technologies have not been available long enough for researchers to analyse their effectiveness in reducing crashes. An exception is ESC, which is now required on all new passenger vehicles in the United States. Studies show that ESC is highly effective, reducing fatal single-vehicle crash risk by 49% and fatal multiple-vehicle crash risk by 20% for cars and SUVs [23]. Studies of insurance claims data have reported substantial reductions in all collision claims [26] and claims for rear-end frontal collisions [27] for vehicles with Volvo's City Safety, a low-speed forward collision avoidance system. Claims also have been reduced for vehicles with forward collision avoidance systems that operate at higher speeds and vehicles with adaptive headlights, which help drivers see better on dark, curved roads by pivoting in the direction of the steering wheel [28]. Early analysis of claims data for other types of technologies are either not showing reductions or yielding mixed results.

Even if these features potentially could eliminate millions of crashes, they will not be available in the vehicles most people, particularly teenagers, drive for many years. HLDI research found that it typically takes three decades for a promising safety feature to spread to 95% of the vehicle fleet [29]. As crash avoidance technologies are increasingly available, research will focus on evaluating not only the effects of different systems on crashes but also their acceptance among drivers and driver adaptation, i.e., whether and how driver behaviour changes in response to the technology.

How will crash avoidance technologies affect teenage drivers?

Crash avoidance technologies would appear to be especially promising for reducing or mitigating teenagers' crashes. However, it also is possible that these technologies could result in more secondary task engagement or increased risk-taking that could offset any protective effects. To evaluate how crash avoidance technologies affect teenage drivers, IIHS, in collaboration with the University of Michigan Transportation Research Institute and the American Honda Motor Company, is conducting a field operational test. In the study, to be completed in 2013, 40 teenage volunteers are driving instrumented cars with and without an integrated vehicle-based safety system over several months. The system includes forward collision warning, curve speed warning, lane departure warning, and lane change/merge warning. Research questions include how the technologies affect teenagers' driving behaviour (e.g., headway distance), safety-relevant events (e.g., near crashes or crashes), and engagement in secondary tasks (e.g., mobile phone use). The results for teenagers will be compared with results from an earlier study of adult drivers.

In-vehicle monitoring technology

As noted above, novice drivers' crash risk is highest in the first months after licensure [4-5]. This finding is based largely on research conducted prior to GDL, which seeks to reduce this risk by imposing restrictions during the intermediate licence phase. Researchers compared the crash rate per month licensed for 16-17 year-olds licensed in North Carolina prior to and under the state's GDL [6]. The crash risk was lower throughout the entire 5-year study period for teenagers licensed under vs. before GDL, but the very high crash risk in the first few months following licensure persisted. This suggests that additional countermeasures during this critical period are needed.

It has been suggested that in-vehicle monitoring technologies may help beginning drivers learn some important driving skills sooner than they would otherwise, thereby extending the protective influence of parents beyond the learner's permit stage. A variety of in-vehicle devices are being marketed to parents to monitor where their teenagers are driving, as well as their driving speeds, how aggressively they are driving, seat belt use, and other behaviours. Parents receive feedback on the teenager's performance through a variety of means, including reports via email, text, or phone, or access to a password-protected website. Some devices also provide in-vehicle alerts or other real-time feedback to drivers.

In the IIHS three-state survey of parents, more than half wanted to know whether their teenagers were speeding and at least a third wanted to know about inattention, mobile phone use, or teenage passengers [30]. Between 40% and 60% of parents said they would consider installing a computer chip that continuously monitored mileage, speed, sudden braking, and sudden acceleration. Only 26-39% said they would consider using a system with a video camera.

Building on this research, IIHS evaluated the effects of an in-vehicle monitoring system on the driving behaviours of teenagers [31]. The device detected all instances of sudden braking, sudden acceleration, exceeding the speed limit (at all and by more than 10 mph), and non use of seat belts. Eighty-four 16 and 17 year-old drivers were assigned randomly to one of four research groups, differing in whether or not an alarm sounded in the vehicle and whether or not parents could access a secure website with notification records of risky driving behaviours. Time trends in event rates per mile travelled were compared. Although the original study design provided no contact with parents after the device was installed, researchers observed few website visits in the initial stages of the study. To encourage more parent participation, families recruited after this point with website access were emailed a brief report card every 2-3 weeks. Figure 9 shows that website visits declined during the study period for parents with and without report cards and that the rate of visits per family was relatively low throughout.

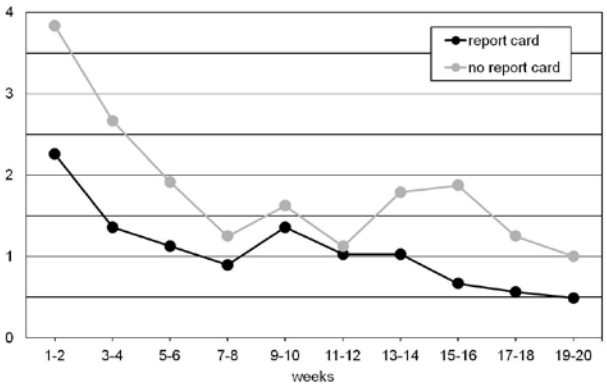

Figure 9: Number of visits to parent websites per family throughout study period for parents with and without emailed report cards in study of effects of in-vehicle monitoring device on teenagers' risky driving behaviours

When the device was activated, rates of sudden braking/acceleration declined for the treatment groups relative to the control groups, especially for the groups with in-vehicle alerts, but the differences were not statistically significant [31]. Seat belt use improved when violations were reported to the parent websites, and improved even more when in-vehicle alerts were activated. Speeding behaviour was reduced only when the alarm sounded in the vehicle, drivers had a chance to correct behaviour before notifications were sent to the website, and speed-related report cards were

emailed to parents every few weeks. Figure 10 summarises results for the group with in-vehicle alerts, delayed parent notification, and emailed reports to parents.

Whether monitoring technologies prove to be an effective countermeasure depends not only on whether they reduce teenagers' risky driving but also on whether they are accepted by families. Even though the study was conducted in a large urban area, recruitment proceeded slowly. Based on interviews conducted at the end of the study, both parents and teenagers thought the overall system was effective in improving teenagers' driving, and most parents said the website and/or device helped them talk to their teenagers about their driving [32]. Parents who declined to participate usually said their teenagers opposed it, or they were concerned about intruding on the children's privacy or jeopardising trust with them.

The researchers concluded that electronic monitoring can reduce risky behaviour among teenage drivers, with more complicated behaviours being more difficult to change. It appeared that effectiveness improved with in-vehicle alerts and direct feedback to parents. The system also worked best when teenagers had a chance to correct behaviour before their parents were notified; this feature may increase the acceptability of monitoring devices as well as their effectiveness. Parental involvement is key to successful behaviour modification, but it is unclear how best to achieve it.

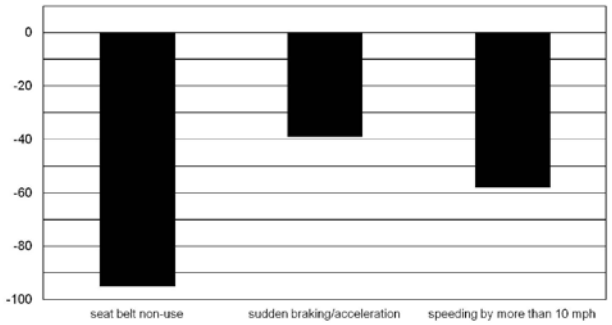

Figure 10: Percentage reduction in risky behaviours with in-vehicle monitoring device for teenagers with alert in vehicle, delayed parent notification, and emailed parent report card [31]

Other potentially beneficial technologies for teenage drivers

Other technologies have the potential to foster safer driving behaviours among all drivers, including teenagers.

Enhanced seat belt reminders

About 15 percent of front seat vehicle occupants in the United States do not buckle up. Seat belt technologies provide the means to increase belt use. Enhanced seat belt reminders have been shown to increase driver belt use by 3-6% [33-35] and to reduce driver fatality rates by 6% [36]. In the IIHS study of an in-vehicle monitoring device for teenagers, a continuous high-pitched belt reminder virtually eliminated non-belt use for this study group [31]. Despite the effectiveness of enhanced reminders, the U.S. National Highway Traffic Safety Administration (NHTSA) has been prohibited from requiring an auditory belt reminder that lasts longer than 4-8 seconds. Although most 2012 passenger vehicle models sold in the United States have enhanced reminders for the driver (91%) and front passenger (77%), only about one-third meet the Australasian NCAP criteria for enhanced reminders. The 2012 federal Moving Ahead for Progress in the 21st Century (MAP-21) law allows NHTSA to require stronger front seat reminders and directs the agency to undertake rulemaking to require rear seat reminders. It is hoped that enhanced reminders can be used more effectively to boost belt use in the United States.

Mobile phone blocking technologies

Many U.S. states prohibit mobile phone use or texting among teenage drivers. However, a recent observational study of North Carolina teenage drivers found the state's restriction on mobile phone use among teenage drivers had no long-term effect on their phone use [37]. As noted above, crash avoidance technologies may help reduce or mitigate crashes due to any form of driver distractions. In the United States, mobile phone blocking technologies to block or restrict use of mobile phones while driving are increasingly available. With some systems, records of violations or tampering attempts are accessible to parents or fleet managers. The current systems have various limitations. For example, drivers may be able to easily activate the passenger override, GPS may detect motion only above a speed threshold such as 10 mph, and GPS-based systems cannot determine the mode of transportation and activate, for example, when travelling by train. There is scant information on how widely the systems are used by fleets or individuals, and there have been no evaluations of the effects on phone use while driving, driving behaviours, or crashes.

Advanced in-vehicle alcohol detection technology

In the United States, progress in reducing fatal crashes involving alcohol-impaired drivers has largely stalled since the mid-1990s. States increasingly are enacting laws that require all people convicted of alcohol-impaired driving to install alcohol ignition interlocks. A joint effort between the federal government and automakers is underway to develop advanced in-vehicle alcohol detection technology

that would be suitable for installation in all vehicles to prevent starting a vehicle if the driver is illegally impaired (i.e., BAC at or above 0.08%). The initiative, Driver Alcohol Detection System for Safety (DADSS), involves researching, developing, and testing technology that is extremely accurate in detecting driver impairment while being virtually invisible to the driver [38]. The effort also will seek to build public support for the technology. The initiative is in its second phase; two technology developers are developing systems that are accurate, reliable, and durable enough to install in test vehicles. It is estimated that more than 7,000 crashes could have been prevented in 2010 in the United States if all drivers' BACs had been reduced to less than 0.08 percent [39].

Naturalistic study approaches

In addition to various technologies intended to help keep drivers safer, new technologies are expanding the kinds of research that can be conducted to study teenagers' real-world driving behaviours. Using data collected from the vehicle network, continuous video, accelerometers, GPS, and other sources, "naturalistic studies" continuously monitor drivers in instrumented vehicles over weeks and even months, without interference. The studies typically use kinematic data triggers to identify crashes and near crashes (high g-force events) or other "safety-relevant events" (e.g., lane deviation) and may generate samples of control episodes of "normal driving" without events. Naturalistic research conducted in the United States has examined changes in teenagers' driving during the first 18 months of licensure, relative to their parents' driving, and the factors associated with crash/near-crash rates and risky driving, including the presence of adult or teenage passengers [40-41]; observed teenagers learning to drive to understand better the amount and types of practice driving and parental instruction [42]; compared the types of driving incidents during the learning phase and initial stage of intermediate licensure [43]; and measured the occurrence of distracted driver behaviours and potentially distracting conditions among teenage drivers and the relationship between distracting activities and driving performance [44]. Although naturalistic study approaches can gather rich data on what drivers actually are doing and how this affects driving performance, the studies to date have had some limitations. Reliance on g-force measures to identify near-crash events means that some events are not detected. More work is needed to validate the risky driving measures. Information on the context of the driving situation (e.g., type of roadway, speed limit, traffic flow) often is limited. The challenge is to develop thoughtful research questions that will add to our knowledge about teenage drivers, guided by the important questions and not by the most readily available measures.

Some limitations of the naturalistic research to date may be addressed in a large-scale naturalistic study underway in the United States. As part of the second Strategic Highway Research Program (SHRP 2) [45], all the trips of 3,100 drivers of all age and gender groups, including teenagers, will be monitored for 12-24 months. The study will collect a plethora of data on the driver and vehicle, including mobile phone billing records and readings from passive alcohol sensors. In addition, trip data will be linked via GPS to roadway inventory data (e.g., grade, lane and shoulder width, speed limit) gathered by a mobile van. The plans called for data to be collection from late 2010 to November 2013, with complete data files available by March 2014.

Conclusion

Much has been learned about the crash risks of teenage drivers. In the United States and elsewhere, graduated driver licensing programs are reducing this risk. More crashworthy vehicles are keeping all drivers safer, and new crash avoidance technologies have the potential to reduce and mitigate crashes. A variety of other technologies, some directed at teenagers and others directed at all drivers, have the potential to reduce teenagers' crash risk and to enable researchers to expand their knowledge of the teenagers' crash risk.

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Challenges for rural and remote road safety

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Abstract

The growing national and international awareness of the increased representation of serious injuries and fatalities in rural and remote areas is the focus of this paper. Australia was one of the earliest countries to try to address this issue with a targeted national action plan in 1996. This was an important document but the most recent national plan fails to dedicate attention to developing countermeasures for the particular problems of improving road safety in these regions.

The findings of a major program of research in Northern Queensland are discussed to stimulate interest and research into potential countermeasures. Specifically, the need to monitor clusters of crashes as a focus for intervention and local ownership is advocated. Taking action towards a national reduction of speed limits on rural roads and investment in proactive research based trials of drink driving countermeasures such as courtesy buses are strongly advocated.