

Motor Vehicle Crashes Among Young Drivers: Systematic Review & Recommendations for BC

BC Injury Research and Prevention Unit

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Forward

The British Columbia Injury Research and Prevention Unit (BCIRPU), directed by Dr. Ian Pike, was established by the Ministry of Health and the Minister's Injury Prevention Advisory Committee in August 1997. BCIRPU opened its doors in January 1998. It is housed within the Centre for Community Child Health Research (CCCHR) at Children's & Women's Health Centre of British Columbia, and supported by the BC Research Institute for Children's & Women's Health. The primary purpose of the Unit includes: *The reduction of unintentional injuries in BC, through the support and evaluation of effective prevention measures, and the establishment of ongoing injury surveillance across the province.*

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EXECUTIVE SUMMARY

Summary Statement

A systematic review of the current review literature was undertaken to identify prevention strategies for motor vehicle crashes (MVCs) and intervention strategies for crash-related injuries occurring among young drivers. Six strategies for keeping young drivers safe were identified from systematic review articles, six strategies were identified from review articles, and two risk factors without accompanying strategies were also found. Recommendations for BC regarding each of these prevention and intervention strategies were formulated based on the collective evidence.

Recommendations & Justifications

Recommendations for Intervention/Prevention Strategies based on Systematic Reviews¹

Prevention/Intervention Strategy

- *Recommendations*
 - *Intervention Description*
 - *Key Findings (Evidence²)*
 - *Currently in BC*
-

Strongly Recommended (Strong Evidence)

Blood-alcohol Concentration

- *Recommendation:* Continued Legislation and Enforcement of Blood-alcohol Concentration limits is **STRONGLY RECOMMENDED**, with meaningful consequences resulting from the violation of zero tolerance among BC's learner and novice drivers.
- *Recommendation:* FURTHER INVESTIGATION into the benefits of decreasing BC's Blood-alcohol Concentration limits is **RECOMMENDED**.
- *Description:* Specifies the level of blood-alcohol above which driving a vehicle is not permitted.
- *Key Findings:* Sufficient evidence that lower blood-alcohol concentration laws are effective in reducing alcohol-related crashes, with a dose-response effect. (Based on 3 systematic reviews, 1 review article, & 13 cited reference articles.)
- *Currently in BC:* The BC Motor Vehicle Act 224 prohibits operating a motor vehicle with a blood-alcohol concentration level over 0.08 percent, with fines ranging from \$100 to \$2,000 or imprisonment from seven days to six months, or both. Learner and novice drivers are subject to zero tolerance laws under the graduated licensing system in BC, with penalties including a 12-hour roadside suspension and possible violation ticket for breach of condition at the discretion of the police officer.

Minimum Legal Drinking Age

- *Recommendation:* Continued Legislation and Enforcement of BC's Minimum Legal Drinking Age is **STRONGLY RECOMMENDED**.
- *Recommendation:* FURTHER INVESTIGATION into the benefits of increasing BC's Minimum Legal Drinking Age to 21 years is **RECOMMENDED**.

¹ Recommendations are made based on the strength of the evidence for topics that have been the focus of one or more systematic review.

² Evidence is provided as the number of systematic reviews and number of review articles contributing to the evidence, as well as the total number of reference articles cited within these systematic reviews and review articles.

- *Description:* Specifies an age below which buying or consuming alcohol is not permitted.
- *Key Findings:* Strong evidence that minimum legal drinking age laws are effective in preventing alcohol-related crashes. Minimum legal drinking age of 21 years appears to be most effective. (Based on 2 systematic reviews, 1 review article, & 38 cited reference articles.)
- *Currently in BC:* The minimum age at which an adult can legally purchase or publicly consume alcohol in BC is 19 years.

Recommended (Sufficient Evidence)

Night-time Driving Curfew

- *Recommendation:* Continued Legislation and Enforcement of BC's Night-time Driving Curfew for learner drivers is RECOMMENDED.
- *Recommendation:* FURTHER INVESTIGATION is required to determine if BC's Night-time Driving Curfew should be expanded to novice drivers. Exemptions to this curfew could be made, e.g. for the purposes of driving to and from work.
- *Description:* Specifies a driving licence or age at which drivers are only permitted to drive between certain night-time hours.
- *Key Findings:* Night-time driving curfews imposed on young drivers have shown to reduce crash rates. (Based on 1 systematic review, 2 review articles, & 8 cited reference articles.)
- *Currently in BC:* Drivers with a learner's licence in BC are allowed to drive between the hours of 5 a.m. and midnight.

Not Recommended (Strong Evidence)

Driver Education

- *Recommendation:* Driver Education is NOT RECOMMENDED as a stand-alone prevention/intervention strategy.
- *Recommendation:* Incentives for completing Driver Education should not shorten the learner period of BC's graduated licensing system.
- *Description:* Driver education curriculum, including both in-class and on-road instruction.
- *Key Findings:* Not protective against MVCs among young drivers. Increases licensure rate among young drivers. May increase risk of MVCs among young drivers. (Based on 2 systematic reviews, 4 review articles, & 14 cited reference articles.)
- *Currently in BC:* The Class 7 road test can be taken nine months after attaining a Class 7 Learner's licence by those who have completed a driver education course approved by the Insurance Corporation of British Columbia (ICBC).

School-based Driver Education

- *Recommendation:* School-based Driver Education is NOT RECOMMENDED as a stand-alone prevention/intervention strategy.
- *Recommendation:* Incentives for completing Driver Education should not shorten the learner period of BC's graduated licensing system.
- *Description:* Driver education curriculum provided in the high school setting including both in-class and on-road instruction.
- *Key Findings:* Not protective against MVCs among young drivers. Increases licensure rate among young drivers. May increase risk of MVCs among young drivers. (Based on 3 systematic reviews, 4 review articles, & 22 cited reference articles.)
- *Currently in BC:* The Class 7 road test can be taken nine months after attaining a Class 7 Learner's licence by those who have completed a driver education course approved by the Insurance Corporation of British Columbia (ICBC).

Further Investigation (Insufficient Evidence)

Minimum Legal Driving Age

- *Recommendation:* FURTHER INVESTIGATION is required to ascertain if the Minimum Legal Driving Age in BC should be raised.
- *Description:* Specifies an age below which driver's licences of any kind can not be obtained.
- *Key Findings:* Increasing the minimum driving age supports age and experience as influencing injury rates among young drivers. (Based on 1 systematic review and 4 cited reference articles.)
- *Currently in BC:* You must be at least 16 years of age to apply for a learner driver's licence in BC for both passenger vehicles and motorcycles.

Practices & Strategies for Further Investigation based on Review Articles³

Prevention/Intervention Strategy

- *Recommendations*
- *Intervention Description*
- *Key Findings (Evidence⁴)*
- *Currently in BC*

Promising Practice

Alcohol Control Laws

- *Recommendation:* Continued Legislation and Enforcement of Alcohol Control is a PROMISING PRACTICE.
- *Description:* Legislation aimed at preventing drivers with high blood-alcohol concentrations from driving.
- *Key Findings:* Dram shop laws, preliminary breath-test legislation, sobriety checkpoints, and anti-plea bargaining statutes have been shown to reduce teenage MVC fatalities. (Based on 1 review article & 3 cited reference articles.)
- *Currently in BC:* Several measures and programs are in place addressing the issue of drinking and driving, including public education and awareness, managing the opportunity to drink and drive, enforcement, sanctions, and rehabilitation.

Completing the *Serving It Right* program (www.servingitright.com) is a requirement for servers working in licensed establishments under the Liquor Control and Licensing Act. This program stipulates the importance of anticipating and managing the potential consequences of over-service. Furthermore, the Occupier's Liability Act stipulates the principle of *duty of care*, where the establishment's licensee and servers are required to protect patrons and others from harm that may be associated with the activity of drinking. This is also known as *dram shop laws*, giving authorization of lawsuits against alcohol servers.

Sanctions currently enforced in BC include (British Columbia 2003):

1. Criminal Code of Canada drinking and driving convictions, where a first conviction carries a \$600 fine and one-year prohibition, a second conviction carries a penalty of 14 days in jail and a two-year prohibition, and a third or subsequent conviction carries a penalty of 90 days in jail and two or more years of prohibition.
2. Motor Vehicle Act sanctions for Criminal Code drinking and driving convictions, where any conviction carries a one-year driving prohibition, a first conviction carries a one-year driver licence

³ Topics that have not been the focus of a systematic review are recommended for further investigation and may be a *Promising Practice* or *Promising Strategy* based on the evidence available.

⁴ Evidence is provided as the number of review articles as well as the total number of reference articles cited within these review articles.

suspension, a second conviction carries a three-year driver licence suspension, and a third or subsequent conviction carries an indefinite driver licence suspension.

3. Administrative Driving Prohibitions (ADP) and Sanctions, including: 24-hour driving prohibition at roadside for driving affected by alcohol; 12-hour driving suspension for novice drivers in violation of zero tolerance for blood-alcohol, with a possible discretionary prohibition from the Superintendent of Motor Vehicles; 90-day administrative driving prohibition for BAC exceeding 0.08 percent (MVA 224) or refusing a breath test (MVA 90.3); and discretionary prohibitions from the Superintendent of Motor Vehicles for a bad driving record including multiple drinking and driving convictions, ADPs and 24-hour prohibitions.

Mandatory Seat-belt Use Law

- *Recommendation:* Continued Legislation and Enforcement of Mandatory Seat-belt Use is a PROMISING PRACTICE.⁵
- *Recommendation:* It is RECOMMENDED that Mandatory Seat-belt Use be a Primary Enforcement Law.
- *Description:* Legislation requiring the use of seat-belts and child restraints by motor vehicle passengers.
- *Key Findings:* Primary enforcement shown to significantly reduce MVC fatalities by eight percent among 16 to 17 year olds, and by ten percent among 18 to 19 year olds. (Based on 5 review articles & 4 cited reference articles.)
- *Currently in BC:*

MVA 220 (1) A seat-belt assembly includes a pelvic restraint, an upper torso restraint or both.

MVA 220 (2) A person must not sell, offer for sale or operate a motor vehicle manufactured or assembled after December 1, 1963, other than a motorcycle, unless it is equipped with at least two seat-belt assemblies in the front seat.

MVA 220 (3) A person must not operate a motor vehicle that has had the seat-belts removed, rendered partly or wholly inoperative, or modified to reduce its effectiveness.

MVA 220 (4) A seat-belt assembly must be worn when a motor vehicle is being operated.

MVA 220 (6) Drivers must ensure that passengers who have attained 6 years of age but are under 16 years of age, are properly restrained.

MVR 36.01 A person shall not operate a motor vehicle in which there is a child under the age of 6 unless the driver ensures that the child is securely fastened by a properly utilized and adjusted restraint system which complies with the MVA.

MVR 36.02 All infants, birth to 9 kg, must be restrained in a rear-facing restraint system which complies with the Canadian Motor Vehicle Safety Standard (CMVSS) 213.1.

MVR 36.03 Toddlers weighing 9 to 18 kg (about 20 - 40 lbs.) in a motor vehicle driven by a parent or guardian must be restrained in a child restraint that complies with the Canadian Motor Vehicle Safety Standard 213 which is installed in the vehicle with the adult seat belt and a top tether strap. Toddlers driven by an adult who is not the parent or guardian may be restrained as defined in 36.03 or by a lap belt.

MVR 36.04 All children under the age of 6 not categorized in sections 36.02 or 36.03 shall be restrained by the lap belt.

MVA infractions carry a \$95 fine with a 15 percent surcharge for research and trauma care, for a total of \$109. Seat-belt use in BC is currently a Secondary Enforcement Law.

⁵ Although the purpose of seat-belts is considered the single most effective means of reducing MVC injuries and deaths, they have not been the topic of a systematic review among the general population or among youth. A systematic review has recently been conducted concerning three interventions to increase the use of safety belts: safety belt laws, primary safety belt laws, and enhanced enforcement programs (Dinh-Zarr, Sleet, Shults et al., 2001).

Passenger Restrictions

- *Recommendation:* Continued Legislation and Enforcement of Passenger Restrictions during learner and novice stages is a PROMISING PRACTICE.
- *Description:* Limiting the number of (young) passengers in a vehicle with a young driver.
- *Key Findings:* Increased risk of at-fault MVCs among young drivers when carrying adolescent passengers. Likelihood of crash being fatal when passengers are in teens or twenties, and when passengers are male. Restriction of teenage passengers without the presence of an adult has shown to be effective in reducing injury. (Based on 3 review articles & 4 cited reference articles.)
- *Currently in BC:* Drivers holding a learner licence must have a supervisor aged 25 years or older holding a valid driver's licence, and may have one other passenger in the car. Drivers holding a novice licence obtained on or after October 6, 2003 can have one passenger alone or two passengers if one is a supervisor aged 25 years or older holding a valid driver's licence. For these novice drivers, passenger restrictions do not apply to immediate family members. Drivers holding a novice licence obtained prior to October 6, 2003 are not subject to any passenger restrictions.

Promising Strategy

Vehicle Crash Worthiness

- *Recommendation:* Increasing awareness of Vehicle Crash Worthiness among young drivers and their parents is a PROMISING STRATEGY.
- *Description:* Awareness of crash worthiness, influenced by size and weight, as well as the inclusion of safety devices.
- *Key Findings:* Risk of 2-vehicle MVC fatality 12 times higher for driver of smaller car when larger car has twice the mass. Risk of single car MVC fatality two to three times higher for drivers of lighter cars, versus heavier cars. (Based on 1 review article & 3 cited reference articles.)

Parental Involvement

- *Recommendation:* Increasing awareness of the value of Parental Involvement is a PROMISING STRATEGY. Parents should be encouraged to negotiate driving privileges with their children.
- *Description:* Parent attitudes and practices as related to teen driving.
- *Key Findings:* Parental influence can affect the amount of practice time for new drivers, delay licensure, and reduce risky behaviour. (Based on 1 review article & 7 cited reference articles.)

Insufficient Evidence

Maximum Speed Laws

- *Recommendation:* There is INSUFFICIENT EVIDENCE regarding Maximum Speed Laws upon which to base a recommendation.
- *Description:* Maximum speed laws are posted on all roads and highways in BC.
- *Key Findings:* Statistical significance was not found in a study of young driver fatalities in a move from a 55 mph to 65 mph speed limit. (Based on 1 review article & 1 cited reference article.)
- *Currently in BC:* Maximum speed laws are posted on all roads and highways in BC. Within city limits, maximum speed on most roads is 50 km/hr. Highway speeds vary up to 110 km/hr.

Other Risks not captured by the Review Literature

Risk Factor

- *Description*
 - *Key Findings*
-

Driver Fatigue

- *Description:* Young drivers may be more prone to driver fatigue than other drivers due to sleep patterns and lifestyle.
- *Key Findings:* Elevated risk of night-time MVCs among 19 to 24 year olds has been documented.

In-vehicle Distractions

- *Description:* Music (radio, CD), cell phones, navigation devices, video systems, etc.
 - *Key Findings:* Young drivers are less able to drive safely when faced with in-vehicle distractions than are more experienced drivers.
-

Actions for Regional Health Authorities

- *Action:* Regional Health Authorities should create a Community Facilitator/Convener position. This would see each Health Authority convening and supporting community coalitions to address MVCs among youth (e.g. Mothers Against Drunk Driving - MADD), including such things as the provision of direct financial support, but more likely in-kind support (facilities for seminars, resources such as AV equipment, educational materials, presentations by health care professionals). This demands that the Health Authority first recognize the players, establish relations, and form a network. In order that they take the co-ordinating role, they must make the case for MVC reduction as a public health priority, and must be seen by others in the network to have committed appropriate resources to assume that role and support the future collaborative efforts.
 - *Action:* Regional Health Authorities should take an Inter-Ministerial Approach. The Health Authorities are well-positioned (particularly if the community efforts as described above are flourishing) to establish inter-ministerial connections and collaboration on the issue of Youth MVC reduction. This would include connections, in the first instance, with the Ministries of Education, Transportation, Attorney General, and others. Public Policy that supports Youth MVC reduction as a public health concern will necessarily require interdisciplinary consideration and inter-ministerial support to move forward.
 - *Action:* Regional Health Authorities should work with community groups to develop programs geared towards reducing the risks of MVCs among youth, such as a volunteer *safe-ride home* to keep young drinking drivers off the road, or encouraging young drivers not to exceed passenger limitations or break night-time driving curfews.
 - *Action:* Regional Health Authorities should advocate for stronger enforcement of current legislation, from blood-alcohol concentration laws and mandatory seat-belt use among all drivers, to night-time driving curfews and passenger restrictions among learner and novice drivers.
 - *Action:* Regional Health Authorities should advocate for greater driver skills education among learner and novice drivers, while supporting an ICBC proposal to require a full 12-month period after attaining a Class 7 Learner's licence before qualifying for the Class 7 road test.
-

Methods

Systematic reviews and review articles addressing the prevention of MVCs and intervention of crash-related injuries among young drivers were identified by systematically searching the following databases from 1994 onwards: Medline, EMBASE, the Cochrane Database of Systematic Reviews (CDSR), PsychINFO, and the UBC Traffic Database. The following electronic journals were also hand searched for the same time period: *Accident Analysis and Prevention*, *American Journal of Preventive Medicine*, *Injury Prevention*, *Journal of Safety Research*, and *Traffic Injury Prevention*.

Eligible reviews were selected independently by two researchers using a two-step process, first based on title and abstract, then based on explicit inclusion/exclusion criteria. Discrepancies were resolved through discussion and third party participation. Quality was assessed using a modified Oxman Checklist for Review Articles (Oxman, 1994; Barns & Bero, 1998).

Data from the 16 selected reviews were extracted using a standardized approach. Recommendations regarding strategies demonstrated to reduce the burden of MVC-related injuries among youth were formulated based on the collective evidence. The strength of the evidence was determined by the number of supporting systematic reviews, review articles, and cited reference articles.

Limitations

Time constraints in producing this report lead to the decision of doing a “review of reviews”. Therefore only prevention and intervention strategies that have been topics of reviews elsewhere have been captured. Also, as this report focuses on youth ages 15 to 24 years, only reviews focused on youth specifically, or presenting data for youth separately from the general population were included.

Furthermore the graduated licensing system as a whole, as currently operating in BC, was not included in this study. However, many different graduated licensing systems and prevention efforts related to graduated licensing, such as driver education and night-time driving curfew, were still of interest. Search strategies were modified in an attempt not to exclude desired prevention strategies.

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Other Articles

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Table of Contents

<i>EXECUTIVE SUMMARY</i>	i
<i>Table of Contents</i>	xi
<i>List of Abbreviations</i>	xii
<i>Summary</i>	1
BACKGROUND	1
Nationally.....	1
Provincially	2
Alcohol Use	7
Unsafe Speed.....	8
Proportion of Young Licensed Drivers.....	10
INTRODUCTION	11
Objectives of the Review	11
Contextual Framework	12
METHODS	12
Search Strategy.....	12
Selection of Eligible Reviews	12
Inclusion Criteria.....	12
Quality Assessment.....	13
Reference Articles	13
Data Extraction	13
Formulation of Recommendations	14
RESULTS & RECOMMENDATIONS	14
Selection of Eligible Reviews	14
Summary of Reviews.....	15
Quality Assessment.....	16
Strength of Evidence – Avoiding Duplication	16
Evidence & Recommendations: Systematic Reviews.....	17
Evidence & Recommendations: Review Articles	22
Other Risks not Captured by the Review Literature.....	27
ACTIONS FOR REGIONAL HEALTH AUTHORITIES	29
LIMITATIONS	29
REFERENCES	31
General References	31
Systematic Reviews	31
Review Articles	32
Other Articles.....	33
APPENDIX A: Search Strategies	35
APPENDIX B: Inclusion Form	41
APPENDIX C: Modified Oxman Form for Quality	45
APPENDIX D: Reference Lists of Relevant Studies from Selected Systematic Reviews and Review Articles	49
APPENDIX E: Summary Results of Included Systematic Reviews & Review Articles	57

List of Abbreviations

ADP	Administrative Driving Prohibition
AV	Audio-visual
BAC	Blood-alcohol Concentration
BC	British Columbia
CDSR	Cochrane Database of Systematic Reviews
CMVSS	Canadian Motor Vehicle Safety Standard
DUI	Driving Under the Influence
ED	Emergency Department
EDISS	Emergency Department Injury Surveillance System
GLS	Graduated Licensing System
ICBC	Insurance Corporation of British Columbia
km/hr	Kilometres per Hour
MADD	Mothers Against Drunk Driving
mg	Milligrams
ml	Millilitres
mph	Miles per Hour
MVA	Motor Vehicle Act
MVC	Motor Vehicle Crash
MVR	Motor Vehicle Act Regulation
MVT	Motor Vehicle Traffic
UBC	University of British Columbia
VISTA	Vital Information Statistics (BC Vital Statistics Agency)

Motor Vehicle Crashes Among Young Drivers: Systematic Review & Recommendations for BC

Summary

Supporting safe and healthy communities is among the current strategic goals of the government of British Columbia (BC), in order to improve the health and wellness of British Columbians. Part of the Ministry of Health's commitment to improving BC's health systems is a new Public Health Act, emphasizing the role of prevention in reducing the direct and indirect economic burden of injury and illness. Towards this end, this systematic review was commissioned by the Ministry of Health as a "review of reviews", focusing on prevention and intervention strategies aimed at keeping young drivers safe. Recommendations based on the available evidence are made in an effort to reduce the prevalence and severity of motor vehicle crashes among BC's youth.

BACKGROUND

Nationally

Motor vehicle crashes (MVCs) resulted in a total of 2,936 deaths in Canada in 2002 (Transport Canada, 2002). Among these crashes, youth aged 15 to 19 years accounted for 11.3 percent (331), while those aged 20 to 24 years accounted for a further 12.4 percent (365) (Figure 1). Among MVCs resulting in injury (227,768), 12.8 percent (29,236) were among youth aged 15 to 19 years, and 13.2 percent (30,073) were among those aged 20 to 24 years (Figure 2).

Figure 1: MVC fatalities in Canada, by age group, 2002. (Transport Canada, 2002)

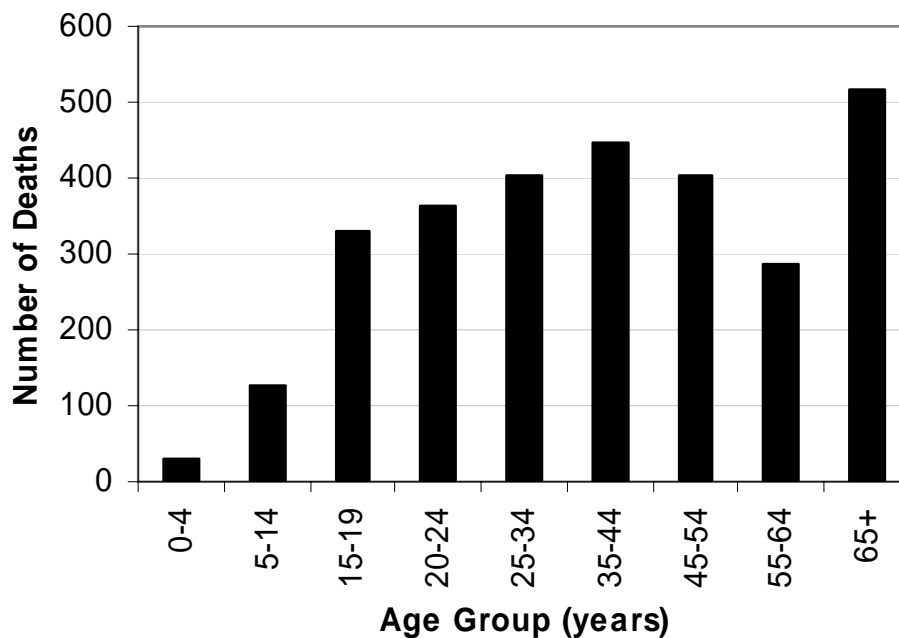
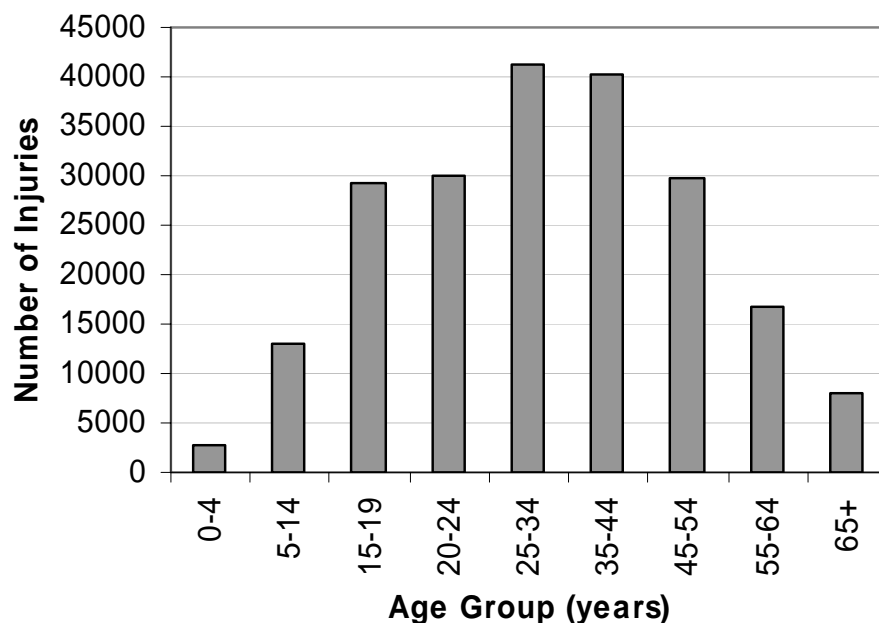


Figure 2: MVC injuries in Canada, by age group, 2002. (Transport Canada, 2002)



Provincially

In British Columbia (BC), MVCs cost approximately \$428 million in 1998, roughly 28 percent of the total costs of unintentional injuries (Cloutier & Albert, 2001). Transport injuries were the leading cause of death from ages five to 44 years, and the fourth leading cause for children aged one to four years (Table 1).

From 1998 to 2002 there were 1,528 motor vehicle occupant deaths, 331 pedestrian deaths, 42 cyclist deaths, and 111 motorcyclist deaths in BC, for a total of 2,012 traffic-related deaths. Youth aged 15 to 24 years accounted for 30.9 percent of motor vehicle occupant deaths, 12.1 percent of pedestrian deaths, 14.3 percent of cyclist deaths, and 30.6 percent of motorcyclist deaths (Figure 3). Annual age-specific mortality rates over this five-year period have remained fairly constant, peaking with the 15 to 19 years age group, and again among the elderly (Figure 4). (VISTA 1998-2002)

Males aged 15 to 24 years accounted for 27.4 percent (552) of these traffic-related deaths, and females 15 to 24 accounted for 7.8 percent (158) (Table 2).

Table 1: Ranking of cause of death, by age group, BC, 1998-2002. (VISTA)

Age Groups (years)									
<1	1-4	5-9	10-14	15-19	20-24	25-44	45-64	65-84	85+
Perinatal	Unintentional Injuries	Transport	Transport	Transport	Transport	Transport	Neoplasms	Circulatory System	Circulatory System
Congenital	Congenital	Neoplasms	Neoplasms	Intentional Injury	Intentional Injury	Signs/Symptoms	Circulatory System	Neoplasms	Respiratory System
Signs/Symptoms	Neoplasms	Unintentional Injuries	Unintentional Injuries	Unintentional Injuries	Unintentional Injuries	Unintentional Injuries	Digestive System	Respiratory System	Neoplasms
Nervous System	Transport	Congenital	Intentional Injury	Neoplasms	Neoplasms	Neoplasms	Unintentional Injuries	Nervous System	Nervous System
Infectious & Parasitic	Signs/Symptoms	Endocrine & Metabolic	Congenital	Circulatory System	Circulatory System	Mental & Behavioural	Intentional Injury	Digestive System	Mental & Behavioural
Endocrine & Metabolic	Circulatory System	Nervous System	Nervous System	Nervous System	Nervous System	Intentional Injury	Respiratory System	Endocrine & Metabolic	Digestive System
Unintentional Injuries	Nervous System	Intentional Injury	Circulatory System	Congenital	Signs/Symptoms	Infectious & Parasitic	Endocrine & Metabolic	Genitourinary System	Endocrine & Metabolic
Respiratory System	Infectious & Parasitic	Infectious & Parasitic	Endocrine & Metabolic	Respiratory System	Endocrine & Metabolic	Endocrine & Metabolic	Infectious & Parasitic	Mental & Behavioural	Unintentional Injuries
Digestive System	Intentional Injury	Circulatory System	Respiratory System	Endocrine & Metabolic	Congenital	Skin & Subcutaneous	Transport	Unintentional Injuries	Genitourinary System
Transport	Blood	Digestive System	Signs/Symptoms	Blood	Respiratory System	Respiratory System	Nervous System	Infectious & Parasitic	Signs/Symptoms

Note: Unintentional Injuries excludes Transport

Transport includes: injured pedestrians, pedal cyclists, motorcyclists, and motor vehicle occupants; injury events among other land transport; water transport, and air and space transport

Figure 3: Traffic-related mortality, by age group, BC, 1998-2002. (VISTA)

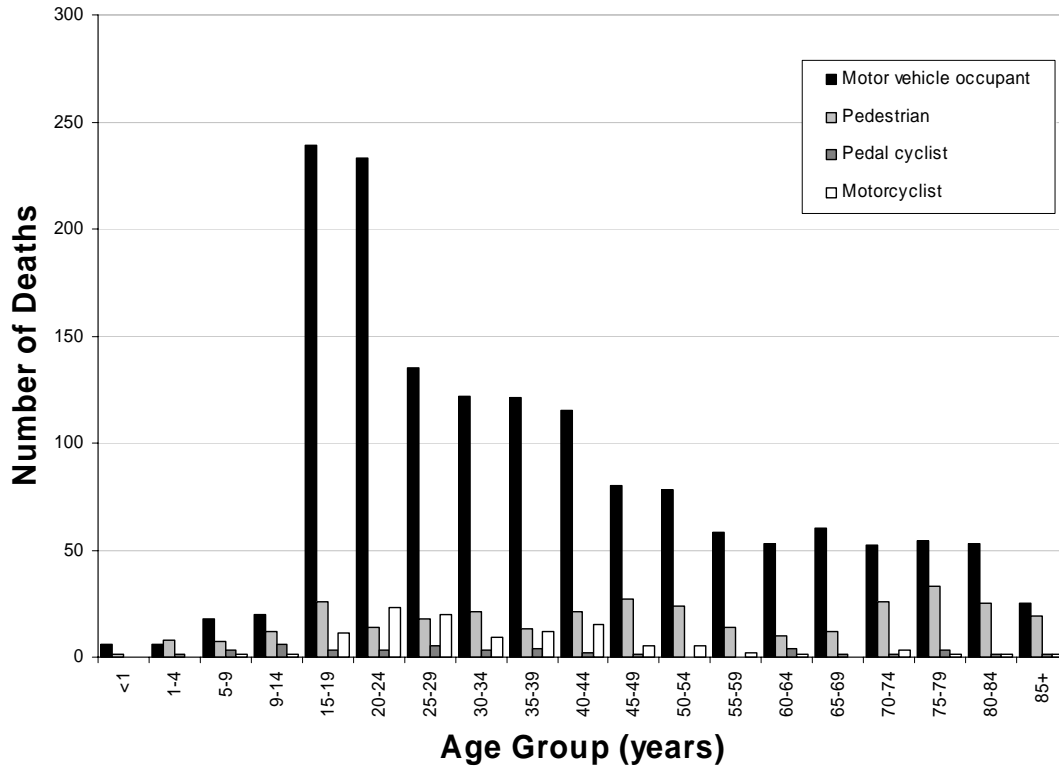


Figure 4: Traffic-related mortality rates per 10,000 population, by age group, BC, 1998-2002. (VISTA)

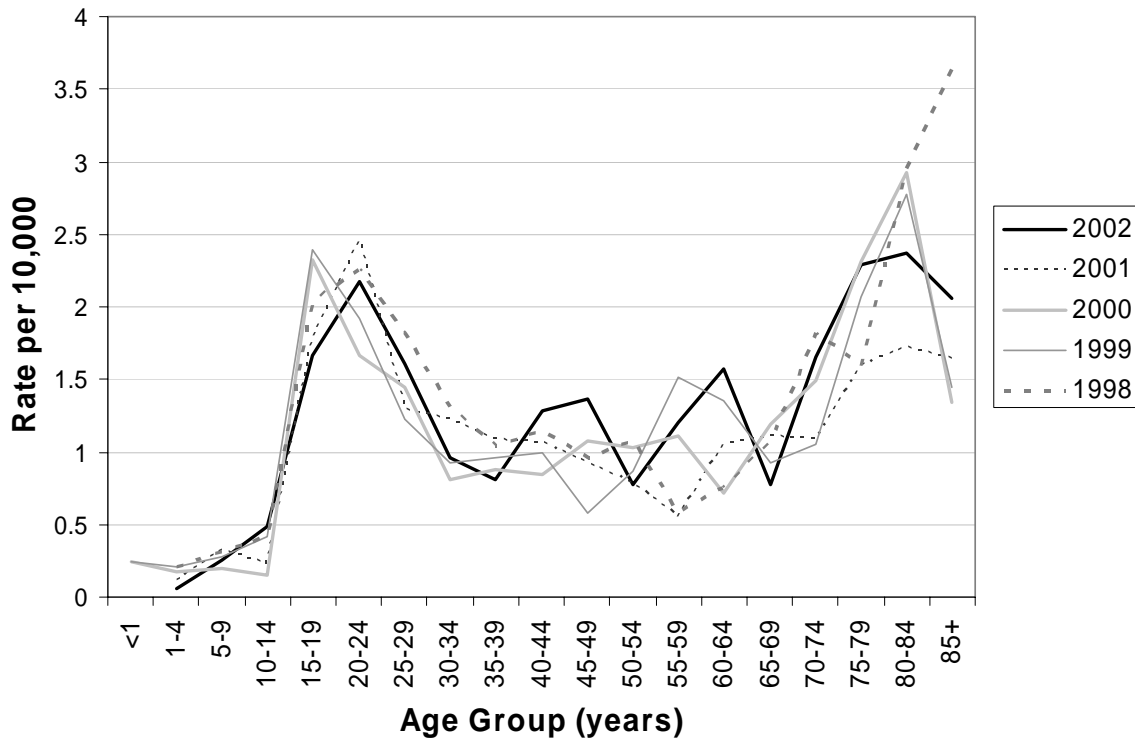


Table 2: Traffic-related deaths among youth 15-19 and 20-24 years, BC, 1998-2002. (VISTA)

Transport	Age Group (years)						Total	
	Sex	15-19			20-24			
		M	F	Total	M	F		Total
Motor Vehicle Occupant		153	86	239	175	58	233	
Pedestrian		16	10	26	12	2	14	
Pedal cyclist		3	0	3	2	1	3	
Motorcyclist		11	0	11	22	1	23	
Total		183	96	279	36	62	273	

From 1998 to 2002, motor vehicle traffic (MVT) injury in BC resulted in 6,237 hospitalizations among youth aged 15 to 24 years, 64.5 percent (4,021) among males and 35.5 percent (2,216) among females (Figure 5) (BC Ministry of Health). MVT injuries include all persons injured by an MVC, such as pedestrians, pedal cyclists and motorcyclists. Annual age-specific hospitalization rates have decreased among youth over the past five years (Figure 6).

MVT injuries accounted for 15.1 percent of all injury-related hospitalizations among 15 to 19 year olds in BC, second only to falls (16.3%), and accounted for 15.6 percent of all injury-related hospitalizations among 20 to 24 year olds (falls 15.0%) (Table 3). The five leading types of injury among occupants included intracranial, fracture of neck and trunk, fracture of lower limb, fracture of skull, and fracture of upper limb (BC Ministry of Health).

Figure 5: Traffic-related hospitalization, by age group and sex, BC, 1998-2002. (BC Ministry of Health)

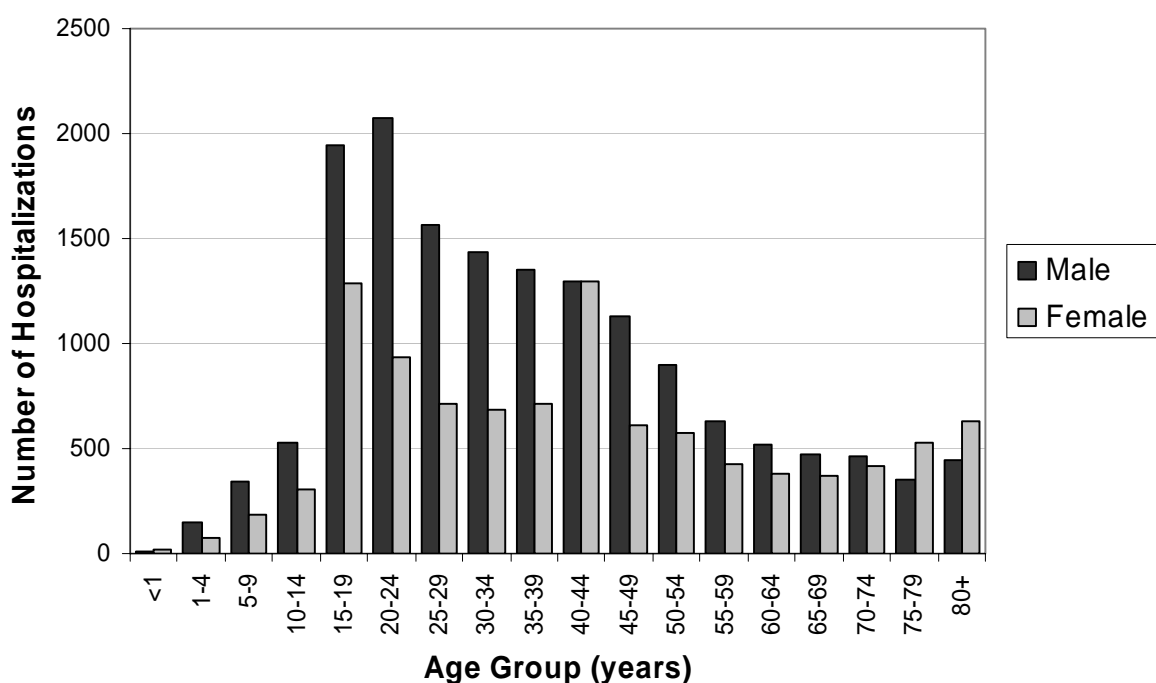


Figure 6: Traffic-related hospitalization rates per 100,000 population, by age group, BC, 1998-2002. (BC Ministry of Health)

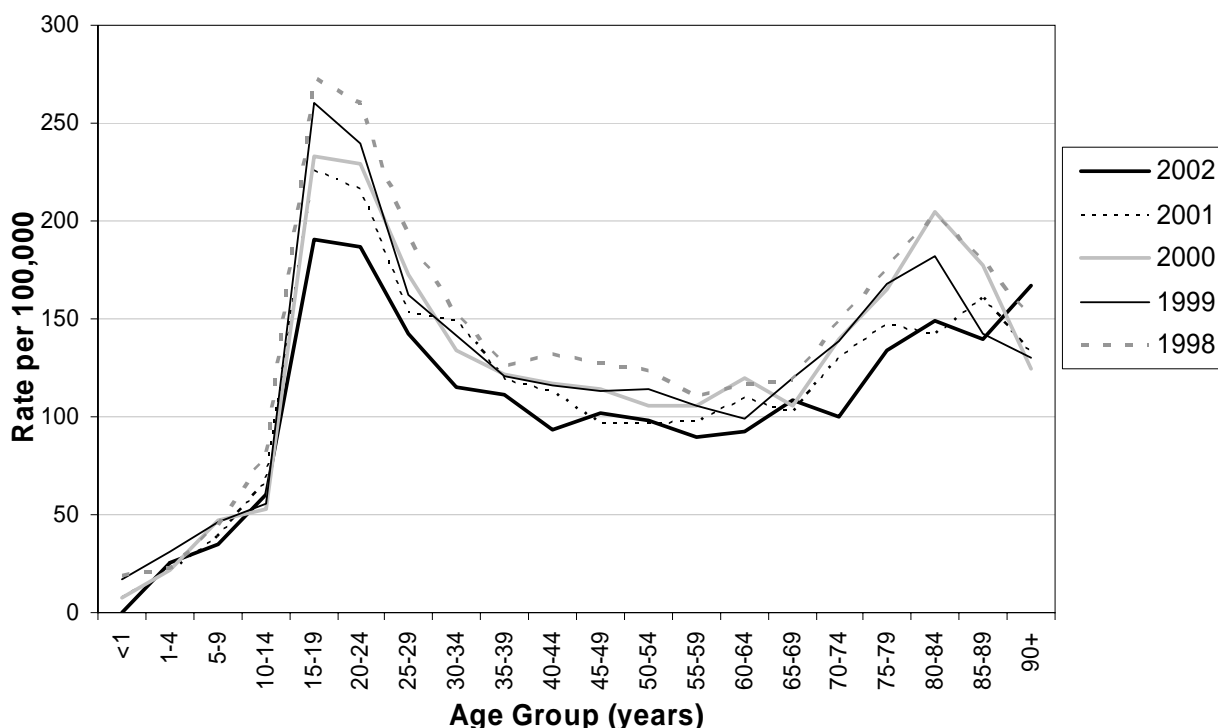


Table 3: Ranking of hospitalization by cause of injury among youth aged 15-19 years and 20-24 years, BC, 1998-2002. (BC Ministry of Health)

15-19 years			20-24 years		
Cause	n	%	Cause	n	%
Falls	3,495	16.3	MV Traffic	3,004	15.6
MV Traffic	3,233	15.1	Falls	2,884	15.0
Suicide	2,854	13.3	Post-op Complications	2,509	13.0
Post-op Complications	2,298	10.7	Suicide	2,208	11.4
Struck by Object	2,207	10.3	Homicide	1,824	9.5
Homicide	1,559	7.3	Struck by Object	1,311	6.8

The BC Emergency Department Injury Surveillance System (EDISS) collected data from 2001 to 2003 in ten selected hospitals within BC.¹ Approximately 11 percent (2,029 of 27,063 visits) of all injury-related emergency department (ED) visits among youth aged 15 to 24 years during this period were caused by MVCs. This was the fourth leading cause of ED visits, following struck by object, falls, and cutting/piercing. MVCs

¹ The Emergency Department Injury Surveillance System (EDISS) was managed by the BC Injury Research and Prevention Unit. Participating hospitals included: Surrey Memorial, Langley Memorial, Delta, Peace Arch (White Rock), Royal Inland (Kamloops), Lillooet District, Prince Rupert Regional, Mills Memorial (Terrace), Kitimat General, and Bulkley Valley District (Smithers).

accounted for 10.1 percent (1,536 of 15,134) among those aged 15 to 19 years, and 12.5 percent (1,493 of 11,929) among the 20 to 24 year olds.

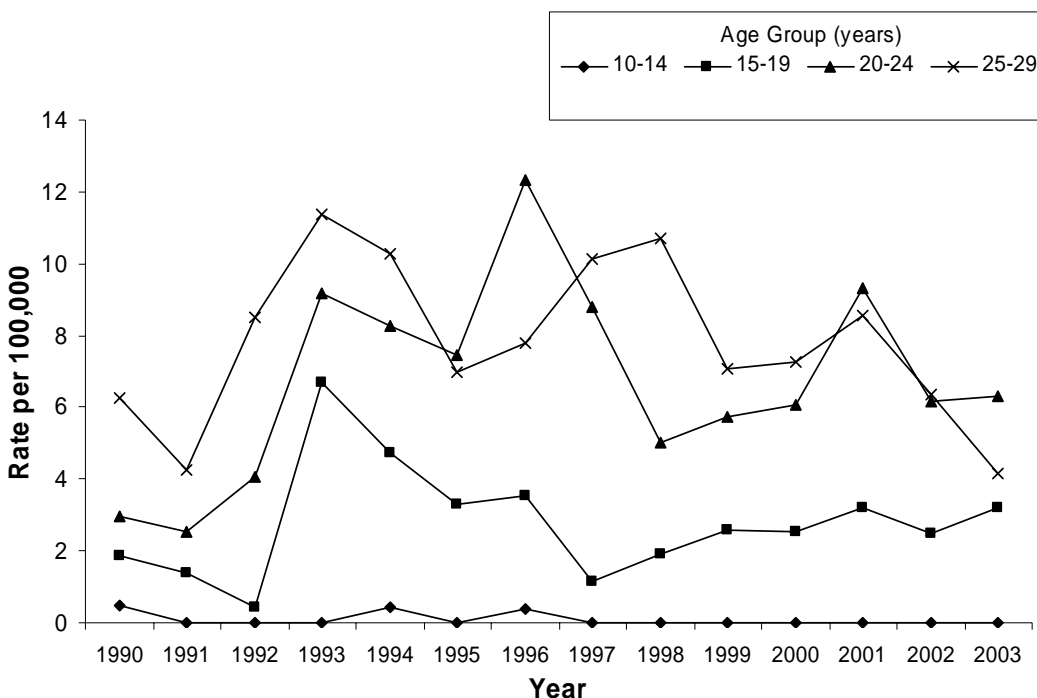
Several risks associated with MVCs among young drivers have been identified, including: alcohol use, unsafe speed, and the overall proportion of young licensed drivers (Insurance Corporation of British Columbia [ICBC], 2002).

Alcohol Use

The association between alcohol use and MVCs is well known. In 2002, 10.4 percent (1,935) of all police attended injury collisions and 25.5 percent (105) of all reported fatal collisions in BC involved alcohol (ICBC, 2002). Combined with the inexperience of young drivers, alcohol increases the risk of being involved in an MVC substantially. Young male drinking drivers are predominately responsible for alcohol-related MVCs. Males aged 21 to 25 years, closely followed by those aged 16 to 21 years, accounted for the highest number of drinking drivers in 2002. Among young females, alcohol involvement in collisions declines gradually with age. Drinking drivers were about equally distributed from ages 16 to 20 years until 41 to 45 years, with the likelihood of alcohol involvement declining after age 45.

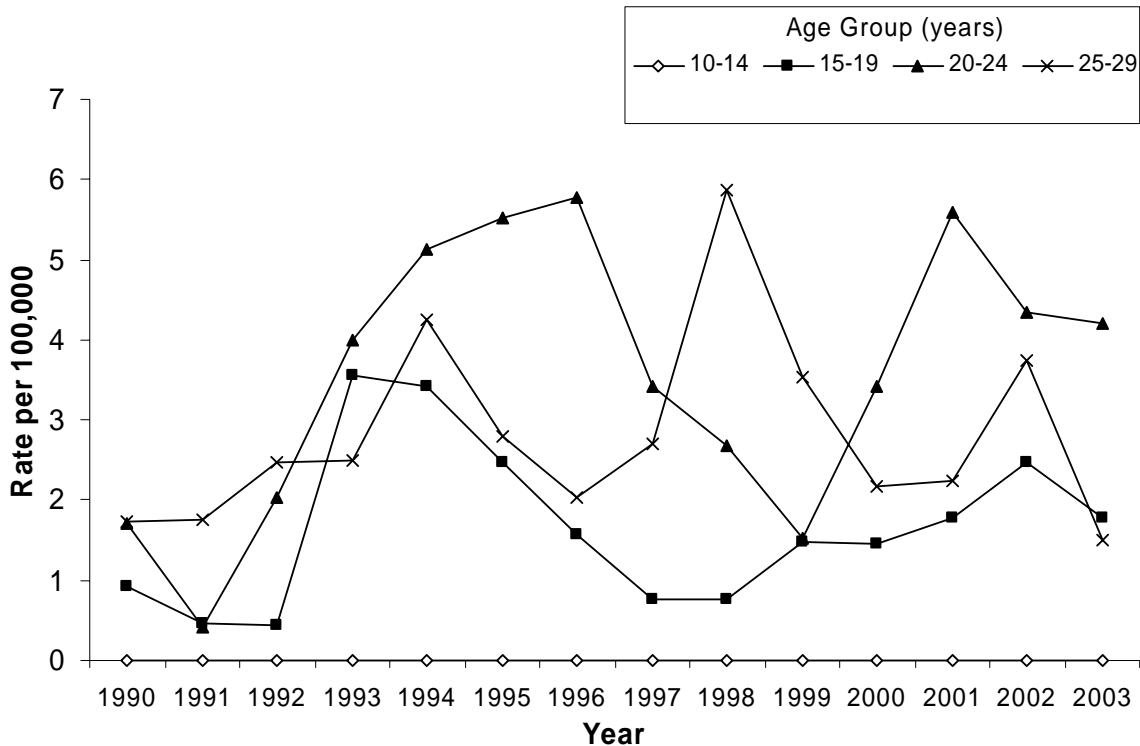
Overall, 16 to 20 year olds, representing 6.7 percent of the total driver population in BC, were responsible for 16.2 percent of all alcohol-related MVC injuries and fatal collisions in 2002 (ICBC, 2002). Young adults aged 21 to 24 years, representing 6.4 percent of the total driver population, were responsible for 16.3 percent of all alcohol-related injuries and fatal MVCs.

Figure 7: Alcohol-related mortality rate per 100,000 population due to unintentional injury, by age group and year, BC, 1990-2003. (BC Vital Statistics Agency)



The rate of alcohol-related mortality, due to unintentional injury as a whole, ranges between 0.5 and 6.7 per 100,000 among 15 to 19 year olds, and between 2.5 and 12.3 per 100,000 among 25 to 29 year olds (Figure 7), with rates highest among 20 to 24 and 25 to 29 year olds (BC Vital Statistics Agency). The rate of alcohol-related mortality due to MVC specifically ranges between 0.5 and 3.6 per 100,000 among 15 to 19 year olds, and between 0.4 and 5.8 per 100,000 among 20 to 24 year olds (Figure 8).

Figure 8: Alcohol-related mortality rate per 100,000 population due to motor vehicle crashes, by age group and year, BC, 1990-2003. (BC Vital Statistics Agency)



Unsafe Speed

Unsafe speed was the single most cited contributing factor to fatal collisions in 2002 in BC, resulting in a total of 5,435 injuries and 182 deaths (ICBC, 2002). Unsafe speed was a factor in 18.1 percent (3,356) of all reported injury collisions, and 38.2 percent (157) of reported fatal collisions during 2002. Male drivers were responsible for 74.2 percent of these collisions: young male drivers between the ages of 16 and 20 years accounted for 26.2 percent of all male driver collisions, and males between the ages of 21 and 30 accounted for 31.4 percent. Of all female drivers traveling at unsafe speeds resulting in an MVC causing injury or death, 24.6 percent were between the ages of 16 and 20 years, and 24.2 percent were between 21 and 30 years.

The percentage of driver injury and driver fatality among speeding drivers was highest among 16 to 20 year olds, decreasing with age (Figure 9) (ICBC, 2002). Among non-speeding drivers, the percentage of driver injury and driver fatality was highest among 21 to 25 year olds (Figure 10).

Figure 9: Percentage of injury and fatality of speeding drivers in unsafe speed collisions, by age group, BC, 2002. (ICBC, 2002)

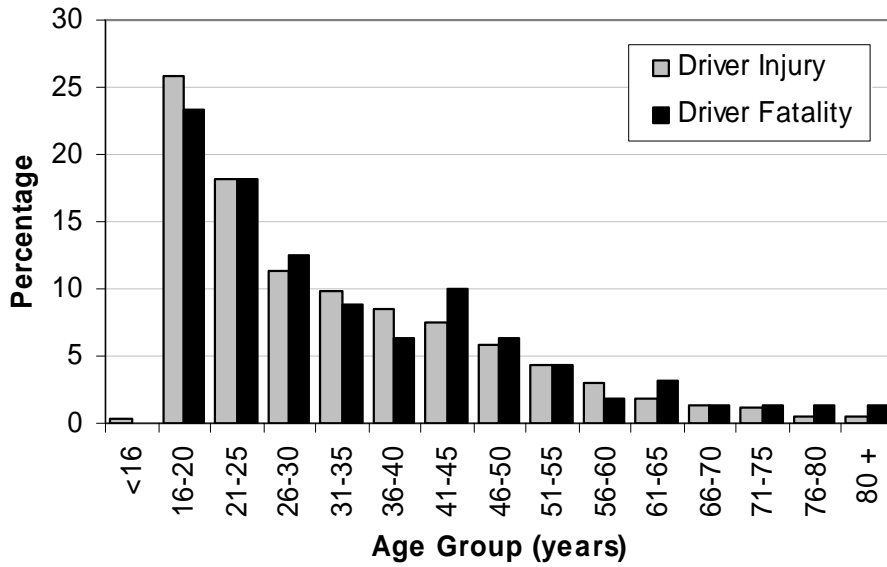
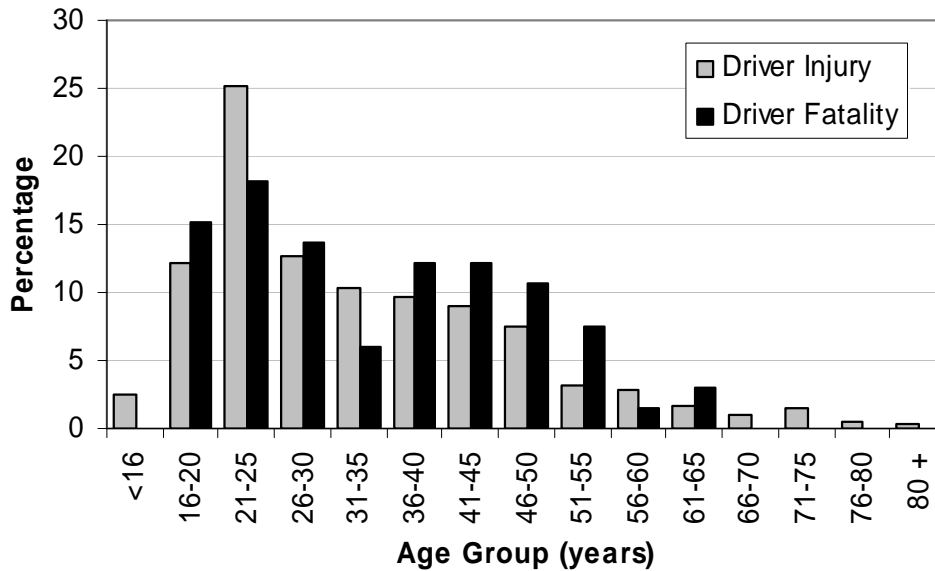


Figure 10: Percentage of injury and fatality of non-speeding drivers in unsafe speed collisions, by age group, BC, 2002. (ICBC, 2002)



Proportion of Young Licensed Drivers

Overall, youth aged 16 to 19 years represented only 5.2 percent of the total BC driver population, but were responsible for 11.8 percent of all MVCs causing injury or death in 2002 (Figure 11) (ICBC, 2002). Young adults aged 20 to 24 years represented 7.9 percent of the driver population and were responsible for 13.6 percent of injury and fatal MVCs.

Figure 11: Percentage of licensed drivers, and licensed drivers in injury or fatal collisions, by age group, BC, 2002. (ICBC, 2002)



INTRODUCTION

Motor vehicle crashes (MVCs) among young drivers are clearly a major public health problem. MVC-related injury is the leading cause of death and disability among adolescents and young adults in BC. This systematic review summarizes the current evidence regarding young drivers, the prevention of MVCs and the intervention of MVC-related injury or death. Recommendations are made regarding strategies demonstrated to reduce the burden of motor vehicle injuries among young drivers ages 15 to 24 years.

In BC, it takes approximately three years for new drivers to attain a full-privilege Class 5 driver's licence (www.icbc.bc.ca). The current graduated licensing system (GLS) consists of four steps:

1. Attain Class 7 Learner's licence (minimum age: 16 years)
2. Class 7 road test (minimum 9-12 months after attaining Class 7L licence)*
3. Class 7 Novice stage (minimum 24 month duration)
4. Class 5 road test (minimum 24 months after attaining Class 7N licence)

** The Class 7 road test can be taken nine months after attaining a Class 7 Learner's licence by those who have completed a driver education course approved by the Insurance Corporation of British Columbia (ICBC). ICBC has considered removing this incentive to take a driver education course; concerned that new drivers require the full 12 months with the Class 7 Learner's licence to gain valuable experience under the restricted conditions.*

Learner and Novice restrictions consist of:

- Qualified supervisor during learner stage
- Passenger restriction during learner & novice stages
- Driving hours between 5 a.m. and midnight during learner stage
- Display "L" or "N" sign on the car during learner and novice stages respectively
- Zero blood-alcohol during learner and novice stages

Violation of any of these licence restrictions, excluding zero tolerance for blood-alcohol, can result in a violation ticket for driving in breach of condition, carrying a standard penalty of three points and a \$75 fine. GLS drivers who violate the zero blood-alcohol restriction can receive, at a minimum, a 12-hour roadside suspension. A violation ticket for breach of condition may also be issued at the discretion of the police officer. The 12-hour suspension notice will be added to the driver's record. (British Columbia Utilities Commission, 2004)

To maintain the focus of this systematic review on prevention and intervention strategies relevant to BC, reviews of graduated licensing systems as a whole were excluded.

Objectives of the Review

This systematic review examines the following research questions:

- What recommendations and best practices are prescribed by the evidence (i.e. systematic reviews & review articles) in literature regarding motor vehicle crashes and youth?

- How can evidence from systematic reviews guide regional health authorities on preventing injuries from motor vehicle crashes among youth?

Contextual Framework

A comprehensive *Health Promotion* perspective was used to identify effective prevention and intervention strategies to prevent MVCs and related injuries among young drivers. The literature review examined all strategies available, including educational, environmental, legislative and social.

METHODS

Search Strategy

In conjunction with a University of British Columbia (UBC) research librarian, the following databases were searched from 1994 onwards: MEDLINE, EMBASE, Cochrane Database of Systematic Reviews (CDSR) and PsychINFO. A systematic search strategy was developed based on the guidelines provided by the National Health Services, Centre for Reviews and Dissemination (Centres for Review & Dissemination, 2001) (Appendix A). Search terms were produced and synonyms generated for the key research themes of youth, motor vehicle crashes, and injuries. Search groupings were combined using AND modifiers among the key facets.

Following the identification of five systematic reviews, searches were rerun removing the “graduated licensing” exclusion from the search strategy. The UBC Traffic Database was also included, as well as ERIC and CINAHL. Hand searching of five key journals from 1994 was also performed: *Accident Analysis and Prevention*, *American Journal of Preventive Medicine*, *Injury Prevention*, *Journal of Safety Research*, and *Traffic Injury Prevention*.

Selection of Eligible Reviews

Eligible reviews were selected from the search outputs in a two-step process. Two researchers assessed all search results independently for applicable articles based on the titles and abstract information. Full articles were then evaluated using the inclusion/exclusion criteria form (Appendix B). Discrepancies were resolved through discussion, with involvement of a third party when necessary.

Inclusion Criteria

To be included in the review, studies met the following four criteria:

Criterion 1: Research evaluating a prevention or intervention strategy to reduce motor vehicle injuries among youth aged 15 to 24 years.

Criterion 2: The study must be a systematic review or designated as a review article.

Criterion 3: The study population must include youth aged 15 to 24 years, or consist of all age groups with a subset of analyses on youth aged 15 to 24.

Criterion 4: The study must report on at least one objective quantified outcome (i.e., injury/crash rate, injury/crash severity, injury/crash frequency, change in behaviour, change in attitude, change in knowledge, or change in surrogate measure).

Quality Assessment

The methodological quality of the selected studies was evaluated using a modified Oxman Checklist for Review Articles (Oxman, 1994; Barns & Bero, 1998) (Appendix C). This checklist evaluated sources of bias involved in a review process related to problem formulation, data collection, data synthesis and interpretation of the results. Each of 12 questions used the rating scheme: Yes = 2; Partial = 1; No/NA = 0. The highest possible score for the Checklist for Review Articles is 24. Two reviewers assessed quality independently. Scores from the two reviewers were summed and then divided by 48 to produce the final score. Scores range between 0 and 1.

The most important criterion for ranking the effectiveness of the prevention/intervention strategies was methodological quality of the research presented. As noted, there are established approaches to quantifying the quality of prevention/intervention studies, both for individual level trials and community-based trials. In this context, systematic reviews are well executed, with minimal sampling or information bias, and provide the strongest evidence for effectiveness. Review articles, with less stringent methodologies, were also assessed using the same criteria.

Reference Articles

Given that this systematic review is based on review articles, both primary research and review articles were found to be duplicated among the cited references of the selected articles. Cited references were extracted from each selected systematic review and review article (Appendix D). Comparison of these references was made to assess if each of the selected reviews presented information from unique sources, or if duplication among cited references existed.

Evidence references appearing in this report are structured to identify both the selected systematic review or review article (marked in ***bold italics***) followed by the primary source as cited within each of the selected reviews. Primary source articles are only listed once if duplication occurred among selected reviews. References are presented from strongest to weakest, as determined by the modified Oxman scores.

Beyond duplication of evidence, it is also important to note that several articles were based on the same study data. Stock et al. (1983), Lund et al. (1986), and Davis (1990) are all based on the DeKalb County, Georgia study from 1978-1981. This was an RCT of high school students who indicated that they would like to get their driver's licence as soon as possible. Students were randomly assigned to one of two driver education curriculum or to a control group.

Data Extraction

Results from each of the 16 selected reviews were extracted into an Excel spread sheet (see Appendix E for data extracted from the six systematic reviews and ten review

articles). Two reviewers worked together to ensure that results from each review were extracted in full using a standardized approach. One of the six systematic reviews (Munro et al., 1995) did not present its data in an easily summarized form, and is therefore not provided in the same format as the other systematic reviews.

Formulation of Recommendations

Based on the findings of this systematic review, recommendations regarding the strategies demonstrated to reduce the burden of MVCs and related injuries among young drivers ages 15 to 24 years are made. For topics that have been the focus of one or more systematic reviews, recommendations are made based on the strength of the evidence. Strength of the evidence was determined by the number of systematic reviews and review articles contributing to the evidence, as well as the total number of reference articles cited within these systematic reviews and review articles. Duplication of evidence among the selected articles was taken into account when formulating the recommendations.

Topics that have not been the focus of a systematic review are recommended for further investigation, and may be considered a *Promising Practice* or *Promising Strategy* based on the available evidence. Evidence is provided as the number of review articles as well as the total number of reference articles cited within these review articles.

RESULTS & RECOMMENDATIONS

Selection of Eligible Reviews

The primary database search yielded 206 articles from MEDLINE (68), EMBASE (36), CDSR (6) and PsychINFO (96). Among these articles, 185 did not meet inclusion criteria and 15 duplicates were identified. A total of five systematic reviews were selected. Of these, two articles were found to be duplicates of the same study.² The four remaining systematic reviews were identified in: MEDLINE (2), EMBASE (1), and CDSR (1).

The secondary database search yielded a further 184 review articles from CINAHL (40), EMBASE (48), ERIC (28), MEDLINE (33), PSYCHINFO (26) and TRANSPORT (9) when the “graduated licensing” exclusion was removed from the search strategy. Three duplicates were identified. One systematic review was selected from MEDLINE. A total of five review papers were selected from: ERIC (3) and CINAHL (2).

Hand searching of five journals (*Injury Prevention*, *Accident Analysis and Prevention*, *American Journal of Preventive Medicine*, *Journal of Safety Research*, and *Traffic Injury Prevention*) from 1994 onwards did not identify any new articles for inclusion.

² The duplicate articles were Vernick et al., 1999 and The Cochrane Injuries Group Driver Education Reviews, 2001. The Vernick article reports on a systematic review of the effects of driver education among high school students, and includes both RCTs and ecological studies. The Cochrane Group article is an update of the Vernick study, focusing only on the RCTs. Results from the update support the results of the original study. The Vernick article was selected for use in this systematic review as it is a landmark article and widely cited in the literature.

Summary of Reviews

Table 4: Summary of selected systematic reviews

Systematic Review	Topic	Interventions
Ker et al., 2004	Advanced Post-Licence Driver Education	Education
Munro et al., 1995	Driver Education, Minimum Legal Driving Age, Impaired Driving, Night-time Driving	Education, Legislation
Roberts et al., 2004	School-based Driver Education	Education
Shults et al., 2001	Alcohol-impaired Driving	Legislation
Vernick et al., 1999	School-based Driver Education	Education
Zwerling & Jones, 1999	Blood-alcohol Concentration	Legislation

Table 5: Summary of selected review articles

Review Article	Topic	Interventions
Grabowski & Morrissey, 2001	Mandatory Seat-belt Use, Maximum-speed-limit, Alcohol-control, Alcohol Taxes	Legislation
Hatcher & Scarpa, 2001	Driver Education, Curfew Laws, Drinking & Driving, Seat-belt Use	Education, Legislation
Heald, 2004	Driver Education, Seat-belt Use, Passengers	Education, Engineering, Social
Mattox, 1997	Antecedent, Consequence and Mixed Interventions: Driver Education, Drinking & Driving, Peer Intervention (Alcohol), Parent Involvement Through Certified Practice, Safety Media Campaigns, Licensing Policies (Curfew, Limited Use of Free Ways, Maximum Speed, Passengers), Driving Restrictions	Education, Legislation, Social
Mayhew et al., 1998	Driver Education	Education
Mayhew & Simpson, 2002	Driver Education	Education
Patel et al., 2000	Driver Education, Alcohol-related Measures, Vehicle-related Measures	Education, Engineering, Legislation
Simons-Morton & Hartos, 2003	Parental Management	Social
Williams, 1995	Driver Education, Maximum Speeds, Night Curfews, Prohibition Against Expressway Driving, Passengers	Education, Legislation, Social
Williams & Preusser, 1997	Night Curfews	Legislation

Quality Assessment

Table 6: Quality assessment of selected systematic reviews

Systematic Review	Modified Oxman Score
Ker et al., 2004	0.98
Munro et al., 1995	0.56
Roberts et al., 2004	0.83
Shults et al., 2001	1.00
Vernick et al., 1999	0.96
Zwerling & Jones, 1999	0.98

Table 7: Quality assessment of selected review articles

Review Article	Modified Oxman Score
Grabowski & Morrissey, 2001	0.33
Hatcher & Scarpa, 2001	0.31
Heald, 2004	0.21
Mattox, 1997	0.31
Mayhew et al., 1998	0.25
Mayhew & Simpson, 2002	0.31
Patel et al., 2000	0.25
Simons-Morton & Hartos, 2003	0.31
Williams, 1995	0.15
Williams & Preusser, 1997	0.25

Strength of Evidence – Avoiding Duplication

Evidence from the selected articles is presented in the following order, based on the quality assessment using the Modified Oxman scale and year of publication, indicating the relative strength of the evidence provided:

Table 8: Order of strength of evidence of selected systematic reviews and review articles, from strongest to weakest

1. Shults et al., 2001	9. Mayhew & Simpson, 2002
2. Ker et al., 2004	10. Hatcher & Scarpa, 2001
3. Zwerling & Jones, 1999	11. Mattox, 1997
4. Vernick et al., 1999	12. Patel et al., 2000
5. Roberts et al., 2004	13. Mayhew et al., 1998
6. Munro et al., 1995	14. Williams & Preusser, 1997
7. Grabowski & Morrissey, 2001	15. Heald, 2004
8. Simons-Morton & Hartos, 2003	16. Williams, 1995

Evidence & Recommendations: Systematic Reviews

This section introduces areas of prevention and intervention research that have been the focus of one or more systematic reviews, and may also be supported by review articles. Topics presented here are accompanied by recommendations based on the evidence.

Education Interventions

Driver Education

Driver education courses provide instruction on the basic operation of a motor vehicle, traffic rules and regulations, safe driving practices, occupant safety, and the hazards of risky behaviour such as drinking and driving (Committee on Injury and Poison Prevention and Committee on Adolescence, 1996). This is typically a two-component program with both in-class and on-road instruction.

Evidence:

- Limited evidence available suggests that driver education has little or no effect on injury rates.
(*Munro et al., 1995*: Raymond et al., 1973; Harrington, 1972; Naatanen & Summala, 1976; Thompson & O'Reilly, 1993; *Mayhew & Simpson, 2002*: Christie, 2001)
- Driver education programs may enable drivers to attain their licence at a younger age.
(*Patel, Greydanus & Rowlett, 2000*: Insurance Institute for Highway Safety and Traffic Injury Research Foundation of Canada, 1999)
- Attaining a driver licence at a younger age may increase the risk for injury.
(*Munro et al., 1995*: Robertson, 1980; *Mayhew & Simpson, 2002*: Christie, 2001)
- Delaying licensure may reduce the population at risk.
(*Hatcher & Scarpa, 2001*: Ulmer et al., 1999)
- Overconfidence leading to more risk taking as a result of driver training has been reported.
(*Mayhew et al., 1998*: Katila et al., 1995)
- Post-licence driver education was not found to be effective at lowering MVC injuries among young drivers.
(*Ker et al., 2004*: Schuman, 1971; Nolen, 2002; *Munro et al., 1995*: Lund, Williams & Zador, 1986; Struckman-Johnson et al., 1989; *Mayhew et al., 1998*: Glad, 1988; Jones, 1983; Katila et al., 1995)

Recommendation:

Driver Education is NOT RECOMMENDED as a stand-alone prevention/intervention strategy.

Incentives for completing Driver Education should not shorten the learner period of BC's graduated licensing system.

School-based Driver Education

School-based driver education is a driver education course conducted within the secondary school (high school) setting, and targeted exclusively towards young drivers.

Evidence:

- School-based driver education was not found to reduce MVCs among youth, but did encourage licensing at a younger age.

(*Vernick et al., 1999*: Strang, 1982; Stock et al., 1983; Lund, Williams & Zador, 1986; Davis, 1990; Seaver, Nichols & Carlson, 1979; Levy, 1988; Levy, 1990; Robertson & Zador, 1978; Robertson, 1980; **Roberts, Kwan & Cochrane Injuries Group Driver Education Reviewers, 2002**: Wynne-Jones, 1984; **Munro et al., 1995**: Redman, Sanson-Fisher & Cockburn, 1988; **Mayhew & Simpson, 2002**: Christie, 2001; Woolley, 2000; **Mayhew et al., 1998**: Ohlson & Stoke, 1986; Barner, 1987; Carstensen, 1994; Jones & McCormac, 1989; Gregersen, 1994; Potvin, Champagne & Laberge-Nadeau, 1988; **Mattox, 1997**: Shaoul, 1975)

- An increase in licensure may lead to an increase in MVCs among youth.

(*Vernick et al., 1999*: Strang, 1982; Stock et al., 1983; Lund, Williams & Zador, 1986; Davis, 1990; Seaver, Nichols & Carlson, 1979; Levy, 1988; Levy, 1990; Robertson & Zador, 1978; Robertson, 1980; **Roberts, Kwan & Cochrane Injuries Group Driver Education Reviewers, 2002**: Wynne-Jones, 1984; **Munro et al., 1995**: Redman, Sanson-Fisher & Cockburn, 1988; **Mayhew & Simpson, 2002**: Christie, 2001; Woolley, 2000; **Mayhew et al., 1998**: Ohlson & Stoke, 1986; Barner, 1987; Carstensen, 1994; Jones & McCormac, 1989; Gregersen, 1994; Potvin, Champagne & Laberge-Nadeau, 1988; **Mattox, 1997**: Shaoul, 1975)

- Programs addressing drinking and driving, increasing awareness of the associated risks and preparing young drivers with strategies when confronted with peer pressure, have shown some success.

(*Hatcher & Scarpa, 2001*: Sheehna et al., 1996; Shope et al., 2001)

Recommendation:

School-based Driver Education is NOT RECOMMENDED as a stand-alone prevention/intervention strategy.

Incentives for completing Driver Education should not shorten the learner period of BC's graduated licensing system.

Legislation Interventions

Blood-alcohol Concentration

The Canadian legal limit for blood-alcohol concentration (BAC) is 80 mg of alcohol per 100 ml of blood. The BC Motor Vehicle Act (MVA) 224 prohibits operating a motor vehicle with a BAC level over 0.08 percent, with fines ranging from \$100 to \$2,000, or imprisonment from seven days to six months, or both. Learner and novice drivers are subject to zero tolerance laws under the graduated licensing system in BC, with penalties including a 12-hour roadside suspension and possible violation ticket for breach of condition at the discretion of the police officer.

Evidence:

- There is sufficient evidence that lower BAC laws are effective in reducing alcohol-related crashes among young or inexperienced drivers.
(*Shults et al., 2001*: Hingson, Heeren & Winter, 1994; Blomberg, 1992; Hague & Cameron, 1989; Maisey 1984; Voas, Lange & Tippetts, 1998; Voas, Tippetts & Fell, 1999; *Zwerling & Jones, 1999*: Smith, 1986; Hingson et al., 1989; *Patel, Greydanus & Rowlett, 2000*: U.S. Dept. of Transportation, 1999; U.S. Dept. of Transportation, 1998)
- A dose-response effect was found when studying laws with different levels of blood-alcohol concentration.
(*Zwerling & Jones, 1999*: Hingson, Heeren & Winter, 1994)
- It was cautioned that the zero tolerance citations given to young drivers are less serious than the driving under the influence (DUI) arrests for adults.
(*Shults et al., 2001*: Voas, Tippetts & Fell, 1999)
- Several barriers to intervention implementation were suggested, including the enforcement of lower BAC laws, and the ability of police officers to find and assess underage drinking drivers.
(*Shults et al., 2001*: Voas, Tippetts & Fell, 1999)
- The effectiveness of stricter enforcement of drinking driving laws is difficult to assess.
(*Munro et al., 1995*: Broughton & Stark, 1986; Dunbar, Penttila & Pikkarainen, 1987; Vingilis & Salutin, 1980)

Recommendation:

Continued Legislation and Enforcement of Blood-alcohol Concentration limits is STRONGLY RECOMMENDED, with meaningful consequences resulting from the violation of zero tolerance among BC's learner and novice drivers.

Further investigation into the benefits of decreasing BC's Blood-alcohol Concentration limits is RECOMMENDED.

Minimum Legal Drinking Age

The legal drinking age is defined by each Canadian province and the class of driving licence (some licences specify no alcohol) (www.bchealthguide.org). The minimum age at which an adult can legally purchase or publicly consume alcohol in BC is currently 19 years.

Table 9: Legal drinking age by province

Province	Current age	legal	Former age	legal	Date of change
Alberta	18		21		1 April 1971
British Columbia	19		21		15 April 1970
Manitoba	18		21		1 August 1970
New Brunswick	19		21		1 August 1972
Newfoundland and Labrador	19		21		25 July 1972
Northwest Territories	19		21		15 July 1970
Nova Scotia	19		21		13 April 1971
Ontario	19		18		1 January 1979
Prince Edward Island	19		18		1 July 1987
Québec	18		20		July 1972
Saskatchewan	19		18		1 September 1976
Yukon	19		21		February 1970

Source: 1999 Canadian Profile, Canadian Centre on Substance Abuse, <http://www.ccsa.ca>

Evidence:

- There is strong evidence that minimum legal drinking age laws are effective in preventing alcohol-related crashes and associated injuries.

(*Shults et al., 2001*: Voas, Tippetts & Fell, 1999; O'Malley & Wagenaar, 1991; Decker, Graitcer & Schaffner, 1988; Legge, 1990; Figlio, 1995; Womble, 1989; Wagenaar & Maybee, 1986; Hoskin, Yalung Mathews & Carraro, 1986; Males, 1986; Hingson et al., 1983; Williams et al., 1983; Smith et al., 1984; Wagenaar, 1986; Durant & Legge, 1993; Lillis, Williams & Williford, 1987; Wagenaar, 1983; Williams, Rich & Zador, 1975; Naor & Nashold, 1975; Ferreira & Sickerman, 1976; Brown & Maghsoodloo, 1981; Whitehead et al., 1975; Smith & Burvill, 1986; Ruhm, 1996; Saffer & Chaloupka, 1989; Saffer & Grossman, 1987a; DuMouchel, Williams & Zador, 1987; Cook & Tauchen, 1984; Chaloupka, Saffer & Grossman, 1993; Saffer & Grossman, 1987b; Dee, 1999; *Grabowski & Morrissey, 2001*: Evans, Neville & Graham, 1991).

- Minimum legal drinking age laws set at age 21 years appear to be most effective. (*Shults et al., 2001*)
- Restricting alcohol consumption among adolescents may translate into an increased risk of alcohol-related crashes when young drivers reach the minimum legal drinking age. (*Shults et al., 2001*: Males, 1986; Asch & Levy, 1990)
- Higher minimum legal drinking ages might be viewed as an unjust punishment for all young people, and therefore be a difficult law to maintain. (*Shults et al., 2001*: Ross, 1992)
- A minimum legal drinking age raised above age 18 years has been reported to reduce MVC fatalities. (*Munro et al., 1995*: Asch & Levy, 1987; Jones, Pieper & Robertson, 1992; MacKinnon & Woodward, 1986; Robertson, 1989; Hingson, Merrigan & Heeren, 1985; Williams et al., 1983)

Recommendation:

Continued Legislation and Enforcement of BC's Minimum Legal Drinking Age is STRONGLY RECOMMENDED.

Further investigation into the benefits of increasing BC's Minimum Legal Drinking age to 21 years is RECOMMENDED.

Minimum Legal Driving Age

You must be at least 16 years of age to apply for a learner driver's licence in BC for both passenger vehicles and motorcycles (www.icbc.bc.ca).

Evidence:

- Increasing minimum legal driving age supports evidence that links age and experience to injury rates among young drivers.
(*Munro et al., 1995*: Levy, 1988; Levy, 1990; Williams, Karpf & Zador, 1983; Preusser, 1988)
- Increasing the minimum legal driving age may increase the rate of injury among motorcyclists, pedal cyclists or pedestrians.
(*Munro et al., 1995*)

Recommendation:

Further investigation is required to ascertain if the Minimum Legal Driving Age in BC should be raised.

Night-time Driving Curfew

Drivers with a learner's licence in BC are allowed to drive between the hours of 5 a.m. and midnight (www.icbc.bc.ca). MVCs as a whole are reported to occur more often during night-time hours. Increased risk has been reported for the hours between 10 p.m. and midnight (*Grabowski & Morrissey, 2001*: Chen et al., 2000).

Evidence:

- Night-time driving curfews imposed on young drivers aged 16 years, and aged 17 years and younger have shown to reduce both crash rates as well as licensure among young drivers.
(*Munro et al., 1995*: Levy, 1988; Levy, 1990; Preusser et al., 1984; Preusser et al., 1990; *Hatcher & Scarpa, 2001*: Preusser, Zador & Williams, 1993; *Williams & Preusser, 1997*: Frith & Perkins, 1992; Ferguson et al., 1996)
- Further investigation of this issue has been suggested.
(*Hatcher & Scarpa, 2001*: Foss & Evenson, 1999)

Recommendation:

Continued Legislation and Enforcement of BC's Night-time Driving Curfew for learner drivers is RECOMMENDED.

Further investigation is required to determine if BC's Night-time Driving Curfew should be expanded to novice drivers. Exemptions to this curfew could be made, e.g. for the purposes of driving to and from work.

Evidence & Recommendations: Review Articles

This section introduces areas of prevention/intervention research that have been summarized in review articles, but have not been the focus of a systematic review. Due to the quality assessment of reviews as a whole (as measured by the Modified Oxman scale), topics presented here are recommended for further investigation.

Environmental Interventions

Vehicle Crash Worthiness

Vehicle crash worthiness is influenced by the size and weight of the vehicle, as well as by the inclusion of safety devices such as seat-belts, automatic airbags, and anti-lock breaks.

Evidence:

- During a two-car collision, a vehicle mass (size and weight) difference of two times increases the risk of the driver of the smaller car dying by 12 times over that of the driver of the larger car.

(*Patel, Greydanus & Rowlett, 2000*: Evans & Frick, 1993; Farrow, 1987; Rivara, Rivara & Bartol, 1998)

- In single car crashes, drivers of lighter cars have a two to three times higher risk of dying than drivers in heavier cars.

(*Patel, Greydanus & Rowlett, 2000*: Rivara, Rivara & Bartol, 1998)

Recommendation:

Increasing awareness of Vehicle Crash Worthiness among young drivers and their parents is a PROMISING STRATEGY.

Legislative Interventions

Alcohol Control Laws

In BC, several measures and programs are in place addressing the issue of drinking and driving, including public education and awareness, managing the opportunity to drink and drive, enforcement, sanctions, and rehabilitation (British Columbia, 2003).

Completing the *Serving It Right* program (www.servingitright.com) is a requirement for servers working in licensed establishments under the Liquor Control and Licensing Act. This program stipulates the importance of anticipating and managing the potential consequences of over-service. Furthermore, the Occupier's Liability Act stipulates the principle of *duty of care*, where the establishment's licensee and servers are required to protect patrons and others from harm that may be associated with the activity of drinking. Giving authorization of lawsuits against alcohol servers is also known as *dram shop laws*.

Sanctions currently enforced in BC include (British Columbia, 2003):

- Criminal Code of Canada drinking and driving convictions, where a first conviction carries a \$600 fine and one-year prohibition, a second conviction carries a penalty of 14 days in jail and a two-year prohibition, and a third or subsequent conviction carries a penalty of 90 days in jail and two or more years of prohibition.
- MVA sanctions for Criminal Code drinking and driving convictions, where any conviction carries a one-year driving prohibition, a first conviction carries a one-year driver licence suspension, a second conviction carries a three-year driver licence suspension, and a third or subsequent conviction carries an indefinite driver licence suspension.
- Administrative Driving Prohibitions (ADP) and Sanctions, including: 24-hour driving prohibition at roadside for driving affected by alcohol; 12-hour driving suspension for novice drivers in violation of zero tolerance for blood-alcohol, with a possible discretionary prohibition from the Superintendent of Motor Vehicles; 90-day administrative driving prohibition for BAC exceeding 0.08 percent (MVA 224) or refusing a breath test (MVA 90.3); and discretionary prohibitions from the Superintendent of Motor Vehicles for a bad driving record including multiple drinking and driving convictions, ADPs and 24-hour prohibitions.

Other alcohol control measures include required licence sanctions for drivers refusing alcohol blood testing (MVA 226), and ignition interlocks for convicted drunk drivers where a negative breath test is required to start their car. Furthermore, anti-plea bargaining is a statute, case law or policy that prohibits plea bargaining or reducing an alcohol-related offence to a non-alcohol related offence (www3.madd.org).

Evidence:

- Dram shop laws are reported to reduce teenage motor vehicle fatalities. (*Grabowski & Morrissey, 2001*: Chaloupka, Saffer & Grossman, 1993; Kenkel, 1993; Ruhm, 1996)
- The following were found to reduce predicted teenage traffic deaths:
 - Preliminary breath-test legislation (*Grabowski & Morrissey, 2001*: Kenkel, 1993)
 - Sobriety checkpoints (*Grabowski & Morrissey, 2001*: Kenkel, 1993)
 - Anti-plea bargaining statutes (*Grabowski & Morrissey, 2001*: Chaloupka, Saffer & Grossman, 1993)

Recommendation:

**Continued Legislation and Enforcement of Alcohol Control is a
PROMISING PRACTICE.**

Mandatory Seat-belt Use Law

BC Seat-belt Laws and Regulations from the MVA and Motor Vehicle Act Regulations (MVR) include (www.icbc.bc.ca):

- MVA 220 (1) A seat-belt assembly includes a pelvic restraint, an upper torso restraint or both.
- MVA 220 (2) A person must not sell, offer for sale or operate a motor vehicle manufactured or assembled after December 1, 1963, other than a motorcycle, unless it is equipped with at least two seat-belt assemblies in the front seat.
- MVA 220 (3) A person must not operate a motor vehicle that has had the seat-belts removed, rendered partly or wholly inoperative, or modified to reduce its effectiveness.
- MVA 220 (4) A seat-belt assembly must be worn when a motor vehicle is being operated.
- MVA 220 (6) Drivers must ensure that passengers who have attained six years of age but are under 16 years of age, are properly restrained.
- MVR 36.01 A person shall not operate a motor vehicle in which there is a child under the age of six unless the driver ensures that the child is securely fastened by a properly utilized and adjusted restraint system which complies with the MVA.
- MVR 36.02 All infants, birth to nine kg, must be restrained in a rear-facing restraint system which complies with the Canadian Motor Vehicle Safety Standard (CMVSS) 213.1.
- MVR 36.03 Toddlers weighing nine to 18 kg (about 20 - 40 lbs.) in a motor vehicle driven by a parent or guardian must be restrained in a child restraint that complies with the Canadian Motor Vehicle Safety Standard 213 which is installed in the vehicle with the adult seat belt and a top tether strap. Toddlers driven by an adult who is not the parent or guardian may be restrained as defined in 36.03 or by a lap belt.
- MVR 36.04 All children under the age of six not categorized in sections 36.02 and 36.03, shall be restrained by the lap belt.

MVA infractions carry a \$95 fine with a 15 percent surcharge for research and trauma care, for a total of \$109.

Primary enforcement laws allow police to cite a driver for having unrestrained occupants, while secondary enforcement laws only allow police to ticket drivers if the vehicle is stopped for other reasons (*Patel, Greydanus & Rowlett, 2000*; Rivara, 1999).

In BC, seat-belt laws and regulations are secondary enforcement laws.

Evidence:³

- Seat-belt laws with primary enforcement have been found to significantly reduce MVC fatalities among 16 to 17 year olds by nearly eight percent and among 18 to 19 year olds by almost ten percent.
(*Grabowski & Morrissey, 2001*: Dee & Evans, 2001; *Patel, Greydanus & Rowlett, 2000*: Rivara, 1999)
- Few programs to promote seat-belt use among adolescents specifically have been implemented and evaluated.
(*Hatcher & Scarpa, 2001*)
- One study successfully demonstrated that education and incentives are effective in increasing seat-belt use among high school students.
(*Mattox, 1997*: Campbell, Hunter & Stutts, 1984)
- One study found that parental use of seat-belts was not an indicator that adolescents in the car would also buckle-up.
(*Heald, 2004*: Williams, McCartt & Geary, 2003)

Recommendation:

Continued Legislation and Enforcement of Mandatory Seat-belt Use is a PROMISING PRACTICE.

It is RECOMMENDED that Mandatory Seat-belt Use be a Primary Enforcement Law

Maximum Speed Laws

Speed is a risk factor for MVCs among young drivers, and those with risk taking behaviours. Within city limits, maximum speed is 50 km/hr unless otherwise posted. Highway speeds vary up to 110 km/hr.

Evidence:

- Statistical significance was not found in a study of young driver fatalities in a move from a 55 mph to 65 mph speed limit.
(*Grabowski & Morrissey, 2001*: Dee & Evans, 2001)

Recommendation:

There is insufficient evidence regarding Maximum Speed Laws upon which to base a recommendation.

³ Although seat-belt use is considered the single most effective means of reducing MVC injuries and deaths, it has not been the topic of a systematic review among the general population or among youth. A systematic review has recently been conducted concerning three interventions to increase the use of safety belts: safety belt laws, primary safety belt laws, and enhanced enforcement programs (Dinh-Zarr, Sleet, Shults et al., 2001).

Passenger Restrictions

It is suggested that young drivers are more likely to engage in risk taking behaviour when in the presence of their peers. Such behaviours include: drinking and driving, speeding, swerving, crossing the centre line, skidding and running red lights (*Grabowski & Morrisey, 2001*; Doherty, Andrey & MacGregor, 1998). Beyond risk taking, it is also suggested that distractibility plays a role, in the form of talking, music, eating, and other social behaviour (*Heald, 2004*; Preusser et al., 1998).

Drivers holding a learner licence in BC must have a supervisor aged 25 years or older holding a valid driver's licence, and may have one other passenger in the car. Drivers holding a novice licence obtained on or after October 6, 2003 can have one passenger alone or two passengers if one is a supervisor aged 25 years or older holding a valid driver's licence. For these novice drivers, passenger restrictions do not apply to immediate family members. Drivers holding a novice licence obtained prior to October 6, 2003 are not subject to any passenger restrictions. (www.icbc.bc.ca)

Evidence:

- Studies have reported an increased risk of at-fault crashes among young drivers when accompanied by adolescent passengers.
(*Grabowski & Morrisey, 2001*: Chen et al., 2000; Doherty, Andrey & MacGregor, 1998; *Heald, 2004*: Preusser et al., 1998)
- The likelihood of a crash being fatal was increased if passengers were in their teens or twenties, and when passengers were male rather than female.
(*Grabowski & Morrisey, 2001*: Chen et al., 2000; Doherty, Andrey & MacGregor, 1998)
- New Zealand's provision that passengers are not allowed with a beginning licence holder without the presence of an adult has shown to be effective in reducing teenage passenger injuries when the driver was also a teenager.
(*Williams, 1995*: Frith & Perkins, 1992)

Recommendation:

Continued Legislation and Enforcement of Passenger Restrictions during learner and novice stages is a PROMISING PRACTICE.

Social Interventions

Parental Involvement

Parental attitudes and practices related to teen driving include: amount of practice driving time, time of licensure (age of new driver), and managing driving privileges after licensure (restrictions placed by parent) (*Simons-Morton & Hartos, 2003*).

Evidence:

- Greater amounts of practice time during the learner period do not reduce crash risks after licensure.
(*Simons-Morton & Hartos, 2003*: McCartt, Shabanova & Leaf, in press)
- Early licensure is a risk factor for MVCs among youth, therefore delaying licensure may be protective.
(*Simons-Morton & Hartos, 2003*: McKnight & Peck, 2002; Preusser, Williams & Lund, 1985)
- A link exists between teen passengers and crashes among young drivers, therefore limits to passengers may be protective.
(*Simons-Morton & Hartos, 2003*: Chen et al., 2000; Doherty et al., 1998)
- Greater parental involvement is associated with less risky teen driving behaviour including increased seat-belt use and less speeding.
(*Simons-Morton & Hartos, 2003*: Beck et al., 2001)
- Low parental monitoring is associated with risky teen driving behaviour including increased traffic violations (4x higher) & MVCs (7x more likely) among teens.
(*Simons-Morton & Hartos, 2003*: Hartos et al., 2000)

Recommendation:

Increasing awareness of the value of Parental Involvement is a PROMISING STRATEGY.

Parents should be encouraged to negotiate driving privileges with their children.

Other Risks not Captured by the Review Literature

Fatigue

Independent of alcohol use, some evidence suggests that acute sleepiness while driving is a risk factor for an injury MVC (*Ferguson, 2003*: Connor et al., 2002). Teenage sleep patterns are documented to shift towards later times for both sleeping and waking (*Ferguson, 2003*: Wolfson & Carskadon, 1998). Therefore, early mornings lead to increased daytime sleepiness which may also affect night-time sleepiness, especially when alcohol is also a factor (*Ferguson, 2003*).

Evidence:

- Elevated night MVC risk among drivers 18 to 24 years old has been documented.
(*Ferguson, 2003*: Akerstedt & Kecklund, 2001)

In-vehicle Distractions

In-vehicle distractions, such as music (radio, CD), cell phones, navigation devices and video systems are becoming more common in this technologically advanced age. The need for standards to limit this potential distraction from in-vehicle devices

is currently being addressed by manufacturers, government regulators and others (*Ferguson, 2003*).

Evidence:

- Young drivers are not as adept as more experienced drivers at dealing with in-vehicle distractions while maintaining focus on the road.
(*Ferguson, 2003*: Mourant & Rockwell, 1972; Summala, 1996)

ACTIONS FOR REGIONAL HEALTH AUTHORITIES

Regional Health Authorities should create a Community Facilitator/Convener position. This would see each Health Authority convening and supporting community coalitions to address MVCs among youth (e.g. Mothers Against Drunk Driving - MADD), including such things as the provision of direct financial support, but more likely in-kind support (facilities for seminars, resources such as AV equipment, educational materials, presentations by health care professionals). This demands that the Health Authority first recognize the players, establish relations, and form a network. In order that they take the co-ordinating role, they must make the case for MVC reduction as a public health priority, and must be seen by others in the network to have committed appropriate resources to assume that role and support the future collaborative efforts.

Regional Health Authorities should take an Inter-Ministerial Approach. The Health Authorities are well-positioned (particularly if the community efforts as described above are flourishing) to establish inter-ministerial connections and collaboration on the issue of Youth MVC reduction. This would include connections, in the first instance, with the Ministries of Education, Transportation, Attorney General, and others. Public Policy that supports Youth MVC reduction as a public health concern will necessarily require interdisciplinary consideration and inter-ministerial support to move forward.

Regional Health Authorities should work with community groups to develop programs geared towards reducing the risks of MVCs among youth, such as a volunteer *safe-ride home* to keep young drinking drivers off the road, or encouraging young drivers not to exceed passenger limitations or break night-time driving curfews.

Regional Health Authorities should advocate for stronger enforcement of current legislation, from blood-alcohol concentration laws and mandatory seat-belt use among all drivers, to night-time driving curfews and passenger restrictions among learner and novice drivers.

Regional Health Authorities should advocate for greater driver skills education among learner and novice drivers, while supporting an ICBC proposal to require a full 12-month period after attaining a Class 7 Learner's licence before qualifying for the Class 7 road test.

LIMITATIONS

This systematic review summarizes the review literature evaluating prevention and intervention strategies for MVCs and related injury among young drivers, where studies reported quantifiable outcomes such as the rate or frequency of MVCs or injury, or changes in behaviour, attitude, knowledge or other surrogate measures.

One criterion of this review was that the study population of eligible articles either be the 15 to 24 year age group specifically, or a population based study that highlighted this age group within its results. Therefore, many population based studies and community level prevention and intervention strategies, such as environmental (traffic calming measures, vehicle safety), and enforcement (road-side checks, random breath testing), that did not highlight youth specifically are not represented in this review.

Furthermore, with the exclusion of the GLS, articles may have been inadvertently missed if they reported on an aspect of some systems, such as driver education, or merely referred to GLS in the abstract. Although completing a driver education course allows learners to test for their novice licences three months early, it is not in itself part of the GLS in BC. In an attempt to account for this, the literature search was repeated removing the “graduated licensing” exclusion.

Time constraints in producing this systematic review influenced the decision to do a “review of reviews”, allowing for the identification of key research without sifting through the mass of primary studies available. Therefore, if an MVC prevention or injury intervention strategy for young drivers has not been the topic of a review itself, it will not have been captured here.

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APPENDIX A

Search Strategies

MEDLINE Strategy

1. meta-analysis.sh,pt. or meta-analy:.tw. or metaanaly:.tw.
2. ((systematic: or quantitativ:) adj (review: or overview:)).tw.
3. (cochrane or medline or cinahl or embase or scisearch or psychinfo or psycinfo or psychlit or psyclit or (national and library)).tw.
4. ((handsearch: or search:) and (cochrane or medline or cinahl or embase or scisearch or psychifo or psycinfo or psychlit or psyclit or (national and library) or (hand: or manual: or electronic: or bibliograph: or database:))).tw.
5. ((review or guideline).pt. or consensus.ti. or guideline:.ti. or literature.ti. or overview.ti. or review.ti.) and (3 and 4)
6. ((synthesis or overview or review or survey) and (systematic or critical or methodologic or quantitative or qualitative or literature or evidence or evidence-based)).ti.
7. 1 or 2 or 3 or 4 or 5 or 6
8. traffic accidents/ or crash:.mp. or collision?.mp,tw.
9. exp automobile driving/
10. (automobile or vehicle? or motor or transport:).mp,tw.
11. 8 or 9 or 10
12. exp accident prevention/
13. (prevent: or reduc: or mortal: or death\$.mp,tw. or pc.fs.
14. exp cause of death/ or exp mortality/ or exp death/
15. 12 or 13 or 14
16. exp aged/ or geri:.mp,tw. or exp middle aged/ or infant.mp,tw. or child.ti. or children.tw. or pre?school.mp,tw.
17. exp walking/ or pedestrian\$.mp. or bicycl:.mp. or swim:.mp. or skat:.mp.
18. exp drugs/ or drug:.mp,tw. or de.fs. or diagnos:.mp,tw. or illness.mp,tw. or disease:.mp,tw. or pain.mp,tw.
19. patient\$.mp,tw. or surg:.mp,tw. or rehab:.mp,tw. or care.mp,tw. or treatment.mp,tw. or therap:.mp,tw.
20. 16 or 17 or 18 or 19
21. 7 and 11 and 15
22. 21 not 20
23. exp adolescence/ or teen:.mp. or you:.mp. or (young adj1 adult).mp. or adult:.mp.
24. 22 and 23
25. limit 24 to human
26. limit 25 to english language

EMBASE Strategy

1. meta-analysis.pt. or meta-analy:.tw. or metaanaly:.tw.
2. systematic: or quantitativ:) adj (review: or overview:)).tw.
3. (cochrane or medline or cinahl or embase or scisearch or psychinfo or psycinfo or psychlit or psychlit or (national and library)).tw.
4. ((handsearch: or search:) and (cochrane or medline or cinahl or embase or scisearch or psychifo or psycinfo or psychlit or psychlit or (national and library) or (hand: or manual: or electronic: or bibliograph: or database:))).tw.
5. ((review or guideline).pt. or consensus.ti. or guideline:.ti. or literature.ti. or overview.ti. or review.ti.) and (3 and 4)
6. ((synthesis or overview or review or survey) and (systematic or critical or methodologic or quantitative or qualitative or literature or evidence or evidence-based)).ti.
7. 1 or 2 or 3 or 4 or 5 or 6
8. traffic accidents/ or crash:.mp. or collision?.mp,tw.
9. exp automobile driving/
10. (automobile or vehicle? or motor or transport:).mp,tw.
11. 8 or 9 or 10
12. exp accident prevention/
13. (prevent: or reduc: or mortal: or death\$).mp,tw. or pc.fs.
14. exp cause of death/ or exp mortality/ or exp death/
15. 12 or 13 or 14
16. exp aged/ or geri:.mp,tw. or exp middle aged/ or infant.mp,tw. or child.ti. or children.tw. or pre?school.mp,tw.
17. exp drugs/ or drug:.mp,tw. or de.fs. or diagnos:.mp,tw. or illness.mp,tw. or disease:.mp,tw. or pain.mp,tw.
18. patient\$.mp,tw. or surg:.mp,tw. or rehab:.mp,tw. or care.mp,tw. or treatment.mp,tw. or therap:..mp,tw.
19. 16 or 17 or 18
20. 7 and 11 and 15
21. 20 not 19
22. limit 21 to human
23. limit 22 to english language

PsycINFO Strategy

1. meta-analysis.sh,pt. or meta-analy:.mp,tw. or metaanaly:.mp,tw.
2. ((systematic: or quantitativ:) adj (review: or overview:)).mp,ti,tw.
3. (cochrane or medline or cinahl or embase or scisearch or psychinfo or psycinfo or psychlit or psyclit or (national and library)).tw.
4. ((handsearch: or search:) and (cochrane or medline or cinahl or embase or scisearch or psychifo or psycinfo or psychlit or psyclit or (national and library) or (hand: or manual: or electronic: or bibliograph: or database:))).tw.
5. ((review or guideline).pt. or consensus.ti. or guideline:.ti. or literature.ti. or overview.ti. or review.ti.) and (3 and 4)
6. ((synthesis or overview or review or survey) and (systematic or critical or methodologic or quantitative or qualitative or literature or evidence or evidence-based)).mp,tw.
7. 1 or 2 or 3 or 4 or 5 or 6
8. traffic accidents/ or crash:.mp. or collision?.mp,tw. or automobile.mp. or vehicle?.mp. or drivers/
9. (accident: or prevent:).mp,tw.
10. 8 and 9
11. 7 and 10
12. limit 11 to yr=1995-2004
13. limit 12 to (200 adolescence or "300 adulthood " or 320 young adulthood)
14. (graduated or licen:).tw,mp. or senior:.mp,tw. or old:.mp,tw.
15. adolescen:.mp,tw. or teen:.tw,mp. or you:.mp,tw. or young adult.mp,tw.
16. 13 not 14
17. 15 and 16
18. limit 17 to journal article
19. limit 18 to human
20. limit 19 to english language
21. limit 20 to abstracts

APPENDIX B

Inclusion Form

INCLUSION FORM

Date: dd _____ mm _____ yr _____ Reviewer: _____ Reference Number _____

1. STUDY TOPIC

Research evaluating:

A prevention or intervention strategy to prevent motor vehicle injuries among youth Yes [] No []

2. STUDY DESIGN

Systematic Review Yes [] No []
Review Articles Yes [] No []

3. STUDY PARTICIPANTS

Study population involves:

Youth (15-24) Yes [] No []
All ages, data presented separately on 15-24 year age group Yes [] No []

4. STUDY OUTCOMES

Study reports:

At least one objective quantified outcome (CIRCLE):
injury rates; frequency of injuries;
change in behaviour / attitude / knowledge Yes [] No []
public policy, environmental safety interventions,
community-based interventions and
education

FINAL DECISION

[] INCLUDE (meets at least one criterion in each category)

[] EXCLUDE - reason: _____

[] UNSURE (need more information)

If disagreement between reviewers, final outcome

[] INCLUDED [] EXCLUDED

Check box if study provides: [] explicit information on motor vehicles crashes among youth
[] useful background information

APPENDIX C

Modified Oxman Form for Quality

Table C: Modified Oxman form for quality

1. Was the purpose of the review clearly stated	2 / 1 / 0
2. Did the authors clearly describe their strategy for identifying primary research studies on the review topic?	2 / 1 / 0
3. Was the search strategy appropriate?	2 / 1 / 0
4. Did the authors clearly report their criteria for deciding which studies to include and exclude?	2 / 1 / 0
5. Were the inclusion/exclusion criteria appropriate?	2 / 1 / 0
6. Did the authors clearly report their criteria for assessing the quality/validity of studies included?	2 / 1 / 0
7. Was the validity assessment appropriate?	2 / 1 / 0
8. Did the authors clearly report their strategy for combining study results (either qualitatively or quantitatively)?	2 / 1 / 0
9. Were study results combined appropriately?	2 / 1 / 0
10. Were the findings clearly summarized (either graphically or in words)?	2 / 1 / 0
11. Did the authors adequately discuss data limitations and study inconsistencies?	2 / 1 / 0
12. Were the stated conclusions supported by the data presented?	2 / 1 / 0

Yes = 2
 Partial = 1
 No = 0
 NA = 0

APPENDIX D

*Reference Lists of Relevant Studies from Selected
Systematic Reviews and Review Articles*

Table D1: Reference Lists of Relevant Studies from Selected Systematic Reviews

Systematic Review	Relevant References
Ker et al., 2004	<p>Nolen, S., Engstrom, I., Folkesson, Jonsson, A., Meyer, B., & Nygard, B. (2002). PILOT – Further education of young drivers. Final report. PILOT – Vidareutbildning av unga bilforare. Slutrapport, Swedish National Road and Transport Research Unit (VIT) 2002; rapport 457.</p> <p>Schuman, S. H., McComochie, R., & Pelz, D. C. (1971). Reduction of young driver crashes in a controlled pilot study: Two year follow-up in one Michigan high school. <i>JAMA</i>, 218(2), 233-237.</p>
Munro et al., 1995	<p>Asch, P., & Levy, D. T. (1987). Does the minimum drinking age affect traffic fatalities: <i>Journal of Policy Analysis and Management</i>, 6, 180-192.</p> <p>Broughton, J., & Stark, D. C. (1986). The effect of the 1983 changes to the law relating to drink/driving. Research report 89. Crowthorne, Berks: Road Safety Division, Safety and Transportation Department, Transport and Road Research Laboratory.</p> <p>Dunbar, J. A., Penttila, A., & Pikkarainen, J. (1987). Drinking and driving success of random breath testing in Finland. <i>BMJ</i>, 295, 101-104.</p> <p>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. <i>Accid Anal Prev</i>, 4, 191-240.</p> <p>Hingson, R., Merrigan, D., & Heeren, T. (1985). Effects of Massachusetts raising its legal drinking age from 18 to 20 on deaths from teenage homicide, suicide and nontraffic accidents. <i>Pediatr Clin North Am</i>, 32, 221-232.</p> <p>Jones, N. E., Pieper, C. F., & Robertson, L. S. (1992). The effect of legal drinking age on fatal injuries of adolescents and young adults. <i>Am J Public Health</i>, 82, 112-114.</p> <p>Levy, D. T. (1988). The effects of driving age, driver education, and curfew laws on traffic fatalities of 15-17 year olds. <i>Risk Anal</i>, 8, 569-574.</p> <p>Levy, D. T. (1990). Youth and traffic safety: the effects of driving age, experience and education. <i>Accid Anal Prev</i>, 22, 327-334.</p> <p>Lund, A. K., Williams, A. F., & Zador, P. (1986). High school driver education: further evaluation of the DeKalb County study. <i>Accid Anal Prev</i>, 18, 349-357.</p> <p>MacKinnon, D. P., & Woodward, J. A. (1986). The impact of raising the minimum drinking age on driver fatalities. <i>Int J Addict</i>, 21, 1331-1338.</p> <p>Naatanen, R., & Summala, H. (1976). <i>Road-user behaviour and traffic accidents</i>. Amsterdam: North-Holland Publishing Company.</p> <p>Preusser, D. F. (1988). Delaying teenage licensure. <i>Alcohol, Drugs and Driving</i>, 4, 283-295.</p> <p>Preusser, D. F., Williams, A. F., Zador, P. L., & Blomberg, R. D. (1984). The effect of curfew laws on motor vehicle crashes. <i>Law and Policy</i>, 6, 115-128.</p> <p>Preusser, D. F., Williams, A. F., Lund, A. K., & Zador, P. L. (1990). City curfew ordinances and teenage motor vehicle injury. <i>Accid Anal Prev</i>, 22, 391-397.</p> <p>Raymond, S., Jolly, K. W., Risk, A. W., & Shaoul, J. E. (1973). An evaluation of the effectiveness of driver traffic education in reducing road accidents among adolescents. Salford: Department of Civil Engineering, University of Salford.</p> <p>Redman, S., Sanson-Fisher, R., & Cockburn, J. (1988). Rehabilitation programs for drink drivers: a critical appraisal. <i>Community Health Studies</i>, 12, 418-427.</p> <p>Robertson, L. S. (1980). Crash involvement of teenaged drivers when driver education is eliminated from high school. <i>Am J Public Health</i>, 70, 599-603.</p> <p>Robertson, L. S. (1989). Blood-alcohol in fatally injured drivers and the minimum legal drinking age. <i>J Health Polit Policy Law</i>, 14, 817-825.</p> <p>Struckman-Johnson, D. L., Lund, A. K., Williams, A. F., & Osborne, D. W. (1989). Comparative effects of driver improvement programs on crashes and violations. <i>Accid Anal Prev</i>, 21, 203-215.</p> <p>Thompson, M., & O'Reilly, D. (1993). The young driver project: County Road Safety Officers Association South East Group. Crowthorne, Berks: Transport and Road Research Laboratory.</p> <p>Vingilis, E., & Salutin, L. (1980). A prevention programme for drinking driving. <i>Accid Anal Prev</i>, 12, 267-274.</p> <p>Williams, A. F., Zador, P. L., Harris, S. S., & Karpf, R. S. (1983). The effect of raising the legal minimum drinking age on involvement in fatal crashes. <i>Journal of Legal Studies</i>, XII, 169-179.</p> <p>Williams, A. F., Karpf, S., & Zador, P. L. (1983). Variations in minimum licensing age and fatal motor vehicle crashes. <i>Am J Public Health</i>, 73, 1401-1403.</p>
Roberts et al., 2004	<p>Stock, J. R., Weaver, J. K., Ray, H. W., Brink, J. R., & Sadoff, M. G. (1983). Evaluation of safe performance secondary school driver education curriculum demonstration project. Final Report. Washington, DC: US Department of Transportation, National Highway Traffic Safety Administration.</p>

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Shults et al. 2001	<p>Asch, P., & Levy, D. T. (1990). Young driver fatalities: the roles of drinking age and drinking experience. <i>South Econ J</i>, 57, 512-520.</p> <p>Blomberg, R. D. (1992). Lower BAC limits for youth: evaluation of the Maryland .02 law. Washington, DC: NHTSA. US Department of Transportation, March 1992; DOT HS 807 860.</p> <p>Brown, D. B., & Maghsoodloo, S. A. (1981). A study of alcohol involvement in young driver accidents with the lowering of the legal age of drinking in Alabama. <i>Accid Anal Prev</i>, 13, 19-22.</p> <p>Chaloupka, F. J., Saffer, H., & Grossman, M. (1993). Alcohol control policies and motor vehicle fatalities. <i>J Legal Stud</i>, 22, 161-186.</p> <p>Cook, P. J., & Tauchen, G. (1984). The effect of minimum drinking age legislation on youthful auto fatalities. <i>J Legal Stud</i>, 13, 169-190.</p> <p>Decker, M. D., Graitcer, P. L., & Schaffner, W. (1988). Reduction in motor vehicle fatalities associated with an increase in the minimum drinking age. <i>JAMA</i>, 260, 3604-3610.</p> <p>Dee, T. S. (1999). State alcohol policies, teen drinking and traffic fatalities. <i>J Public Econ</i>, 72, 289-315.</p> <p>DuMouchel, W., Williams, A. F., & Zador, P. (1987). Raising the alcohol purchase age: its effects on fatal motor vehicle crashes in twenty-six states. <i>J Legal Stud</i>, 16, 249-266.</p> <p>Durant, R., & Legge, J. S. (1993). Policy design, social regulation and theory building: lessons from the traffic safety policy arena. <i>Political Res Q</i>, 46, 641-656.</p> <p>Ferreira, J., & Sickerman, A. (1976). The impact of Massachusetts reduced drinking age on auto accidents. <i>Accid Anal Prev</i>, 8, 229-239.</p> <p>Figlio, D. N. (1995). Effect of drinking age laws and alcohol-related crashes: time-series evidence from Wisconsin. <i>J Policy Anal Manage</i>, 14, 555-566.</p> <p>Hague, M. O., & Cameron, M. (1989). Effect of the Victorian zero BAC legislation on serious casualty accidents: July 1984 – December 1985. <i>J Safety Res</i>, 20(3), 129-137.</p> <p>Hingson, R., Heeren, T., & Winter, M. (1994). Lower legal blood-alcohol limits for young drivers. <i>Public Health Rep</i>, 109(6), 738-744.</p> <p>Hingson, R., Scotch, N., Mangione, T., et al. (1983). Impact of legislation raising the legal drinking age in Massachusetts from 18 to 20. <i>Am J Public Health</i>, 73, 163-169.</p> <p>Hoskin, A. F., Yalung Mathews, D., & Carraro, B. A. (1986). Effect of raising the legal minimum drinking age on fatal crashes in 10 states. <i>J Safety Res</i>, 17, 117-121.</p> <p>Legge, J. Jr. (1990). Reforming highway safety in New York State: an evaluation of alternative policy interventions. <i>Soc Sci Q</i>, 71, 373-382.</p> <p>Lillis, R., Williams, T., & Williford, W. (1987). The impact of the 19-year-old drinking age in New York. <i>Advances in Substance Abuse, Suppl 1, Control Issues in Alcohol Abuse Prevention: Strategies for States and Communities</i>, 133-46.</p> <p>Maisey, G. E. (1984). The effect of lowering the statutory alcohol limit for first year drivers from 0.08 to 0.02 gm/100 ml (monograph). 22 Mount Street, Perth, Western Australia: Western Australia Police Department, Research and Statistics Section.</p> <p>Males, M. (1986). Minimum purchase age for alcohol and young-driver fatal crashes: a long-term view. <i>J Legal Stud</i>, 15, 181-211.</p> <p>Naor, E. M., & Nashold, R. D. (1975). Teenage driver fatalities following reduction in the legal drinking age. <i>J Safety Res</i>, 7, 74-79.</p> <p>O'Malley, P. M., & Wagenaar, A. C. (1991). Effects of minimum drinking age laws on alcohol use, related behaviours and traffic crash involvement among American youth: 1976-1987. <i>J Stud Alcohol</i>, 52, 478-491.</p> <p>Ross, H. (1992). <i>Drunk driving: social policy for saving lives</i>. New Haven: Yale University Press.</p> <p>Ruhm, C. J. (1996). Alcohol policies and highway vehicle fatalities. <i>J Health Econ</i>, 15, 435-454.</p> <p>Saffer, H., & Chaloupka, R. (1989). Breath testing and highway fatality rates. <i>Appl Econ</i>, 21, 901-912.</p> <p>Saffer, H., & Grossman, M. (1987a). Drinking age laws and highway mortality rates: cause and effect. <i>Econ Inquiry</i>, 25, 403-417.</p> <p>Saffer, H., & Grossman, M. (1987b). Beer taxes, the legal drinking age, and youth motor vehicle fatalities. <i>J Legal Stud</i>, 16, 351-374.</p> <p>Smith, D. I., & Burvill, P. W. (1986). Effect on traffic safety of lowering the drinking age in three Australian states. <i>J Drug Issues</i>, 16, 183-198.</p> <p>Smith, R. A., Hingson, R. W., Morelock, S., et al. (1984). Legislation raising the legal drinking age</p>

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- Levy, D. T. (1988). The effects of driving age, driver education, and curfew laws on traffic fatalities of 15-17 year olds. *Risk Anal*, 8, 569-574.
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Table D2: Reference Lists of Relevant Studies from Selected Review Articles

Review Article	Relevant References
Grabowski & Morrissey, 2001	<p>Asch, P., & Levy, D. T. (1990). Young driver fatalities: the roles of drinking age and drinking experience. <i>South Econ J</i>, 57, 512-520.</p> <p>Chaloupka, F. J., Saffer, H., & Grossman, M. (1993). Alcohol control policies and motor vehicle fatalities. <i>Journal of Legal Studies</i>, 22, 161-186.</p> <p>Chen, L-H., 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. <i>JAMA</i>, 283(12), 1578-1582.</p> <p>Cook, P. J., & Tauchen, G. (1984). The effect of minimum drinking age legislation on youthful auto fatalities. <i>Journal of Legal Studies</i>, 13, 169-190.</p> <p>Dee, T. S., & Evans, W. N. (2001). Teens and Traffic Safety. In <i>An Economic Analysis of Risky Behavior among Youths</i>. Ed. J. Gruber, 121-165. Chicago: University of Chicago Press.</p> <p>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. <i>Acid Anal Prev</i>, 30, 217-222.</p> <p>Evans, W. N., Neville, D., & Graham, J. D. (1991). General deterrence of drunk driving: evaluation of recent american policies. <i>Risk Analysis</i>, 11, 279-289.</p> <p>Kenkel, D. S. (1993). Drinking, driving and deterrence: the effectiveness and social costs of alternative policies. <i>Journal of Law and Economics</i>, 36, 877-913.</p> <p>Lund, A. K., Williams, A. F., & Zador, P. (1986). High school driver education: further evaluation of the DeKalb County study. <i>Acid Anal Prev</i>, 18, 349-357.</p> <p>Males, M. (1986). Minimum purchase age for alcohol and young-driver fatal crashes: a long-term view. <i>J Legal Stud</i>, 15, 181-211.</p> <p>Ruhm, C. J. (1996). Alcohol policies and highway vehicle fatalities. <i>Journal of Health Economics</i>, 15, 435-454.</p> <p>Saffer, H., & Grossman, M. (1987b) Beer taxes, the legal drinking age, and youth motor vehicle fatalities. <i>J Legal Stud</i>, 16, 351-374.</p>
Hatcher & Scarpa, 2001	<p>Foss, R. D., & Evenson, K. R. (1998). Effectiveness of graduated driver licensing in reducing motor vehicle crashes. <i>Am J Prev Med</i>, 16(1S), 47-56.</p> <p>Lund, A. K., Williams, A. F., & Zador, P. (1986). High school driver education: further evaluation of the DeKalb County study. <i>Acid Anal Prev</i>, 18, 349-357.</p> <p>McKnight, A. J., & McPherson, K. (1986). Evaluation of peer intervention training for high school alcohol safety education. <i>Acid Anal Prev</i>, 18(4), 339-347.</p> <p>Preusser, D. F., Zador, P. L., & Williams, A. F. (1993). The effect of city curfew ordinances on teenage motor vehicle fatalities. <i>Acid Anal Prev</i>, 25(5), 641- 645.</p> <p>Sheehan, M., Schonfeld, C., Ballard, R., Schofield, F., Najman, J., & Siskind, V. (1996). A three year outcome evaluation of a theory based drink driving education program. <i>Journal of Drug Education</i>, 26(3), 295-312.</p> <p>Shope, J. T., Elliott, M. R., Raghunathan, T. E., & Waller, P. F. (2001). Long-term followup of a high school misuse prevention program's effect on students' subsequent driving. <i>Alcoholism: Clinical and Experimental Research</i>, 25(3), 403-410.</p> <p>Shults, R. A., Elder, R. W., Sleet, D. A., Nichols, J. L., Alao, M. O., Carande-Kulis, V. G., Zaza, S., Sosin, D. M., Thompson, R. S., & the Task Force on Community Preventive Services. (2001). Reviews of evidence regarding interventions to reduce alcohol-impaired driving. <i>Am J Prev Med</i>, 21(4S), 66-88.</p> <p>Ulmer, R. G., Preusser, D. F., Ferguson, S. A., Williams, A. F. (1999). Teenage crash reduction associated with delayed licensure in Louisiana. <i>Journal of Safety Research</i>, 30(1), 31- 38.</p> <p>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. <i>Am J Prev Med</i>, 16(1S), 40-46.</p> <p>Zwering, C., & Jones, M. P. (1999). Evaluation of the effectiveness of low blood-alcohol concentration laws for younger drivers. <i>Am J Prev Med</i>, 16(1S), 76-80.</p>
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APPENDIX E

***Summary Results of Included
Systematic Reviews & Review Articles***

Table E1: Ker et al., 2004 – Post-licence driver Education for the prevention of road traffic crashes

Study	Methods	Participants	Interventions	Outcomes	Results
Nolen, 2002 (Sweden)	Assignment was determined by alternation and drawing lots. Allocation concealment was unclear. Participants responded to an invitation to attend a driver education course. Twenty-nine per cent of participants were lost to follow-up.	Senior students from a Michigan High School, aged 18 to 20 years, all of whom had completed a questionnaire concerning road experience (n=133).	Advanced driver education in a group setting	Subsequent crashes	RR = 0.75 (0.30 – 1.88)
Schuman, 1971 (USA)	The participants in the treatment and control groups were randomly selected from a senior class list of a Michigan High School. Allocation concealment was unclear and no information was reported on loss to follow-up.	Swedish drivers between the ages of 18 and 24 who had insurance with the Swedish Insurance company, Skandia. Drivers had responded to an invitation to participants in the course (n=2305).	Advanced driver education in a group setting	Subsequent injury crashes	RR = 0.94 (0.74 – 1.20)

Table E2: Munro et al., 1995 – Can we prevent accidental injury to adolescents? A systematic review of the evidence (Overall summary)

Topic	General Conclusions & Recommendations	Key References
Education: Driver Education School-based Driver Education	Limited evidence on educational and training interventions indicates that enhanced driver education courses have little or no effect. School-based programs have demonstrated changes in self reported behaviour, attitudes and knowledge, but not in objective behavioural changes. Multi-factorial programs seeking to alter several aspects of adolescents' beliefs, skills and values may be more effective than single focus programs. Programs that unintentionally enable adolescents to drive at a younger age may have negative effects.	Harrington, 1972; Levy, 1990; Lund, Williams & Zador, 1986; Naatanen & Summala, 1976; Raymond et al., 1973; Robertson, 1980; Struckman-Johnson et al., 1989; Thompson & O'Reilly, 1993
Legislation: Minimum Legal Driving Age Minimum Legal Drinking Age Blood-alcohol Concentration Night-time Curfew Driving	Age as well as experience have been shown to influence MVCs. Studies have ignored the impact that raising the minimum legal driving age may have on other road users (motorcyclists, pedal cyclists, pedestrians). A minimum legal drinking age above 18 years has been reported to reduce MVC fatalities. The effectiveness of stricter enforcement of drinking driving laws is difficult to assess. Research suggests that curfew laws prohibiting young driving from driving during late evening or early morning hours are effective, and may delay the age at which young drivers are licensed.	Asch & Levy, 1987; Broughton & Stark, 1986; Dunbar, Penttila & Pikkarainen, 1987; Hingson, Merrigan & Heeren, 1985; Jones, Pieper & Robertson, 1992; Levy, 1988; McKinnon & Woodward, 1986; Preusser, 1988; Preusser et al., 1984; Preusser et al., 1990; Redman, Sanson-Fisher & Cockburn, 1988; Robertson, 1989; Vingilis & Salutin, 1980; Williams et al., 1983; Williams, Karpf & Zador, 1983

Table E3: Roberts et al., 2004 - Characteristics of included studies on the effectiveness of school based driver education

Study	Methods	Participants	Interventions	Outcomes	Results
Stock, 1983 (USA)	RCT: students were assigned to 1 of 3 groups using a stratified random sampling plan. Stratification was based on parents' socioeconomic status, student grade point average and sex. Allocation was by central computer.	16,338 high school students who applied for driver education in DeKalb County high schools and who said that they wanted to get their licence as soon as possible	1) The Safe Performance Curriculum (SPC): 72 hours of formal instruction and testing 2) The Pre-Driver Licensing Curriculum (PDL): the minimum training requiring to pass the driving test, involved 24 hours of formal instruction and testing. 3) Control group: No formal driver education apart from any teaching provided by their parents or by private driver training schools	The number of students who have been licensed before or within 6 months of their 16th birthday or the course completion date whichever is later. The number of students who were involved as a driver in one or more crashes.	Licensing 1) SPC: 4829 (88.4%) odds ratio = 1.05(1.03-1.06) 2) PDL: 4681 (86.2%) odds ratio = 1.02(1.01-1.04) 3) Control: 4588 (84.3%) Crashes 1) SPC: 1563 (28.6%) odds ratio = 1.07 (1.01-1.14) 2) PDL: 1437 (26.5%) odds ratio = 0.99 (0.93-1.05) 3) Control: 1456 (26.7%)
Strang, 1982 (Australia)	Cluster randomised-controlled trial: organisations were randomly assigned to 1 of 4 experimental conditions. Random allocation was done within strata (state high schools, secondary technical schools, catholic secondary schools, independent secondary schools, employers of young men, technical colleges).	779 males aged 17-19 years holding a current learner permit and living in the Melbourne area	1 of 3 driver education courses or a control group. Participants in each of the three trained groups received 5 hours behind the wheel training. Participants in the control group were given no formal training but were allowed to arrange driving practice or lessons during the course of the study.	Proportion of participants having at least one accident since being licensed	Driver education 230/549 (42%) Control 80/139 (42%)

Study	Methods	Participants	Interventions	Outcomes	Results
Wynne-Jones, 1984 (New Zealand)	RCT: students were selected by ballot within each school, stratified by sex, either to attend the driving course or to be left to their own devices to learn to drive	848 secondary school students aged 15-18 years from 23 schools in Christchurch. About 60 students were excluded from the experiment because of failure to correctly complete the enrolment form, filling out more than one form, or being selected on some other non-random basis.	The Automobile Association driver training programme, largely undertaken during school hours, consists of 8 hours behind the wheel instruction, 8 hours as a passenger while another student is being instructed, eight lectures on road traffic and correct attitudes and two lectures on motor mechanics. At the end of the programme the students take the driving test.	Number of days from trial enrolment until driving licence obtained (licensing delay) Crashes by self report Crashes by official record	Licensing delay: Boys experimental = 111 days Boys control = 300 days T=7.190 (p<0.001) Girls experimental = 105 days Girls control = 415 days T=9.881 (p<0.001) Crashes by self report: Boys experimental 29/206 (14%) Boys control 19/119 (16%) Odds ratio = 0.86 (0.46-1.62) Girls experimental 53/355 (15%) Girls control 5/108 (5%) Odds ratio = 3.62 (1.41-9.29) Crashes by official records: Boys experimental 4/206 (2%) Boys control 7/119 (6%) Odds ratio = 0.32 (0.09-1.11) Girls experimental 4/355 (1%) Girls control 2/108 (2%) Odds ratio = 0.60 (0.11-3.34)

Table E4: Shults et al., 2001 - Characteristics of included studies evaluating the effectiveness of lower blood-alcohol concentration (BAC) laws for young or inexperienced drivers

Study	Methods Quality of execution	Study description	Effect measure	Reported effect	Follow-up time
Bloomberg, 1992 (USA: Maryland 1985-1990)	Time series	0.02 BAC law for drivers < 21 years Law implemented Jan 1, 1989 Comparison: pre-law period	Percent change in crashes involving drivers <21 years who had been drinking according to the police report	-11%, significant	2 years
Haque, 1989 (Australia 1/78-12/85)	Time series with concurrent comparison	Zero BAC law for learners and for first year probationary and disqualified or unlicensed drivers Law implemented May 22, 1984 Comparisons: pre-law period and injury crashes occurring during "non alcohol times" among target group and standard licence holders	Percent change in crashes resulting in a death or hospitalized injury for target drivers during "alcohol times"	-3.8%, p = 0.21	19 months

Study	Methods Quality of execution	Study description	Effect measure	Reported effect	Follow-up time
Hingson, 1994 (USA: 12 States 1975-1992)	Before and after with concurrent comparison	Lower BAC laws implemented for young drivers in 12 states; ages of target group and legal BAC limit varied by state; BAC range: 0.02% - 0.06% Laws implemented between 1975 and 1990 Comparisons: pre-law period and crashes among drivers of the same ages from 12 comparison states	Percent change in proportion of all single vehicle night-time fatal crashes among teen drivers	-17%, p<0.001	1-8 years
Maisey, 1984 (Western Australia 12/81- 12/96)	Before and after with concurrent comparison	0.02 BAC law for first year drivers Law implemented Dec 1982 Comparisons: pre law period, daytime fatal or nonfatal injury crashes among drivers <18 years, and fatal or nonfatal injury crashes among drivers 18 years	Percent change in nigh- time fatal or nonfatal injury crashes among drivers < 18 years	-17%, p<0.1	1 year
Voas, 1998 (USA: California 1/88-12/96)	Time series with concurrent comparison	0.01 BAC law for drivers < 21 years Law implemented Jan 1994 Comparisons: pre-law period and proportion of all fatal crashes alcohol-related among drivers of the same ages from 4 comparison states	Percent change in proportion of all fatal crash-involved drivers <21 years with BACs >0.00%	-9.3%, p = 0.377	3 years
Voas, 1999 (USA: 50 States & D.C. 1982- 1997)	Time series with concurrent comparison	0.02 or lower BAC laws for drivers <21 years Laws implemented during 1982-1997 Comparisons: pre-law period and ratio of alcohol-related fatal crashes to non-alcohol-related fatal crashes in states without 0.02 BAC laws	Percentage change in the ratio of fatal crashes involving drivers <21 years with BACs 0.00% vs. BACs = 0.00%	-24.4%, p<0.001	<1-15 years

Table E5: Shults et al., 2001 – Characteristics of studies evaluating the effectiveness of raising the minimum legal drinking age (MLDA) for decreasing crashes

Study	Methods Design Suitability (DS) Quality of Execution (QoE)	Study description	Results	Value used in summary	Follow-up time
Hingson, 1983 (USA: Massachusetts 4/67-4/81)	Before and after with concurrent comparison DS: Greatest; QoE: Fair	MLDA raised from 18 to 20 on 9/1/81. Comparison with 18-19 year olds upstate New York drivers.	Single vehicle night-time fatal crashes among 18-19 year olds decreased 15% (net change = -31%, p<0.05). Survey data indicate decrease in reported driving after drinking (net change = -22%, p<0.05), and drinking in bars (net change = -57%, p<0.05), but no significant decrease in general alcohol consumption.	Fatal crashes: -31%	24 months
Williams, 1983 (USA: 9 States 1/75-9/80)	Before and after with concurrent comparison DS: Greatest QoE: Good	MLDA raised by varying amounts in different states; increases took effect between 1976 and 1980. Comparison of groups affected by the law change with older drivers <22 years of age, adjacent "no change" states, and daytime crashes.	Single vehicle night-time fatal crashes: <ul style="list-style-type: none"> • Net change for directly affected drivers relative to all comparison conditions of -25% (p>0.05). • Net change for younger drivers not directly affected by the law change relative to older drivers of -3%. • Net changes for night-time fatal crashes (-23%, p<0.05) and total fatal crashes (-14%, p <0.05) consistent with the reported effect. 	Fatal crashes: -25%	>=9 months
Wagenaar, 1983 (USA: Maine 1/75-9/80)	Interrupted time series with concurrent comparison DS: Greatest QoE: Fair	MLDA raised from 18 to 20, Oct 1977. Comparison with drivers aged 20-21.	Single vehicle night-time male injury/fatality crashes among 18-19 year olds decreased 18% (t = -1.4, p>0.05; net change = -33%). Single vehicle night-time male property damage crashes among 18-19 year olds decreased 22% (t = -3.5, p<0.01; net change = -18%). Similar net changes result from comparisons with daytime crashes and Pennsylvania drivers.	Injury crashes: -33% Other crashes: -18%	14 months
Smith, 1984 (USA: Massachusetts 4/76-4/82)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA raised from 18 to 19 on 4/16/79. Study evaluated effect on 16 and 17 year olds drivers. Comparison with 16-17 year old upstate New York drivers.	Single vehicle night-time fatal crashes among 16-17 year olds increased 4% from a mean of 25.7/year (net change = -22%, p>0.05). Survey data indicate decrease in reported driving after drinking (net change = -20%, p<0.05), and drinking in bars (net change = -61%, p<0.05), but smaller changes in general alcohol consumption (net change = -9%, p>0.05).	Fatal crashes: -22%	36 months

Study	Methods Design Suitability (DS) Quality of Execution (QoE)	Study description	Results	Value used in summary	Follow-up time
Hoskin, 1986 (USA: 10 States 1975-1983)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA raised by varying amounts in different states; increases took effect between 1977 and 1981. Comparison with drivers 25- 29 years old.	Single vehicle night-time fatalities/1000 drivers decreased by 15% (net change = -28*, p<0.01, 1- tailed)	Fatal crashes: -28%	>=24 months
Males, 1986 (USA: 13 States 1975-1983)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA raised by varying amounts in different states; increases took effect between 1977 and 1981. Comparison with drivers 21- 24 years old and matches states.	Median ratio of single vehicle night-time fatal crash involvement for affected vs. 21-24 year old drivers: • For drivers affected by MLDA change decreased by 23% (net change adjusted for comparison states = -14%) • For drivers <=17 years old decreased by 15% (net change = +9%) Author argues that MLDA increase causes an increase in fatalities among older drivers that are 'new drinkers'; for this group, the median change in single vehicle night-time crashes was -4% (net change = +14%).	Fatal crashes: -14%	>=24 months
Wagenaar, 1986 (USA: Michigan 1976-1984, monthly)	Interrupted time series with concurrent comparison DS: Greatest QoE: Fair	MLDA raised from 18 to 21, Dec '78. Comparison with drivers >21 years old.	Single vehicle night-time injury crash rates among 18-20 year olds were unchanged (net change = - 16%, p<0.05). Had-been-drinking injury crash rates among 18-20 year olds decreased 6% (net change = -19%, p<0.05). Effect sizes presented are comparable to similar studies evaluating the impact of Michigan's increased MLDA over various time periods (e.g. Wagenaar 1986a, 1986b, 1987).	Injury crashes: -16%	72 months
(USA: Texas 1978-1984, monthly)	Interrupted time series with concurrent comparison DS: Greatest QoE: Good	MLDA raised from 18 to 19 on 9/1/81. Comparison with drivers 19- 20 years olds.	Single vehicle night-time serious injury crash rates among: • 18 year olds decreased 11% (p<0.05, 1-tailed; net change = -6%) • 16-17 year olds decreased 8% (p<0.05, 1-tailed; net change = -3%) Author found that the estimated decrease in crashes was unchanged when as economic indicator was included in the model.	Injury crashes: -6%	39 months

Study	Methods Design Suitability (DS) Quality of Execution (QoE)	Study description	Results	Value used in summary	Follow-up time
Lillis, 1987 (USA: New York State 12/4/81-12/3/83)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA raised from 18 to 19 on 12/4/82. Intervention occurred in context of general anti-DUI campaign begun 11/81. Comparison with 19 and 20 year old age groups.	Had-been-drinking injury crashes/10,000 licensed drivers: <ul style="list-style-type: none"> Decreased 21% among 18 year olds (baseline n = 732, net change = -15%) Decreased 24% among 17 year olds baseline n = 393, net change = -17%) Self reported purchase of beer decreased from 51.6% (n = 213) to 32.6% (n = 212) in the target group (relative change of -37%, net change = -24%, p<0.001). Self reported 47% decrease in drinking and driving (net change = -30%, p <0.05).	Injury crashes: -15%	12 months
Decker, 1988 (USA: Tennessee 1980-1986)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA raised from 19 to 21 on 8/1/84; includes grandfather clause. Comparison with drivers 18-23 years olds, unaffected by the changed MLDA.	Single vehicle night-time fatalities per hundred million vehicle miles: <ul style="list-style-type: none"> Decreased by 38% for 19-20 year old drivers (net change = -41%) Decreased by 15% for 15-18 year old drivers (net change = -18%) 	Fatal crashes: -41%	28 months
Womble, 1989 (USA: 13 States 1975-1986)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA raised by varying amounts in different states; increase took effect between 1976 and 1980. Comparison with drivers 18-23 years olds, unaffected by the changed MLDA.	Net decrease in fatal crash rates for affected drivers relative to unaffected drivers was 12% (95% C.I.: -16%, -8%). Study replicates Arnold 1985, which covers a period from 1975 to 1983 and also found a 12% decrease.	Fatal crashes: -12%	>=72 months
Legge, 1990 (USA: New York State 1975-1987, monthly)	Interrupted time series DS: Moderate QoE: Fair	MLDA raised from 18 to 19 on 12/1/82, and from 19 to 21 on 12/1/85. The effect of two other traffic safety interventions during the study period was also modeled.	Male single vehicle night-time fatalities for drivers of all ages (interpolated from graph): <ul style="list-style-type: none"> Increased 1% when MLDA raised from 18 to 19 (t = 0.12, p>0.05, n.s.) Increased 24% when MLDA raised from 19 to 21 (t = 1.89, p>0.05, n.s.) Daytime fatalities also increased by 8.62/month (t=2.16, p not reported) following the 1985 MLDA increase, suggesting that the observed increase was not specific to alcohol-involved crashes.	Fatal crashes: +13%	>=25 months

Study	Methods Design Suitability (DS) Quality of Execution (QoE)	Study description	Results	Value used in summary	Follow-up time
O'Malley, 1991 (USA: 13 States 1973-1990)	Interrupted time series DS: Greatest QoE: Fair	MLDA raised by varying amounts in different states; increase took effect between 1978 and 1986. Comparison with daytime fatal crashes.	Single vehicle night-time fatal crash rates among drivers <21 years old decreased by 15% across all 13 states ($p < 0.05$; net change = -2%). Self reported alcohol consumption among high school seniors in MLDA age 18 states converged from -0.14 standard deviations higher than in MLDA age 21 states to similar levels when MLDA became 21 nationwide.	Fatal crashes: -2%	36 months
Durant, 1993 (USA: Michigan 1975-1993, monthly)	Interrupted time series DS: Moderate QoE: Fair	MLDA raised from 18 to 21 on 12/23/1978. Effects of drinking-driving reforms implemented 3/30/1983 and changes in unemployment rate were also modeled.	Crash-related fatalities involving drivers under 21 decreased an estimated 17% ($p < 0.05$) Time series results suggest that the effect of the change in MLDA is stable over time (change = 0.938) Several comparison time series were modeled, but insufficient data were provided to calculate net changes	Fatal crashes: -17%	108 months
Figlio, 1995 (USA: Wisconsin 1976-1993, monthly)	Interrupted time series DS: Greatest QoE: Fair	MLDA raised to 19, July 1984; raised to 21, September 1986. Comparison with all drivers >21 years old.	Had-been-drinking crashes/1000 drivers: <ul style="list-style-type: none">Decreased 19% (0.35/1000 drivers) for 18 year olds (net change = -17%)Decreased 27% (0.6/1000 drivers) for 19-20 year olds (net change = -25%)	Other crashes: -21%	>=87 months
Cook, 1984 (USA: 48 contiguous states 1970-1977, yearly)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA decrease modeled along with the state and time variables in a fixed effects ANCOVA. Comparison with 21 to 24 year old drivers and states that did not change MLDA.	Estimated effect of an increase in MLDA from 18 to 21 on fatality rates: <ul style="list-style-type: none">9% decrease for 18 to 20 year olds (95% CI: 2%, 16%)6% decrease for 16 to 17 year olds (95% CI: -4%, 15%)No change in fatality rates for 21 to 24 year olds States that lowered drinking age had systemically lower initial fatality rates. Authors obtained similar results to those reported using various estimation methods	Fatal Crashes: -9%	Not reported
Du Mouchel, 1987 USA: 48 contiguous states 1975 - 1984, yearly)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA raised in 26 states between 9/1976 and 8/1984. Comparison with states that did not change MLDA.	Increased MLDA associated with a 13% decrease in night-time fatal crashes among affected age groups (95% CI: -18%, -8%). Results of MLDA change stable over time. 'Beginning drinker' status associated with 2% increase in crashes (95% CI: -4%, 8%).	Fatal Crashes: -13%	>=5 months

Study	Methods Design Suitability (DS) Quality of Execution (QoE)	Study description	Results	Value used in summary	Follow-up time
Saffer, 1987a (USA: 48 contiguous states 1975 - 1981, yearly)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA included as one of several independent variables in a logistic regression modeling a reciprocal causal effect between MLDA and fatality rates. Comparison with 21 to 24 year old fatality rates and states that did not change MLDA.	Estimated effects on fatality rate of increased MLDA from 18 to 21: <ul style="list-style-type: none">• 29% decrease among 18 to 20 year olds (b=-0.166, t=2.63; net change = -24%)• 19% decrease among 15 to 17 year olds (b=-0.073, t=1.79; net change = -14%)	Fatal Crashes: -24%	Not reported
Saffer, 1987b (USA: 48 contiguous states 1975 - 1981, yearly)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA included as one of several independent variables in three logistic regression models. Results of the most comprehensive model reported. Comparison with 21 to 24 year olds fatality rates and states that did not change MLDA.	Estimated effects on fatality rate of increased MLDA from 18 to 21: <ul style="list-style-type: none">• 13% decrease among 18 to 20 year olds (b=-0.045, t=5.12; net change relative to older drivers = -8%)• 1% increase among 15 to 17 year olds (b=-0.003, t=0.003; net change relative to older drivers = +6%)	Fatal Crashes: -13%	not reported
Saffer, 1989 (USA: 48 contiguous states 1980 - 1985, yearly)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA included as one of several independent variables in a logistic regression. Comparison with states that did not change MLDA.	Based on the authors' reported regression coefficient of -0.043 (p<0.05), night-time crash fatality rates for 15 to 24 year olds estimated to decrease 12% with an MLDA increase from 18 to 21.	Fatal Crashes: -12%	not reported
Chaloupka, 1993 (USA: 48 contiguous states 1982 - 1988, yearly)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA included as one of several independent variables in a logistic regression model. Comparison with states that did not change MLDA.	Night-time crash fatality rate for 18 to 21 year olds estimated to decrease 4.4% with uniform 21 MLDA and increase 12.1% with uniform 18 MLDA (relative change = -15%, p<0.01)	Fatal Crashes: -15%	> 24 months
Ruhm, 1996 (USA: 48 contiguous states 1982 - 1988, yearly)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA included as one of several independent variables in a fixed effects logistic regression. Comparison with states that did not change MLDA.	Based on the authors' reported regression coefficient of -0.044 (p<0.05), fatality rates for 18 to 20 year olds estimated to decrease 12% with an MLDA increase from 18 to 21. Multiple analyses highlight the sensitivity of regression parameter estimates to "reasonable changes in model specifications".	Fatal Crashes: -12%	> 24 months
Voas, 1999 (USA: 50 States 1982 - 1997, yearly)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA increase modeled as proportion of the state's youth population affected by the law. Comparison with states that did not change MLDA.	Raising MLDA to 21 associated with as estimated 19% decrease in ration of drinking (estimated BAC >=0.01 g/dl) to non-drinking drivers involved in fatal crashes.	Fatal Crashes: -19%	> 132 months

Study	Methods Design Suitability (DS) Quality of Execution (QoE)	Study description	Results	Value used in summary	Follow-up time
Dee, 1999 (USA: 48 contiguous states 1977 - 1992, yearly)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA and beer tax modeled in a fixed effects logistic regression. Comparison with states that did not change MLDA and to daytime fatality rates.	Based on a regression coefficient of -0.12 (p<0.05), night-time driver fatality rates for 18 to 20 year olds estimated to decrease 7% more than daytime fatality rates (b=-0.05, p>0.05).	Fatal Crashes: -7%	> 72 months
Naor, 1975 (USA: Wisconsin 1968 - 1973)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA for wine and spirits lowered from 21 to 18 on 3/23/1972. MLDA for beer remained 18 throughout study period. Comparison with non-alcohol related crashes.	Proportion of driver fatalities with BAC > 0.05% decreased 5% following MLDA change (p > 0.05, net change = +2%).	Fatal Crashes: +2%	21 months
Whitehead, 1975 (Canada: London, Ontario 1/1968 - 6/1973)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA lowered from 21 to 18 on 7/1971. Comparison with daytime crashes.	Night-time crashes involving male drivers: <ul style="list-style-type: none"> Involving 16 to 17 year olds increased 34% from a baseline of 127 (net change = +30%) Involving 18 year olds increased 58% from a baseline of 114 (net change = +19%) Involving 19 year olds increased 52% from a baseline of 138 (net change = +32%) Involving 20 year olds increased 31% from a baseline of 140 (net change = +14%) Involving 24 year olds increased 1% from a baseline of 110 (net change = -17%) Study also reported large increases in overall crashes for affected age groups relative to older drivers.	Other Crashes: +22%	22 months
Williams, 1975 (USA: MI & WI; Canada: Ontario 1968 - 1973; 3 years before/1 year after law change)	Time series with concurrent comparison DS: Greatest QoE: Fair	MLDA lowered from 21 to 18 on 1/1/1972, 3/23/1972 and 7/28/71, respectively. Comparison adjacent states: IN, MN, IL.	Night-time fatal crashes among 18-20 year olds: <ul style="list-style-type: none"> Increased 17% in MI (net change = +6%) Increased 43% in Ontario (net change +4%) Increased 11% in WI (net change = +14%) Night-time fatal crashes among 15 to 17 year olds <ul style="list-style-type: none"> Increased 16% in MI (net change = +10%) Increased 61% in Ontario (net change = +13%) Increased 23% in WI (net change = +14%) F (3,15) = 3.92, p<0.05 for aggregate change in fatalities. Generalizability limited as Wisconsin's change in MLDA involved only wine and spirits.	Fatal Crashes: +8%	12 months

Study	Methods Design Suitability (DS) Quality of Execution (QoE)	Study description	Results	Value used in summary	Follow-up time
Ferreira, 1976 (USA: Massachusetts 1/1969 - 9/1973)	Interrupted time series with concurrent comparison DS: Greatest QoE: Fair	MLDA lowered from 21 to 18 on 3/1/1973. Comparison with 21 to 23 age group.	Fatal crashes among 18 to 20 year olds increased 39% from a baseline of 13.7/month ($p < 0.05$, net change = +38%).	Fatal Crashes: +38%	7 months
Brown, 1981 (USA: Alabama 1972-1974/1976- 1979)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA lowered from 21 to 19 on 7/22/1975. Comparison with crashes not designated as had-been- drinking.	Among 18 to 20 year olds, had-been-drinking crashes increased 250% from a baseline of 1232 (net change = +186%). Proportion of had-been-drinking crashes involving 18 to 20 year old drivers increased 39% from baseline of 0.12 ($n = 1232$, $p < 0.05$).	Other Crashes: +186%	36 months
Smith, 1986 (South Australia 1/1968 - 6/1970)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA lowered from 21 to 20 on 12/19/1968. Comparison with 21 to 29 year olds drivers.	Crash-related injuries for 17 to 20 year old age group increased 1405 from baseline of 1239 (net change = +1%, $p > 0.05$). Net change for between-state comparison (Queensland) of +3% ($p > 0.05$).	Injury Crashes: +1%	24 months
(South Australia 1970 - 1973)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA lowered from 20 to 18 on 4/8/1971. Comparison with 21 to 25 year old drivers.	Crash-related injuries for 17 to 20 year old males increased 280% from baseline of 1225 (net change = +22%, $p < 0.05$). Net change for between-state comparison (Queensland) of +21% ($p < 0.05$).	Injury Crashes: +22%	32 months
(Western Australia 1968 - 1973)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA lowered from 21 to 18 on 7/1/1970. Comparison with 21 to 29 year old drivers.	Crash-related injuries for 17 to 20 year old males increased 30% from baseline of 1641 (net change = -2%, $p > 0.05$). Net change for between-state comparison (Queensland) of -9% ($p < 0.05$). Authors assert that there was widespread violation of drinking age laws in Western Australia prior to the MLDA change.	Injury Crashes: -2%	36 months
(Australia: Queensland 1971 - 1976)	Before and after with concurrent comparison DS: Greatest QoE: Fair	MLDA lowered from 21 to 18 on 2/18/1974. Comparison with 21 to 29 year old drivers.	Crash-related injuries for 17 to 20 year old males increased 12% from baseline of 4102 (net change = +10%, $p < 0.01$). Net change for between-state comparison (Western Australia) of +15% ($p < 0.001$).	Injury Crashes: +10%	34 months

Table E6: Vernick et al., 1999- Characteristics of studies on the effectiveness of high school driver education; randomized controlled trials (RCTs)

Study	Methods	Participants	Interventions	Outcomes	Results	Results		
						licensing	violations	crashes
Strang, 1982 (Australia Melbourne, 1978-1981)	RCT	742 males aged 17-19	Randomly assigned to 1 of 3 driver education curriculum: <ul style="list-style-type: none"> • Shepparton On Road (SOR), • Off-road (SFR), • Royal Auto Club of Victoria (RAC), • Control group 	Relative risk of crash involvement and violation conviction	SOR SFR RAC		1.33(1.03, 1.73) 1.01(0.75, 1.36) 1.04(0.79, 1.37)	1.12(0.89, 1.41) 1.00 (0.78, 1.28) 0.92(0.73, 1.18)
Stock et al., 1983 (DeKalb County, Georgia 1978- 1981)	RCT	16,338 high school students	Randomly assigned to 1 of 2 curriculum; <ul style="list-style-type: none"> • Safe Performance (SPC) • Pre-driver Licensing (PDL) • control. 	Relative risk of crash involvement and violation conviction, and licensing	SPC PDL	1.05(1.03, 1.06) 1.02(1.01, 1.04)	1.05(1.01, 1.10) 1.03(0.98, 1.07)	1.07(1.01, 1.14) 0.99(0.93, 1.05)
Lund et al., 1986 (DeKalb County, Georgia 1978- 1981)	RCT		Re-analysis of data from Stock, 1983	Relative risk of crash involvement, violation conviction, and licensing	SPC PDL	1.16 1.10	1.08 1.04	1.11 1.01
Davis, 1990 (DeKalb County, Georgia 1978- 1981)	RCT		Re-analysis of data from Stock, 1983	Relative risk of crash involvement and violation conviction	SPC PDL		1.01(0.87, 1.16) 0.97(0.84, 1.12)	1.02(0.88, 1.17) 1.00(0.86, 1.15)

Table E7: Vernick et al., 1999 – Characteristics of studies on the effectiveness of high school driver education; ecological design

Study	Methods	Interventions	Outcomes	Results
Robertson, 1978 (USA: 27 States 1967-1973)	Ecologic analysis of group differences	Driver education available to 16-19 year olds	Relationship between the proportion of teens receiving driver education and 1) fatal crash involvement and 2) licensure of teen drivers	The proportion of teens receiving driver education: 1) was not associated with lower fatal crash involvement per licensed driver, 2) but was associated with increased licensure of teen drivers. Concludes: "as much as 80% of 16-17 year olds who took driver education obtained licences that they would not have obtained until they were at least 18 years old".
Seaver et al., 1979 (USA: 50 States and Washington DC 1965-1975)	Ecological time series analysis	Driver education available to 16-17 year olds	Relationship between the proportion of 16-17 year olds receiving driver education and licensure of 16-17 year olds	From 1971-1975, for every 100 students enrolled in driver education, an average of 42 additional 16-17 year olds were licences, 95% C.I. (20, 64).
Robertson, 1980 (USA: Connecticut 1975-1977)	Ecological analysis of group differences	Elimination of driver education in 9 school systems (n = 509,000) and retention of driver education in 9 school systems (n = 458,000)	1) Total years of licensing of 16-17 year olds 2) Crashes per 100 16-17 year olds	1) 57% decline in school systems that eliminated driver education compared with a 9% decline in those that retained driver education 2) Approximately 27% reduction for school systems that eliminated driver education, compared with virtually no change for those that retained it
Levy, 1988 (USA: 47 States 1975-1984)	Ecological time series analysis	State laws mandating driver education for licensure before age 18	1) Licensure rates of 15-17 year olds 2) Fatal crash involvement rates, per population, of 15-17 year olds in single and multi vehicle crashes	1) State driver education laws are associated with increased licensure: RR = 1.10, (95% C.I. (1.04, 1.16)). 2) When the minimum driving age is held constant, state laws are associated with lower fatal crash involvement rates in single vehicle, RR = 0.84, 95% C.I. (0.78, 0.90) and multi vehicle crashes, RR = 0.85, 95% C.I. (0.79,0.91).
Levy, 1990 (USA: 47 States 1976-1984)	Ecological time series analysis	State laws mandating driver education for licensure before age 18	Fatal crash involvement rates, per population of 15-17 year olds in single vehicle and all crashes	Controlling for licensure rates, state driver education laws are associated with lower fatal crash involvement rates in single vehicle, RR = 0.84, 95% C.I. (0.80, 0.88), and multi vehicle crashes, RR = 0.84, 95% C.I. (0.80, 0.88).

Table E8: Zwerling & Jones, 1999- Characteristics of included studies evaluating the effectiveness of restricted blood-alcohol concentration legislation

Study	Methods	Participants	Interventions	Outcomes	Results
Maisey, 1984 (Western Australia)	Pre and post study	Drivers under 18 years compared with those 18 years or older	0.02 BAC for first-year drivers	Night-time injuries	17% net reduction in night-time injuries, but not statistically significant
Smith, 1986 (Australia)	Pre and post study	Drivers 17 to 20 years old in Tasmania compared to peers in Queensland	Zero BAC for first-year drivers, Tasmania	Injuries	18% net reduction in injuries
		16 year-olds compared to 21 to 25 year-olds in South Australia	0.05 BAC for first-year drivers		28% net reduction in injuries among males No reduction among females
		17 to 20 year-olds compared to 21 to 25 year-olds in Western Australia	0.02 BAC for first-year drivers		12% net reduction in injuries among males 24% net reduction among females
Hague and Cameron, 1989 (Australia: Victoria)	Interrupted time series and pre and post study	Compared serious injuries among first year drivers to more experienced drivers	Zero BAC for first-year drivers	Serious injuries (someone killed or hospitalized) at night	4% net reduction in serious injuries using interrupted time series; 6% net reduction using pre and post study. Neither was statistically significant.
Hingson et al., 1989 (USA: 2 States)	Pre and post study	Maine teenage drivers compared to older drivers in Maine and to teenage drivers in Massachusetts	0.02 BAC for drivers under 20 years of age	Night-time fatalities	22% net reduction in fatal crashes in Maine compared to 13% reduction in Massachusetts. Differences between states were not statistically significant.
Blomberg, 1992 (USA: Maryland)	Interrupted time series	Teenage drivers compared to older drivers	0.02 BAC for drivers under 21 years of age	Crashes with driver considered to "have been drinking"	Reduction of either 11% or 33% in "had been drinking" crashes depending on model chosen. Both were statistically significant.
Hingson et al., 1994	Pre and post study	Drivers 15 to 20 years of age in intervention states compared to peers in control states and older drivers in both states	Restricted BAC laws for younger drivers in 12 states	Single vehicle, night-time fatalities	17% net reduction in night-time fatal crashes among younger drivers (P<0.001). 1% net reduction among older drivers

Table E8: Review Articles- General Conclusions and Recommendations^{9,10}

Review Article	Topic	General Conclusions & Recommendations	Key References
Grabowski & Morrisey, 2001	Mandatory Seat-belt use, Maximum-speed-limit, Alcohol-control, Alcohol Taxes	Education/training programs have limited success in reducing unsafe driving behaviours of young drivers. Unsafe driving may stem from an apparent disregard for one's own safety, peer pressure, use of alcohol.	Asch & Levy, 1990 ; Chaloupka, Saffer & Grossman, 1993 ; Chen et al., 2000 ; Cook & Tauchen, 1984 ; Dee & Evans, 2001 ; Doherty, Andrey & MacGregor, 1998 ; Evans, Neville & Graham, 1991 ; Kenkel, 1993 ; Lund, Williams & Zador, 1986 ; Males, 1986 ; Ruhm, 1996 ; Vernick et al., 1999 ; Saffer & Grossman, 1987
Hatcher & Scarpa, 2001	Driver Education, Curfew Laws, Drinking & Driving, Seat-belt Use	<p>Overall, results concerning driver education suggest that delaying licensure may be an effective strategy to reduce population risk of MVCs.</p> <p>Curfew laws may be effective in preventing MVCs among adolescents at night (further investigation required).</p> <p>Some school-based programs to prevent drinking and driving have met with success, increasing awareness of the risks and preparing adolescents with ways to deal with situations and associated pressures. Lowering the legal BAC for young drivers may reduce motor vehicle-related fatalities.</p> <p>Available research suggests that seatbelt laws may be a viable intervention to promote seatbelt use. There is a need for further implementation and evaluation of programs designed to promote seatbelt use among adolescents.</p>	Foss & Evenson, 1999 ; Lund, Williams & Zador, 1986 ; McKnight & McPherson, 1986 ; Sheehan et al., 1996 ; Shope et al., 2001 ; Shults et al., 2001 ; Preusser, Zador & Williams, 1993 ; Ulmer et al., 1999 ; Vernick et al., 1999 ; Zwerling & Jones, 1999
Heald, 2004	Driver Education, Seat-belt Use, Passengers	<p>Driver education does not provide sufficient hours of practice behind the wheel to establish skill and confidence. The immaturity of adolescents that leads to risk taking is not mitigated.</p> <p>Seat-belt use among parents does not influence seat-belt use among adolescent passengers.</p> <p>Crash risk for young drivers is increased relative to the number of adolescent passengers, as a result of distractibility from verbal interactions, music, playing, eating, cosmetic application, coupled with risk taking such as speeding and driving without lights on.</p> <p>Most successful efforts to reduce MVC among young drivers have been legislative, such as seat-belt laws, GLS, and zero tolerance.</p> <p>Education by nurse practitioners aimed at both adolescents and their parents is recommended.</p>	Chen et al., 2000 ; Doherty, Andrey & MacGregor, 1998 ; Preusser et al., 1998 ; Vernick et al., 1999 ; Williams, McCartt & Geary, 2003

⁹ References provided in grey indicate duplicate references that have been cited in another review.

¹⁰ Underlined references indicate articles that were selected for this review.

Mattox, 1997	Antecedent, Consequence and Mixed Interventions: Driver Education, Drinking & Driving, Peer Intervention (Alcohol), Parent Involvement Through Certified Practice, Safety Media Campaigns, Licensing Policies(Curfew, Limited Use of Free Ways, Maximum Speed, Passengers) Driving Restrictions	Behavioural traffic interventions that target young driver safety are highly variable in both the nature and the effectiveness of the interventions. The most effective programs that demonstrated a direct impact on traffic safety measures, crashes or traffic fatalities include: minimum drinking age laws, BAC laws, and delayed licensure laws.	Blomberg, 1992 ; Campbell, Hunter & Stutts, 1984 ; Ferguson et al., 1996 ; Frith & Perkins, 1992 ; Hingson, Heeren & Winter, 1994 ; Lund, Williams & Zador, 1986 ; McKinnon & Woodward, 1986 ; Potvin, Champagne & Laberge-Nadeau, 1988 ; Preusser, Williams & Zador, 1984 ; Shaoul, 1975 ; Stock et al., 1983
Mayhew et al., 1998	Driver Education	Little evidence to support driver education as a safety countermeasure. Do not recommend the introduction of driver education/training into a GLS if there is not a precedent in the existing licensing system. Do not recommend that the length of the GLS be reduced for the completion of a driver education/training course. Recommend changes to driver education/training: methods to motivate young drivers to use safety skills, redesign into a multi-phased course to compliment the phases of GLS, change content and delivery to better address safety need of young drivers.	Barner, 1987 ; Carstensen, 1994 ; Glad, 1988 ; Jones, 1983 ; Gregersen, 1994 ; Jones & McCormac, 1989 ; Katila et al., 1995 ; Ohlson & Stoke, 1986 ; Potvin, Champagne & Laberge-Nadeau, 1988 ; Stock et al., 1983 ; Wynne-Jones & Hurst, 1984
Mayhew & Simpson, 2002	Driver Education	Traditional short-term driver education/training programs should move towards a multi-stage approach. Parent supervised practice driving should be augmented. Key areas to address include: psychomotor, cognitive and perceptual skill deficiencies; value of safety practices and motivating novices to drive safe; make novices aware of their limitations to counteract overconfidence; address lifestyle and psychosocial factors that can mitigate any beneficial effects of training and lead to risk taking; and competency based programs that recognize individual differences, addressing individual skill sets.	Christie, 2001 ; Roberts & Kwan, 2002 ; Vernick et al., 1999 ; Woolley, 2000
Patel, Greydanus & Rowlett, 2000	Driver Education, Alcohol-related Measures, Vehicle-related Measures	No convincing data that completion of a high school driver education course leads to a reduction in motor vehicle crashes or violations. Early licensure may lead to an increased crash rate by novice drivers. Effective alcohol-related measures include BAC laws, minimum drinking law, designated driver concept, ignition interlock devices, "administrative per se" laws, random screening program. Vehicle-related measures include seat-belt use and vehicle crash-worthiness (larger size and weight).	Doherty, Andrey & MacGregor, 1998 ; Evans & Frick, 1993 ; Farrow, 1987 ; Insurance Institute for Highway Safety and Traffic Injury Research Foundation of Canada, 1999 ; Preusser, Ferguson & Williams, 1998 ; Rivara, 1999 ; Rivara, Rivara & Bartol, 1998 ; U.S. Dept. of Transportation, 1999 ; U.S. Dept. of Transportation, 1998 ; Vernick et al 1999 ; Zwerling & Jones, 1999

Simons-Morton & Hartos, 2003	Parental Management	<p>Parent attitudes and practices affect teen driving: practice driving time, time of licensure, managing driving privileges after licensure.</p> <ul style="list-style-type: none"> • Increased practice time during the learner period did not reduce crash risks after licensure. • Delaying licensure may be protective. • Link between teen passengers with MV. • Increased parental involvement reduces risky teen driving and promotes increased seat-belt use and less speeding. • Low parental monitoring increases risky driving behaviour, traffic violations (4x higher & MVC (7X more likely) among teens. 	<p>Beck et al., 2001; Chen et al., 2000; Doherty et al., 1998; Hartos et al., 2000; McKnight & Peck, 2002; McCartt, Shabanova & Leaf, in press (2003); Preusser, Williams & Lund, 1985; Vernick et al., 1999</p>
Williams, 1995	Driver Education, Maximum Speeds, Night Curfews, Prohibition Against Expressway Driving, Passengers	<p>Licensing policies that enhance safety compromise mobility and vice versa. Driver education is not effective in reducing crash risk among young drivers, where as restrictions reduce the amount of driving time on the roads.</p>	<p>Frith & Perkins, 1992; Lund, Williams & Zador, 1986; Preusser, Williams & Zador, 1984</p>
Williams & Preusser, 1997	Night Curfew	<p>Curfews that limit recreational driving at night without an adult have been found to substantially reduce night-time crashes.</p>	<p>Ferguson et al., 1996; Frith & Perkins, 1992; Preusser, Williams & Zador, 1984</p>