

Medical interventions to reduce motor vehicle collisions

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Trauma caused by motor vehicle collisions is a common cause of death, accounting for more than 3000 deaths each day worldwide (about 7 of which occur in Canada).¹ For each person who dies, an additional 80 people sustain injuries and 300 suffer financial losses.² Trauma from motor vehicle collisions places a substantial load on emergency services and collectively costs Canada more than \$100 million per day in total societal expenditures.³ About 50% of related deaths occur within minutes of impact, reinforcing the need for effective prevention strategies.⁴ Motor vehicle collisions are projected to be the fifth leading cause of death overall by the year 2020 and are currently the most common cause of death in Canada from birth to middle age.^{5,6}

The high burden of this trauma contrasts with the topic's low visibility in medical school curricula and evidence-based medical literature,⁷ possibly because injury prevention does not typically entail prescribing a medication or performing a surgical procedure. In addition, the traditional view is that a physician's role is not to make patients virtuous, but to save them from the consequences of their vices. Thus, the management of trauma caused by motor vehicle collisions mostly emphasizes resuscitation and rehabilitation in the aftermath of the incident.⁸ The purpose of this article is to review what physicians can do to prevent this trauma for their patients. The evidence for this review comes pri-

marily from rigorous observational studies and meta-analyses (Box 1).

What societal interventions have been effective?

Since the mass production of automobiles began, Canadian road safety has emphasized government regulations such as driver licensing, road patrols and vehicle standards. Additional enhancements to infrastructure have included the standardization of road signs, school crossing warnings, sidewalk segregation and highway design. The longest series of changes has focused on laws to prevent driving under the influence of alcohol, which became an indictable offence in 1925 and was revolutionized by curbside breath testing in 1962. Perhaps the most widely debated single change was the seat belt law introduced in 1976 (years after similar laws were introduced in some other countries). Most specific interventions have yielded a modest survival benefit (Table 1).⁹⁻¹⁸

Interventions for preventing trauma caused by motor vehicle collisions fall into a 4-part framework that has not changed in decades and mostly

Box 1: Evidence used in this review

We searched MEDLINE and PubMed using the following medical subject headings and text words: "motor vehicle crash," "traffic accident," "road trauma," "roadway collision," "transportation incident" and "driver safety." We restricted our review to literature published in English within the last 30 years. We validated our approach by checking the Cochrane Library headings "Orthopaedics and trauma, Prevention of road traffic injuries" and "Public health, Prevention of road traffic injuries." Further articles were identified by checking references, in addition to using the PubMed function "Search all related." We included trials that involved randomization or rigorous observational analytical methods. In addition, we included selected governmental background documents from the World Health Organization, Transport Canada and the Ontario Ministry of Transportation.

KEY POINTS

- Almost all motor vehicle collisions can be prevented; serious collisions suggest a failure of prevention.
- Drivers who are involved in a collision have often visited a physician in the year before the event.
- Heavy alcohol consumption contributes to one-third of motor vehicle collisions.
- Medical warnings by physicians to patients who are potentially unfit to drive are effective for preventing serious collisions.
- The efficacy and cost-effectiveness of screening patients with indeterminate fitness to drive are uncertain, and there are no strong data to guide clinicians who ask questions such as "Which screening interventions for safe driving are cost-effective?"

excludes physicians: enforcement, engineering, economic forces and education.¹⁹ Enforcement involves regulating behaviour using roadside police control (e.g., RIDE [Reduce Impaired Driving Everywhere] checkpoints to deter impaired driving and to allow police to verify passenger restrictions, roadway restrictions and alcohol restrictions for new drivers under graduated licensing programs).²⁰ Engineering emphasizes changes to roads or vehicles for collision avoidance and protection (e.g., divided highways and collapsible steering columns).²¹ Economic forces include incentives that reduce total driving or specific driving patterns (e.g., economic recessions and fuel prices).²² Educational interventions involve promoting safety messaging (e.g., broadcast warnings and formal driver education).²³

What restrictions are recommended for reversible medical conditions?

Effective modern medical care reduces risk even if physicians are unaware of the benefits to road safety. For example, correcting a patient's

hypothyroidism might indirectly prevent the patient from becoming an impaired driver; temporary cautions against operating heavy machinery are standard when treatment involves an invasive procedure, systemic chemotherapy, brain radiotherapy or sedative medications; and guidelines for care after cervical spine surgery advise against driving until neck mobility is sufficiently restored.²⁴ Each of these short-term medical restrictions are based on blatant clinical situations, have not been tested in formal trials and are accepted practice.²⁵

Physicians have no evidence from randomized controlled trials to guide their decisions concerning the duration of temporary restrictions on driving. Instead, prevailing recommendations reflect expert opinion and clinical experience.²⁴ Anesthesia guidelines caution against patients driving for 3–12 hours after having a procedure that involved sedation.²⁶ Cardiology guidelines caution against patients driving for 2–7 days after angioplasty.²⁷ Surgery guidelines caution against patients driving for 4–8 weeks after a major cardiac procedure.²⁸ These landmarks might serve as guides for clinicians in other settings (e.g., recommending

Table 1: Interventions and their effects on mortality in motor vehicle collisions

Intervention	Effect of intervention	RR (95% CI)
Use of seat belts	Reduced mortality for vehicle occupants using a seat belt when compared with unbelted passengers in the same vehicle ⁹	0.39 (0.37–0.41)
Conviction for traffic infraction	Reduced risk of driver being involved in a fatal crash during the first month after a conviction for a traffic infraction ¹⁰	0.65 (0.55–0.80)
Use of air bags	Reduced mortality attributed to airbag use for drivers in head-on collision compared with other driver in the same collision ¹¹	0.71 (0.58–0.87)
Use of helmets by motorcyclists	Reduced mortality for motorcyclists wearing helmets in a crash compared with passengers, as analyzed by double pairs ¹²	0.72 (0.64–0.80)
Graduated licensing	Reduced risk of a fatal crash for 16-year-old drivers who have graduated licences compared with those with regular licences ¹³	0.74 (0.65–0.84)
Treatment at level 1 trauma centres	Reduced in-hospital mortality for patients treated at level 1 trauma centres compared with patients at nontrauma centres ¹⁴	0.80 (0.66–0.98)
Traffic-calming measures	Reduced fatal and nonfatal collisions on traffic-calmed roadways before and after intervention ¹⁵	0.85 (0.75–0.96)
Daytime running headlights	Reduced odds of multivehicle daytime collision before and after implementation of daytime running lights ¹⁶	0.89 (0.85–0.92)
Increased speed limits	Reduction in fatality after increased speed limits compared with same roads before increased speed limits ¹⁷	0.97 (NA)
Driver education	No decrease in serious motor vehicle collisions with driver education from meta-analysis of randomized trials ¹⁸	0.98 (0.96–1.01)

Note: CI = confidence interval, NA = not available, RR = risk ratio.

that ophthalmology patients not drive for a few hours after iris dilation). The lack of scientific evidence, however, implies that judgment is necessary, dissenting opinions are inevitable, and conflicts are difficult to resolve. Various Internet resources are available to guide physician and patient decision-making (Box 2).

Box 2: Additional resources

CMA driver's guide: determining medical fitness to operate motor vehicles, 8th edition

- A comprehensive review compiled by Canadian leaders and targeted at physicians. Available: www.cma.ca/driversguide

Ontario Road Safety annual reports

- Annual surveillance reports for Ontario providing detailed data on the burden of losses from motor vehicle trauma. Available: www.mto.gov.on.ca/english/safety/orsar/

Transport Canada

- The Canadian government agency focusing on transportation, including health losses. Available: www.tc.gc.ca/eng/menu.htm

Global plan for the decade of action for road safety 2011-2020

- A global summary of motor vehicle trauma from an international perspective. Available: www.who.int/roadsafety/decade_of_action/plan/en/index.html

Physician's guide to assessing and counseling older drivers, 2nd edition

- A comprehensive review compiled by American authorities with some nuances for Canadian physicians. Available: www.ama-assn.org/resources/doc/public-health/older-drivers-guide.pdf

How should we address drivers with chronic health conditions?

Physicians sometimes give explicit medical warnings to patients with chronic diseases that may render them potentially unfit to drive. Canadian programs began in 1968 focusing on seizures, syncope and other conditions marked by a sudden loss of consciousness.²⁹ The most recent epidemiologic study suggests that such warnings yield a 45% reduction in serious crashes (95% confidence interval [CI] 36–52). For example, drivers with alcoholism have a significantly lower annual serious crash rate after receiving such a warning (Table 2).³⁰ Reductions in crash rates after physicians' warnings are large and sustained, but they are also accompanied by increases in patient dissatisfaction and depression. Warnings are equally reliable regardless of whether the responsible physician is a generalist or specialist.

Previous research shows that medical warnings are not completely effective at preventing crashes. A total of 11 studies are available from 1968 to 2009,^{31–41} and they rely primarily on statistical modelling, ecologic comparisons, case-control pairings, time series analysis or survey designs. Overall, 4 of the 11 studies report no significant effect from warnings, 3 report modest benefits, and the remaining 4 report ambiguous findings. The 2 most rigorous studies from Canada showed a relative risk reduction of 13% (95% CI 6–20) and 32% (95% CI 17–47) for road crashes.^{35,39} The variable effectiveness of medical warnings suggests that patients do not always follow medical advice.⁴²

The essential components of an effective medical warning are unknown and rarely scrutinized owing to the privacy of doctor-patient relationships. In Ontario, physician warnings to drivers deemed medically unfit to drive generally involve direct discussion with the patient and a cursory notification to the driver-licensing agency. A warning does not necessarily lead to a suspended licence. However, a warning can mean that the patient's vehicle insurance might be denied in the event of a serious crash (tantamount to the patient driving with no insurance). Untangling the effects of each component of a medical warning (doctor, government, insurer) is problematic given the additional indirect influences from family and acquaintances.

Most chronic diseases are not characterized by a sudden loss of consciousness and do not always prompt physicians to consider a patient's fitness to drive.⁴³ As such, less than 1% of adult patients receive a medical warning about driving, a rate substantially below that of the Canadian

Table 2: Selected diseases, risks and effectiveness of medical warnings in preventing motor vehicle collisions

Disease	Event rate*		RR (95% CI)
	At baseline	After warning	
Dementia	2.92	0.86	0.31 (0.18–0.58)
Stroke	3.5	1.15	0.32 (0.19–0.60)
Depression	8.75	3.6	0.38 (0.25–0.60)
Syncope	5.91	2.95	0.49 (0.38–0.64)
Epilepsy	5.92	3.23	0.53 (0.36–0.78)
Diabetes	4.49	2.71	0.59 (0.43–0.82)
Sleep disorder	6.1	3.85	0.62 (0.46–0.85)
Alcoholism	7.24	4.91	0.64 (0.46–0.91)

Note: Data adapted from Redelmeier and colleagues.³⁰ CI = confidence interval, RR = risk ratio.
*The benchmark rate in the general population is about 1.96 serious crashes per 1000 drivers annually.

prevalence of single chronic diseases, such as alcoholism.⁴⁴ In response, 7 provinces currently mandate warnings (with the exceptions of Alberta, Quebec and Nova Scotia), and 1 province (Ontario) further encourages physicians through a financial incentive (\$36.25 per warning).^{45,46} Such incentives doubled the number of warnings given by physicians to patients in Ontario (Judy Taggart, Ministry of Transportation, personal communication, Aug. 6, 2013). Whether such programs might be effective in other regions is unknown.

Should drivers at indeterminate risk undergo screening?

Many patients have an equivocal risk of driving impairment because of multiple chronic diseases, fluctuating severity of disease or uncertain functional ability. On-road driver testing has been proposed for the evaluation and assistance of these patients. However, such testing is controversial owing to its uncertain effectiveness and the high cost and stress to patients. No large randomized controlled trials have examined whether on-road testing reduces serious crashes; moreover, results from small case series are discouraging.⁴⁷⁻⁵⁰ The lack of consensus for on-road driver testing has led to a variety of less elaborate in-clinic assessment tools, including the CANDRIVE mnemonic for conditions that warrant screening for fitness to drive (Table 3),⁵¹ which is currently undergoing clinical trials.⁵²⁻⁵⁵

The medical disorder with the most research concerning in-clinic screening for driver safety is dementia. The largest meta-analysis of in-clinic cognitive tests to predict driving ability included 27 studies and identified only modest correlations after excluding patients who did not have dementia (correlation coefficients -0.06 to 0.31).⁵⁶ The most recent systematic review of in-clinic cognitive predictors included 16 studies and concluded that data were inadequate to base fitness-to-drive guidelines solely on the scientific literature.⁵⁷ For Canada, the *CMA driver's guide: determining medical fitness to operate motor vehicles* remains the resource of choice for in-clinic assessments.²⁴ Although lengthy and sometimes vague, the guide provides a comprehensive approach for screening for diverse medical disorders that could impair driving ability (Table 4).²⁴

Some patients have already been involved in a motor vehicle collision and may be at risk of another event, even if peoples' natural tendency is to blame the other driver. Such cases might be more common than physicians generally realize — each year, about 2% of Canadians are

involved in a collision.⁵⁸ Thus, physicians may want to ask patients about motor vehicle collisions when eliciting a medical history.

The strongest data on secondary prevention focuses on brief alcohol interventions for survivors of crashes, which yield a reduction in recidivism of about 50%.^{59,60} Other options of uncertain effectiveness in the aftermath of a col-

Table 3: The CANDRIVE mnemonic

Domain	Examples
Cognitive impairment	Dementia, depression, inattention
Acute (fluctuating) illness	Delirium, pre-syncope, arrhythmia
Neuromuscular disease	Parkinson disease, hypoglycemia
Drugs	Benzodiazepines, opioids
Record	Collisions, infractions
In-vehicle experiences	Near incidents, vehicle damage
Vision	Night vision, field defects
Ethanol use	Mixing alcohol with driving

Note: Adapted from Molnar and colleagues.⁵¹

Table 4: Health conditions that may contribute to risk of collision fatality

Health condition	Mandatory testing	Method for testing*
Vision		
Visual acuity loss	Yes†	Visual acuity test
Visual field defect	Commercial drivers only	Visual field test
Diplopia	No	Examination by a physician
Cognition		
Alcohol dependence	No	Questionnaire
Sleep disorder	No	Sleep study
Dementia	No	Cognitive test
Psychiatric disorder	No	Examination by a physician
Seizure	No	Electroencephalography
Concussion	No	Cognitive test
Miscellaneous		
Diabetes mellitus	Commercial drivers only	Glucose diary, laboratory investigation (acetated hemoglobin level)
Hearing loss	Commercial drivers only	Audiometry
Aortic aneurism	No	Imaging study

Note: Adapted from the *CMA's driver's guide: determining medical fitness to operate motor vehicles, 8th edition*.²⁴

*Specific methods for screening are generally based on criteria for commercial drivers.

†All provinces and territories require testing for visual acuity and also impose a statutory duty on physicians relating to warning patients who are potentially unfit to drive. The duty to warn and report is mandatory in all provinces and territories, with the exceptions of Alberta, Nova Scotia and Quebec.

lision include screening for glaucoma, drug abuse, psychiatric disorders and dementia.^{61,62}

Who merits special consideration of risk for motor vehicle trauma?

Several populations merit special attention as particularly large contributors to motor vehicle trauma or particularly missed by general countermeasures. Heavy alcohol consumption contributes to one-third of total crashes, and people who consume large quantities of alcohol are likely to make frequent visits to physicians.²¹ Young Canadians, including infants with improperly installed car seats, children engaging in careless behaviour and teenagers with attention deficits, are overrepresented in serious road crashes despite previous contacts with physicians.⁶³ Adults whose lifestyles include thrill-seeking adventures such as off-roading are resistant to general countermeasures.⁶⁴ Whether these groups would be responsive to prevention strategies from physicians is unknown.

Truck drivers and other commercial vehicle operators contribute to about 1 in 5 fatal motor vehicle crashes in Canada, mostly due to the quantity of time they spend on the road. However, the actual fatality rate per billion vehicle-kilometers for this population is about one-third of that seen for all vehicles in Canada (2.5 v. 7.2, respectively).⁶⁵ The safety profile of commercial drivers is a reflection of multiple countermeasures, including government regulation of work hours, licensing requirements, automatic speed limiters, on-board recorders and professional training. In addition, commercial drivers require physician certifications, similar to those required for pilots.⁶⁶ However, a considerable problem

among commercial drivers is fatigue, sometimes due to a medical sleep disorder, with prevalences ranging from 10% to 78% in some studies.^{67,68}

Unanswered questions

Most ongoing research on driving focuses on what patients can do for themselves rather than on data to guide clinicians. The Strategic Highway Research Program 2 (SHRP 2) Naturalistic Driving Study is the largest continuing field study using specially instrumented vehicles ($n = 2360$) to investigate how driver inattention and other behaviours might contribute to crash risk.⁶⁹ The Candrive Cohort Study of Older Drivers is perhaps the largest Canadian research effort, following older drivers ($n = 1000$) over 5 years to evaluate clinical factors that potentially predict unsafe driving.⁷⁰ The DRUID Study (Driving under the Influence of Drugs, Alcohol and Medicines) involves drivers in 18 European countries ($n = 50\,000$) to assess the prevalence of psychoactive substances in contributing to crashes.⁷¹ In addition, small studies scattered over a variety of commercial domains examine potential improvements in vehicle technology.

Many questions remain for future research. Identifying risk factors for motor vehicle collisions is problematic, because such studies require intercepting motorists and screening for background prevalence rates among those who do not have collisions (an obstacle even in assessing the risks from alcohol). Determining the importance of medical conditions is also difficult owing to behavioural offsets, in which patients self-regulate their driving to compensate for their deficits. The validation of screening interventions is similarly limited by selecting participants who might be inherently health-conscious and safety-minded. Thus, clinicians have no strong data to support asking even rudimentary questions, such as “When is it unsafe for my patient to drive?” and “Which screening interventions for safe driving are cost effective?”

Summary

Trauma attributable to motor vehicle collisions is a widespread cause of morbidity and death. Most Canadian patients will be in a serious collision at least once in their lifetime.⁷² Practising physicians might help prevent some death and morbidity using effective resuscitation in the aftermath of a crash, advocating general countermeasures toward road safety and issuing medical warnings to potentially unfit drivers, in addition to using unproven indirect strategies (see illustrative case in Box 3). The past half-century

Box 3: Fictional case

A 52-year-old chef presents with a history of weakness in his left hand, which has now resolved. The patient has poorly controlled hypertension (200/100 mm Hg) and is a heavy smoker (1 pack of cigarettes/d). The patient consumes alcohol (1 case of beer/wk) and reports using marijuana. The patient drives 40 minutes per day to work and was in a vehicle collision 3 years ago, which led to chronic neck pain. He has no other medical history and dislikes visiting physicians.

Computed tomographic imaging of the head shows lacunar infarcts of diverse ages. How can you reduce the patient's risk of further motor vehicle injury?

The patient has multiple vascular risk factors and had a recent transient ischemic attack. As a physician, you have a duty to warn him about safe driving. The patient may resume driving if a neurologic assessment shows no residual deficits and the underlying causes have been addressed (including impaired driving). A warning might influence subsequent adherence to follow-up and lifestyle recommendations. Having the patient undergo screening for fitness to drive would be debatable. Reporting this patient to licensing agencies would be mandatory in some Canadian provinces.

has shown an improvement of about 30%–50% in total traffic fatalities through a combination of interventions that each had modest effectiveness.⁷³ The role for physicians in preventing collisions may expand given the shift in age demographics and ongoing advances in convenient and reliable motor vehicles.

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