DRUGS AND DRIVING: A REVIEW OF THE EVIDENCE

INTRODUCTION

This review looks firstly at prevalence for the phenomenon of substance impaired driving and adverse outcomes (especially in Canada and particularly with regard to younger drivers). It then considers findings on impairment effects of drugs on driving performance and liability, to suffering serious injury, before proceeding to take account of public perception of such risk. Attention is also paid to factors that are associated with impaired driving among youth. The discussion then takes up the question of effective responses toward reducing this behaviour and its harmful consequences.

SUMMARY

Substance impaired driving is a continuing concern in Canada (as elsewhere), and responding to it in an effective manner remains a difficult, complex task. This report reviews literature on various aspects of this challenge and summarizes perspective gained from the investigation.

Alcohol-affected driving is still the most predominant hazardous and harmful behaviour of this sort. After years of decreasing rates, a more recent plateau in figures and indication of a reversing turn back upward demonstrates a need for renewed action on that front. Evidence regarding use of other drugs (in particular cannabis) in conjunction with driving signals some significant increase and represents a more complicated phenomenon to deal with, action-wise and in messaging. This disparity is owing to difference in pharmacological effects (along with less comprehensiveness and precision in measuring those), use contexts and patterns, cultural connections, legal status and regulatory mechanisms.

Drinking and driving is more recognized as a dangerous activity though the public can afford to become more conscious of the extent to which alcohol compromises capacity. The negative effect of cannabis use on driving and liability is not generally appreciated as much as it should be, even granting present limitations in precisely confirming severity of impact.

A range of diverse features come into play in influencing the uptake and continuation of substance impaired driving (and riding as a passenger in such situations) among adolescents and young adults. These various factors that are conducive or contribute to the behaviour call for different kinds of responses to mitigate or undermine their effect.

Some broad principles in approach apply across the board in terms of the advisability of a social-ecological model of health promotion and the need for a comprehensive package of strategies that will in combination address larger-scale environmental and community-wide associated factors, relational and interpersonal dynamics, as well as influences operating more at the individual, intrapersonal level. Key community contexts for action include government, school, health and social services (besides other social and cultural organizations to which individuals belong).

PREVALENCE

What percentages of people in Canada, particularly among youth, are using drugs and driving or, more to the point, are driving in a dangerously impaired state occasioned by their use? Among those suffering or causing adverse consequences (e.g., collisions, injuries, death) from their driving, what proportions do so as a result of drug impairment? Some answers to such pertinent questions come from a variety of sources such as surveys, roadside testing initiatives and studies of drivers that have been killed or injured. Enforcement data (e.g., numbers of impaired driving charges) would give some suggestion too,

though this information is subject to obvious limitations associated with varying rather than uniform commitments to conducting enforcement exercises, along with disparities in capacity for detecting different substances.

In short, the most recent evidence indicates that the youngest drivers are now less represented relative to other age brackets among those driving under the influence of alcohol, but that this quickly changes for the worse at the end of teenage years. Youth moving toward and into adulthood are already a significant percentage of those driving under greater impairment, or riding with an impaired driver, and are also disproportionately high among alcohol-related fatalities. In comparison to older adults, the behaviour of driving after cannabis use shows up fairly strongly among late teens. These are indicators of concern within a larger population-wide picture in which impaired driving and its often harmful outcome remain a front on which further progress in health and safety still needs to be made.

Drinking and driving in Canada

The Canadian Addiction Survey of 2004 had 11.6% of licensed drivers (14.5% of non-abstaining licensed drivers) reporting driving within an hour of consuming two or more drinks at least once in the past 12 months. Such drinking drivers were more likely than non-drinking drivers to be male, unmarried, younger (among females), employed full-time, and enjoying a significantly higher average income. They also reported significantly more frequent and heavier use of alcohol within that past year, including more instances of episodic excess. The age bracket most likely to report driving after drinking were 16-19 and 20-24 year olds, with more than one in four males in both those age groups implicated (and one in five for the two genders across those two age groups combined).

Most of those acknowledging driving after drinking reported doing so infrequently, with 11.7% reporting a rate of more than once a month. This latter group tended even more to be males (93.6%) and to have more frequent and heavier drinking patterns, consuming at more hazardous and harmful levels. They also manifested more prevalent use of illegal drugs, suggestive of greater liability to driving under impairment from that source as well (Beirness & Davis, 2008; cf. Beirness & Davis, 2007).

The 2010 edition of the Road Safety Monitor in Canada has 24.7% of Canadians admitting to driving after consuming some amount of alcohol in the past 30 days (TIRF, 2010b). This continues an increase over a five year period, leaving the proportion above a 1998 level and reversing earlier declines that had come after that point. Only 5.5% reported driving when they thought they were legally impaired, which marks a significant drop from early- and mid-decade (and more so yet from 1998), but may also evidence some slight dissipation of effects from tougher drunk driving federal legislation enacted in 2008. It remains to be confirmed whether those who are drinking and driving are drinking less on a continuing basis. Among youth aged 16-24, the proportion reporting taking the wheel after use of alcohol in the past 30 days was conspicuously below the overall sample findings (11.9% to 24.7%), but disconcertingly above them on acknowledged driving under impression of impairment (7.9% to 5.5%; TIRF 2011b). Also disturbing, over half (54.4%) of those young drivers admitting the latter behaviour reported that the last instance of it included transporting passengers.

The British Columbia Roadside Survey of June 2010, conducted in five BC communities in different areas of the province, found 9.9% (10.3% male, 8.3% female) of drivers randomly selected and voluntarily tested for BAC (n=2,449) registering a breath sample of .005% or higher, with women (2.6%) just as likely as men (2.0%) to have a BAC greater than the legal threshold of .08%. Age-wise, those 16-18 had relatively low percentages testing positive (3.4% for BAC ≥.005%; 0.8% for BAC >.05%; 0.0% for BAC >.08%). The 19-24 bracket had more elevated rates (9.3% for BAC ≥.005%; 2.3% for BAC >.05%; 1.4% for BAC >.08%). These proportions were well below those registered among 25-34 (12.6%; 5.9%; 4.4%) and 35-44 year-olds (12.7%; 5.7%; 1.6%) for those respective BAC categories (≥.005%; >.05%; >.08%). As on

CAS, those drinking and driving were more frequent, heavier, and more frequent heavy episodic drinkers than non-abstaining drivers who did not drive with a measurable amount of alcohol still in their system. Alcohol use among drivers was more common on weekends and during late-night hours. In cases involving a BAC above .08%, 30% were coming from the home of a friend or relative, 22.5% from a bar or nightclub, 20% from a restaurant, and 15.5% from their own residence (Beirness & Beasley, 2011). As the sixth instalment in a series of surveys of this sort starting in 1995 in regard to drinking and driving, the established trend was one in which there was no longer a decline in drinking and driving, and also a slight increase in incidence of BAC over .08%.

As of 2008, annual fatalities from crashes involving a drinking driver (790 that year) marked a second year decrease, aligning with a decline pattern from the 1990s through the early 2000s and reversing a more recent two year rise (TIRF, 2010b). While the percentage of tested fatally injured drivers registering positive for presence of alcohol had progressively decreased from 62% in 1982 down to 33.1% in 1999, it then levelled off at 35% and above after that point (38.1% in 2007, 38.7% in 2008, 37.6% in 2009: TIRF, 2009a, 2010a, 2011a). Among the 12,978 drivers killed in vehicular crashes on public roadways in Canada during the years 2000-2007, 10,900 (84%) were tested for the presence of alcohol. A total of 5,929 were tested for both alcohol and other drugs, with 2,143 or 36% of these testing positive for alcohol – alone or along with another drug (22%, 14% respectively, Beasley et al., 2011).

Within the category of those driver fatalities testing positive for alcohol in 2008 and 2009, 85% registered above .08% BAC. The age groups most highly represented among the fatally injured drinking drivers (and among the subset testing above .08% BAC) were 20-25 and 26-35 year olds, followed by the 36-45 and 46-55 brackets. Slightly lower than those over 55 were those aged 16-19, comprising 10% of drinking driver mortalities (10.1%, 2008; 9.1%, 2009) and 8% of those driver fatalities registering above .08% (8.5%, 2008; 7.5%, 2009; TIRF, 2010a, 2011a). Relative to their proportion of the overall population, older teens and young adults are over-represented in the ranks of those suffering alcohol-related traffic deaths. Under 16 year olds accounted for just 2.1% of alcohol-related traffic deaths in 2006 though comprising 19% of the population; 16-19 year olds were fatalities in 12% of all alcohol-related deaths though constituting only 5.4% of the population; 20-25 year olds were killed in 21.4% though making up just 7.8% of the population; still disproportional, 26-35 year olds, 21.7% among such deaths though 12.9% of the populace; 36-45 year olds, 19.3% of these fatalities though 15.4% of the populace; thereafter older age brackets are less represented among alcohol-related fatalities (Solomon et al., 2009; cf. Chamberlain & Solomon, 2008, Solomon & Chamberlain, 2006 for comparable disparities in earlier years in the decade).

Other drug use and driving in Canada

The 2004 Canadian Addiction Survey had 4.8% of licensed drivers (33.3% of drivers using cannabis in the past year) reporting operating a vehicle within two hours of cannabis use at least once in the past 12 months (mean number of instances 24.5, median 10). Compared to those not driving under its influence, such individuals driving after consuming cannabis were more likely to be male, quite a bit younger, and single. They also had more frequent use of cannabis, earlier initiation into it, and were more likely to report use of other illicit drugs. They scored higher on both more problematic use of cannabis (on the ASSIST measure) and of alcohol (on the AUDIT measure), with considerably more likelihood of driving after drinking. In contrast to age distribution for those drinking after driving, where rates continue fairly stable after age 24, the behaviour of drinking after cannabis use declines progressively across age brackets 16-19, 20-24, 25-34, 35-44, 45+. In the first bracket, report of driving after cannabis use exceeded that of driving after drinking (20.6% to 19.6%, Beirness & Davis, 2006). This latter finding aligned with evidence gathered from surveys of high school students in two different regions of Canada

(Beirness & Porath-Waller, 2009), namely, Ontario (Adlaf et al., 2003; Paglia-Boak et al., 2009) and the Atlantic provinces (Asbridge et al., 2005).

The British Columbia Roadside Survey found 7.2% (9.5% male, 3.3% female) of drivers randomly tested (n=2000) for presence of a potentially impairing substance other than alcohol registering positive after voluntarily providing an oral fluid sample. Age-wise, the proportion of drivers testing positive was similar across brackets (again 16-18, 19-24, 25-34, 35-44, 45-54, 55+) in contrast to the findings around BAC. In this survey, a positive result for some other substance does not necessarily signify the driver was impaired; detection thresholds varied somewhat among the kinds of drugs checked for (amphetamines, benzodiazepines, cannabis, cocaine, methamphetamine and opiates). The most commonly detected drugs were cannabis (4.5%) and cocaine (2.3%), with the vast majority of those testing positive for the former doing so in THC concentrations suggestive of reduced capacity for the driver to conduct a vehicle safely. Unlike alcohol, drug use was not more apparent on weekends or during late-night hours. In cases involving a positive sample, the origin of their trip was most commonly home (34.7%), secondly a friend's/relative's place (32.3%), with other less likely points of departure being the workplace (10.5%), a sports/recreation context (7.3%), restaurant (6.5%), bar/pub/nightclub (4%), or some service location like a grocery store or gas station or airport (4.8%). Being only the second instalment to test for presence of drugs, no trend could yet be established (Beirness & Beasley, 2011).

Of the 12,978 drivers killed in vehicular crashes on public roadways in Canada during the years 2000-2007, 6,016 (46.4%) were tested for drugs other than alcohol. Among the 5,929 tested for both, 1,097 or 18.5% came up positive for a psychoactive substance though negative for alcohol, and another 842 or 14.2% positive for at least one other drug along with alcohol. The proportion of drug use within the population of fatally-injured (and jointly tested) drivers was only slightly shy of the percentage of those consuming alcohol: 33% versus 36% (Beasley et al., 2011). Central nervous system (CNS) depressants and cannabis were the leading categories of substances detected, followed in turn by CNS stimulants and then narcotic analgesics. Other groups such as hallucinogens, dissociative anaesthetics and inhalants were rarely represented. Cannabis use showed most highly in younger age brackets (<19, 19-24), gradually diminishing thereafter. Presence of drugs other than alcohol did not amount to a confirmation of impairment.

Consistent with the findings of the BC roadside survey, driver fatality patterns where alcohol or other drug use was evident corresponded with driving patterns where those uses were detected. With the other drugs, the crashes, like the instances of detection, tend to be much more broadly distributed across hours of the day and days of the week in contrast to the tendency of alcohol-affected driving and lethal outcomes to occur in later hours and on weekends. Crashes in which other drugs were in the driver's system (though impact was undetermined) had greater probability of involving more than one vehicle as opposed to alcohol's tendency to be present more in single-vehicle crashes (Beasley et al., 2011).

In spite of the fact that use of alcohol remains quite a bit more popular than cannabis use among youth, levels of reported driving under the influence of the latter (DUIC) are now equivalent to or slightly surpass DUIA within this age bracket. This indicates that DUIC is a behaviour worthy of attention, one which young people evidently approve more, fear less and are more likely to engage in (cf. Fergusson et al., 2008).

PHYSICAL IMPAIRMENT EFFECTS AND ELEVATED RISK OF INJURY

Impairment effects relative to driving ability ride on a range of factors including type and amount of substance consumed, time lapse between ingestion and driving, and individual variability itself

encompassing several features (e.g., health condition, experience, tolerance). Broadly applicable measurement of adverse impact of drug use on people's driving performance is attempted along several lines of examination and assessment.

In short, the disabling effects of alcohol are well established, to the detriment of drivers even with low concentrations in their system. Likewise, amply attested is alcohol's capacity in combination with other drugs to cause worse debilitation than any of these substances alone would bring about. While for drugs other than alcohol, studies are not so definitive, enough is known to indicate compromising effects from use of cannabis preceding driving, and even stimulants of various sorts pose problems that make their consumption ill-advised in this connection.

METHODS EMPLOYED TO STUDY HOW SUBSTANCES AFFECT DRIVING AND OUTCOMES

Basically, three different types of study have been conducted to indicate extent of relevant impairment from substance use and the impact of such effects on susceptibility to collision, and even likelihood of an impaired driver's involvement in vehicular crashes:

1. cognitive laboratory studies (measuring effects of the drug on processes considered integral to safe driving)
2. experimental studies (on risk of collision for people under the influence using a driver simulator or a driving road course)
3. epidemiological field studies (on the statistical relationship between use and accidents, usually by testing injured drivers, attempting to assess actual risk of causing an accident for impaired versus sober drivers under similar conditions, with relative risk expressed as an odds ratio [OR])

The first type, cognitive studies, permits observation of impairment under different dosages, albeit within ethical constraints on allowable amounts such that these fall short of heavier, more harmful exposures. The laboratory setting is removed from real driving contexts and thus unable to confirm actual injurious impacts under those conditions. The samples tend to be of smaller size and not random, which does not legitimate generalization to larger populations.

The second sort, experimental studies, can sometimes be carried out on public roads (rather than just in simulators or on closed circuit courses) provided that the test vehicles are equipped with override controls manned by licensed instructors. Still, this kind of testing suffers several weaknesses: subjects are aware of being examined, so the results are a better measure of intent than performance; ethical constraints limit dosage; and the administration doesn't necessarily reflect real world conditions on other counts beside dosage, such as quality of drug and use history. Again, given representation among the test subjects, there are limitations in regard to how far such tests can be applied: more to certain subgroups of the populace rather than the general public.

The third kind, epidemiological studies, do assess effect under real life conditions, and are suited to correlate an indicated concentration to an actual risk. However, they too have some deficiencies: by including only crash-involved drivers, they cannot show causality, with limited ability to show the impact of other variables. Timely collection of the indicator is more difficult with substances other than alcohol. Epidemiological field research itself falls into two distinct forms: culpability studies and case control studies. Culpability studies assign drivers degree of responsibility for fatal/non-fatal crashes, then compare on drug use in those categories: if greater among those culpable, the drug is then judged as contributing to greater risk. Besides difficulty in attributing singular fault, they are also susceptible to confounding in which a delay to sampling puts some affected users in a non-use group, and in which use of a metabolite for identification puts some non-impaired drivers into an impaired group. For case control studies, which compare prevalence of use among drivers involved in accidents with a control

group of other drivers, the challenge is to be able to match cases with controls, which is not easy to achieve.

Despite limitations cited above, the collective weight of these different approaches to indication of impairment effects has still been helpful in pointing to the hazards substances can pose for the demanding activity of driving (Sewell et al., 2009; Grotenhermen et al., 2007; Ogden & Moskowitz, 2004; Kelly et al., 2004; Hammond, 2009; Mallick et al., 2007; Arcuri, 2009; Vingilis & Macdonald, 2002; Ramaekers et al., 2004).

EFFECTS OF ALCOHOL INTAKE ON DRIVING

In short, alcohol works against driving capacity in numerous respects. It poses a particular threat for younger and otherwise inexperienced drivers.

General physical depressant effects caused by alcohol have been charted accurately enough in terms of BAC (Blood Alcohol Content/Concentration) levels as to permit broad demarcations on a scale of ascending impairment. Some modest degree of reduced functioning relevant for driving has been shown at very minimal levels of absorption (0.02-0.03% BAC), and severity of motor vehicle accidents that imperil life has been found to increase significantly at 0.01% BAC (Breitmeier et al., 2007; Phillips & Brewer, 2011). Such results legitimate overall advice not to drive while still under any influence, and serve as a valid basis for zero tolerance requirements within graduated licensing for new and younger drivers. Designation of common ceilings for legally tolerable BAC at .08, if not even .05 and below, is well grounded (Sewell et al., 2009; Babor et al., 2010; Ogden & Moskowitz, 2004; Moskowitz & Fiorentino, 2000; Blomberg et al., 2005).

Besides diminishing ability to perceive, visually process, concentrate, attend to a complex situation with divided tasks and new developments, and as well as reducing eye-hand coordination and reaction time, the influence of alcohol tends to cause not only underestimation of this impairment but also increased speed and more aggressiveness (e.g., following other vehicles more closely and overtaking them more often) while lowering appreciation of risk, all of which contribute to elevated likelihood of involvement in a serious collision. Some of those effects, along with alcohol's role in facilitating inadequate use of seatbelts, explain alcohol's implication in greater crash severity. While the public associates impaired driving and its contribution to fatal crashes largely with individuals suffering from a condition acute enough to qualify as a diagnosable disorder, those drivers only occasionally indulging in episodic excess have greater odds of being involved in alcohol-related fatal crashes, and (given their more substantial proportion in the general population) drinking drivers who never get intoxicated constitute a majority percentage in alcohol-related crashes that result in death (Babor et al., 2010; Sewell et al., 2009; Phillips & Brewer, 2011). Even with less frequent driving patterns, young drivers under age 21 with positive BACs have been found to have higher crash risk than their older counterparts. The greater liability to intoxication that attaches to greater intake in heavy drinking episodes, particularly for those youth less physically equipped and accustomed to process alcohol, could be compounded for these youth with their disadvantage of having less experience as novices in avoiding crashes. Any greater propensity for risk-taking (including speeding) that attaches to this age bracket would also be exacerbated by alcohol with resultant increased susceptibility, though certain other features such as the influence of night-time driving and passengers also are part of the equation as additionally hazardous conditions for the youngest driver group (Peck et al., 2008; Bingham et al., 2009).

As documented and summarized in references cited above, there is a wealth of consistent evidence demonstrating alcohol's debilitating influence on people's capacity to drive safely and how their odds of experiencing grave injury are increased when they drive under such impairment, beginning in low doses

and escalating at greater exposures. In combination with other drugs, alcohol – even in doses beneath ordinary levels for illegal impairment (e.g., 0.05% BAC) – can readily contribute to greater debilitation than the other substance alone would deliver, not just in the case of fellow depressants (e.g., benzodiazepines), but also with cannabis. Stimulants cannot be expected to offset alcohol's own sedative liabilities, nor will it necessarily conveniently soften their intensifying effects. Polydrug use before driving, especially when it involves alcohol, escalates the likelihood of incurring injurious outcomes (Hammond, 2009; Mallick et al., 2007; Stough & King, 2010; Kelly et al., 2004).

Research results over the last few decades have been somewhat equivocal on whether caffeinated beverages can to some degree counter the adverse impairment effects of alcohol on driving ability, with some studies showing some reversal on psychomotor speed, reaction time and divided attention, but other investigations not confirming such gains (Ferreira et al., 2004, 2006; cf. Fillmore et al., 2002). One recent laboratory study indicates that consumption of energy drinks along with alcohol affects behavioural control in one respect differently than will intake of alcohol alone, but in another respect does not (Marczinski et al., 2011; cf. Marczinski & Fillmore, 2003). Consumption of energy drinks mixed with alcohol

- does antagonize or counteract some of the alcohol-induced impairment of response activation (it does work against alcohol-caused slower reaction time), but
- does not counteract alcohol-induced deficiencies in response inhibition (it doesn't lessen alcohol-caused failure to avoid or refrain from impulsive behaviour).
- On a more subjective count, administration of energy drinks along with alcohol appears to
- heighten the consumer's sense of stimulation beyond that reported with just alcohol alone, but
- deliver comparable ratings on subjective effects such as one's impression of impairment, level of intoxication and ability to drive.

Another recent study (Howland et al., 2011a) comparing different drinking conditions and utilizing a simulated driving device conversely found the addition of caffeine to have no offsetting impact on the impaired performance and slowed reaction time caused by an intoxicating exposure to alcohol. However, this study did not find the presence of caffeine to compromise estimation of one's BrAC (breath alcohol concentration). Even if an improvement in reaction time might occur for some, this is not a uniformly established benefit, and does not compensate for other negative effects such as alcohol's adverse impact in weakening inhibition of impulsive behaviour. Adding energy drinks into the mix does not mean one will be less inclined to be aggressive, take chances, or make errors in judgment.

Even if the addition of energy drinks to alcohol may not further diminish a person's ability to estimate their own degree of impairment, it does not aid the person in assessing their situation and may mislead. The presumption that the energy drink factor will enhance performance is undermined by evidence that such expectation in itself actually discourages compensatory measures people might otherwise employ and leaves people more vulnerable to impairment (Howland et al., 2011b). Another concern in regard to ingestion of energy drinks in conjunction with alcohol is the indication that in such combined situations young people end up drinking more alcohol (perhaps because of the added stimulation as BAC level first rises, perhaps because of weakened sedation at a later stage), which not only leaves them at greater risk of acute harm from assault, but indeed appears to lead to more readiness to make behavioural choices that occasion injury, such as driving after drinking or riding with someone who has been drinking (O'Brien et al., 2008; Price et al., 2010; Thombs et al., 2010; cf. Marczinski & Fillmore, 2006).

IMPACT OF CANNABIS USE ON DRIVING

In short, effects of cannabis consumption on driving performance are not nearly as clear-cut as with alcohol, but have to be considered adverse and as posing some degree of threat to safety.

Extensive laboratory and experimental findings show impairment from cannabis across a broad range of functioning pertinent to operation of a vehicle, including visual functions, tracking ability, divided attention, motor coordination, with some studies indicating delayed reaction time as well. While results from simulator and on-road course driving studies have not been uniform in confirming under-performance, some detriment is amply attested. Those driving following use have shown increased propensity to hit obstacles, miss signs, drive more slowly and be slower in responding to traffic light changes and in making decisions about passing (Sewell et al., 2009; Stough & King, 2010; Kelly et al., 2004; Ogden & Moskowitz, 2004; Ramaekers et al., 2004; Berghaus et al., 1995; Ronen et al., 2008).

Indications of compensating behaviour whereby users tend to reduce risk by cutting down on speed and exercising more caution on distance are somewhat undermined by (a) the apparent inability of such a strategy to overcome attention and processing deficit (particularly but not only in response to unexpected events), as well as (b) difficulty in maintaining consistent lane position, plus (c) evidence indicating that such counterbalancing efforts (to whatever degree they are helpful) are often discarded within an hour and a half from smoking, when impairment is less subjectively evident yet still somewhat operative (Mallick et al., 2007; Hammond, 2009; Ramaekers et al., 2004; Lenné et al., 2004; Papafotiou et al., 2005). Performance has been shown worst affected by cannabis in the areas of operational skill or routine and automatic processing, which takes place faster and is relatively inflexible, involving such elements as tracking and speed adjustment. Less but still negatively impacted, particularly at higher doses, are the domains of maneuvering (keeping distance and braking) and strategizing (observation and comprehension of traffic, assessment of risk and planning), components which both require more demanding attention and slower, more flexible processing (Ramaekers et al., 2004; cf. Grotenhermen et al., 2007; Sewell et al., 2009).

Of course, higher doses compromise ability more, particularly among those who have not acquired tolerance (Ronen et al., 2008; Ramaekers et al., 2006). What can be said with more specificity and precision about cannabis dosage, time lapse factor, and measurement of impairment and comparative risk? The particular psychoactive constituent of concern in cannabis is Δ^9-tetrahydrocannibinol (THC for short); other cannabinoids in the plant lack its potency and testing, which simply detects the long lingering presence of inactive metabolites, is of no value in confirming impairment from use. When smoked, THC is quickly absorbed through the lungs into the bloodstream, reaches the brain within minutes and immediately begins to exercise its effects on the central nervous system. Peak concentrations in the blood are reached promptly, with full impairment effects following a further 20 minutes or more after, when those levels are already in rapid decline (Ashton, 2001; Swann, 2000; O'Kane et al., 2002; Sewell et al., 2009). Laboratory cognition testing and experimental tests on driving skill show debilitating effects of THC to be highest during the first hour after smoking (or 1-2 hours after oral intake) and to fall to zero over 3-4 hours after use (with heaviest doses producing the most prolonged effects). Recent investigation shows signs of impairment in the range between 2-5 ng/ml THC concentration in blood serum as corresponding to 0.03% BAC (Ramaekers et al., 2006). Meta-analyses of experimental tests suggest a serum concentration of 4-5 ng/ml, like a BAC of 0.04%, impair driving-related skills by about 30%, and that a level of 7-10 ng/ml aligns with the impairment impact of 0.05% BAC (Grotenhermen et al., 2007).

Though not so precise and substantial in their implications, epidemiological studies point in the same direction, indicating increasing accident risk with driver THC concentrations of 10 ng/ml (Grotenhermen

et al., 2007; Drummer et al., 2004; cf. Bédard et al., 2007). The lower limit of 7 ng/ml would be high enough to minimize false impairment positives from individual variability across a time lapse between smoking and testing, as well as from previous use residual concentrations from passive exposures and from medicinal dosages. It would also account for analytical errors in blood testing (Grotenhermen, 2007). Self-reported collision risk studies lack the rigour of epidemiological investigation but, without demonstrating a causal role to impairment, these surveys do still support the conclusion that cannabis use before driving raises risk of involvement in vehicle crashes (Mann et al., 2007, 2010; Asbridge et al., 2005).

While it is apparent that cannabis impairment can allow drivers to exercise cautionary measures, these adaptive actions should not be deemed safety-ensuring (though they are somewhat enhancing). This stands in conspicuous contrast to the tendency of alcohol to prevent those under its influence from recognizing its effects and to prompt more aggressive risky behaviour. Though the effects of cannabis itself are significant in their own right to call for several hours' delay before driving (Sewell et al., 2009), the combination of this substance with alcohol, even in small doses of each, raises impairment levels markedly above what equivalent amounts of either alone would produce, with combined effects being not just additive but perhaps even synergistic and multiplicative, and any adaptive compensation lost (O'Kane et al., 2002; Ogden & Moskowitz, 2004; Kelly et al., 2004; Ramaekers et al., 2000, 2004; Sewell et al., 2009; NHTSA, 2000).

INFLUENCE OF OTHER DRUGS ON DRIVING

In short, effects will vary depending on the type of drug, but some effects are clearly incompatible with the process of driving, no substance qualifies as appropriate for driving, and combinations of drugs are especially hazardous. Even stimulants that are supposed to enhance performance provide some negative potential that calls for avoidance rather than misplaced confidence in connection with driving. Some medicinal applications may be acceptable for seniors under monitored use.

Discussion of drugs other than alcohol and cannabis in regard to impairment effects and related risk of harm in driving while under the influence sometimes categorizes them in terms of which drugs are illicit and which are pharmaceuticals. Classification more sensitive to psychoactive characteristics and functions, as well as prevalence of use, tends to group these others instead in five or so brackets: benzodiazepines, opioids (heroin and relatives), stimulants (amphetamines, including ecstasy, cocaine), antihistamines and antidepressants (e.g., Walsh et al., 2004; cf. Kelly et al., 2004; Mallick et al., 2007; Hammond, 2009; Stough & King, 2010). Hallucinogenic drugs with their dissociative capacity are more readily recognized as dangerous for a driving context. A powerful depressant like GHB is likewise inimical and rarely appears in this connection (Jones et al., 2008; Barker & Kosoho, 2008; Couper & Logan, 2001, 2004a). Polydrug use in connection with driving also elicits some attention, with combined effects typically appearing worse than the impairment from a singular substance. The particular case of alcohol along with some other drug remains a substantially occurring and generally most dangerous combination (Stough & King, 2010; Hammond, 2009; Mallick et al., 2007; Kelly et al., 2004; Ogden & Moskowitiz, 2004).

Among youth, ecstasy-impaired driving rates some mention. Ecstasy adversely impacts some functions, particularly in visual scanning, sensing and controlling speed, as well as maintaining vehicle positioning. It also lends itself to increased risk-taking. Combined with sleep loss (pertinent in view of use at extended late-night party gatherings), deleterious effects can be compounded. A minority of people may have the misimpression that use can be advantageous for driving, and confuse ecstasy's capacity to offset drowsiness with its inability to counter impairment from alcohol. Disparity between quality utilized in testing and ingested in real life is a mitigating factor in assessing impact (Kuypers et al., 2006,

2007; Ramaekers et al., 2006; Ramaekers & Kuypers, 2006; Stough & King, 2010; Hammond, 2009: Mallick et al., 2007).

Looking more broadly among stimulants than ecstasy in particular, amphetamine-impaired driving may merit minor attention among this bracket. While amphetamines in low doses can add to alertness and attention for simple (but not more complex) tasks, in larger amounts they can be conducive to greater risk-taking. Where use is heavier and sustained, the result can be very hazardous "rebound fatigue" following extended periods of wakefulness. Indications are that, among users, there is greater perception of supposed benefit (enhanced attentiveness, sharper reflexes, energy boost) and comparative lack of awareness on detrimental effects, with resultant liability to overconfidence (Stough & King, 2010; Hammond, 2009; Mallick et al., 2007; Ogden & Moskowitz, 2004; Couper & Logan, 2004b).

Little research has been devoted to effects of pharmaceutical drugs on driving. Discussion of benzodiazepines is more pertinent for older adults. Evidence on benzodiazepines is suggestive of rather than conclusive on hazardous impairment, most likely a concern in higher dosage and during initial stage of use, with longer exposure and stabilization through tolerance diminishing the threat (Mallick et al., 2007; cf. Hammond, 2009; Kelly et al., 2004; Ogden & Moskowitz, 2004; Stough & King, 2010; Dubois et al., 2008; Beirness et al., 2006). By alleviating certain medical conditions, pharmaceuticals can sometimes serve to enhance driving ability (Mallick et al., 2007).

PERCEPTIONS OF RISK AROUND SUBSTANCE IMPAIRED DRIVING

In short, driving after drinking is broadly perceived as a serious problem, while driving a vehicle after use of some other drug, particularly cannabis, is not viewed as so significant a safety concern among younger drivers. Less information and a lower profile (including around enforcement initiatives) contribute to this disparity.

The 2009 instalment of an annual public opinion survey in Canada conducted by the Traffic Injury Research Foundation indicates that a strong majority of Canadians recognize significant risk in drinking and driving. Over 75% affirmed a high level of concern about it, higher than any other societal issue mentioned in the poll, with road safety coming second at just over 65% (ahead of, e.g., crime, price of gas, airline safety). Within the realm of road safety issues polled, close to 85% (including young drivers aged 16-24) cited drinking drivers as a very or extremely serious problem, above all other particulars listed (e.g., excessive speeding, running red lights, tired truck drivers, the number of large trucks on the road) except for texting.

Nearly 20% of Canadians (fully that percentage of those 16-24) can identify a family member or close friend to some degree victimized by, rather than responsible for, an alcohol-related collision. On the other side of the coin, close to 15% (over 16% for 16-24 year olds) are aware of a close relation or friend who was at fault in causing a collision in the context of drinking and driving. Canadians by and large recognize driving under the influence of alcohol as dangerous and view it as unacceptable. Given that most drinking drivers are consuming in a social context rather than alone, there is opportunity for other people to exercise more of a restraining influence on them (TIRF, 2011b, 2010b, 2009b).

Acknowledgment of scientifically recognized impairment effect from alcohol (and ability of breathalysers to detect its extent) is fairly widespread among the population, though not an automatic deterrent for all who admit this impact. Over three-quarters (77%) of adult drivers in Canada 25 years old and up acknowledge they can't drive safely after consuming alcohol; 86% of those 16-24 show greater appreciation by admitting the same (TIRF, 2011b). Collective familiarity with recommendations of a minimum one hour (preferably 1.5 hour) interval after consuming a standard drink remains to be ascertained. Appreciation of the seriously elevated risk involved for drivers who have consumed some

alcohol in conjunction with ingesting other drugs (especially cannabis, benzodiazepines) could also afford to be enhanced.

If what is true of other similar jurisdictions (such as Australia and New Zealand: Mallick et al., 2007; Hammond, 2009; Kelly et al., 2004) holds for Canada, a majority also view using other drugs and driving with suspicion as likewise risky and not meriting any approbation. But age-related perspective factors in. Canadian adult drivers over 25 have expressed comparable levels of perception (83%, 80%) of their younger (16-24) fellow drivers as a serious safety issue when driving under the influence of alcohol or other drugs respectively. Among the younger 16-24 bracket in regard to themselves, a full 82% saw drinking drivers in their own age demographic as very much a cause for concern, with a shade under 70% viewing their peers who drive affected by other drugs as a highly serious problem. While 84% in the 25-up group agree that they cannot drive safely after taking illegal drugs, that proportion slips below 80% for the under-25 group. Thus, whereas younger drivers are more persuaded of compromising impact for alcohol than those older, these youthful automobile pilots are less convinced than their elders of the undermining effects of other drugs (TIRF, 2011b).

Cannabis consumption in connection with driving would be most tolerated, given the larger percentage of users, increasing public (particularly peer) acceptance of them and uncertainty concerning the potential for harm from the drug in general and in relation to driving (cf. Fischer et al., 2006; McCarthy et al., 2007; Danton et al., 2003; Davey et al., 2005b; Terry & Wright, 2005). Illicit drug users tend to be more wary of the effects of alcohol than the illegal substances they were ingesting and feeling familiar with (but perhaps underestimating, their experience notwithstanding). While perhaps conscious of particular points of vulnerability (e.g., when withdrawing or nodding off from effects), besides a prevailing confidence in their capacity to handle drugs and driving at least for the most part, various aspects of their situation may hinder readiness to drive after use: use of a vehicle to get drugs and promptly leave a point of acquisition, desire to use promptly, perceived advantage in a vehicle's privacy for undetected or undisturbed use, and lack of concern over an added instance of illegal behaviour (Aitken et al., 2000; Davey et al., 2005a; McIntosh et al., 2008; Terry & Wright, 2005).

Public recognition of significant enough impairment for driving from cannabis is not nearly so established as with alcohol; indeed, opinion is fairly widespread that disabling effects are rather minimal at most. Nor has awareness of and confidence in validity for detection procedures recently introduced into enforcement practice taken root within the public. There is evident need for education in these areas as part of an effort encouraging people not to combine cannabis use with driving. Even among those acknowledging generally applicable cannabis impairment effects on driving after use, there can remain undue confidence of one's own personal ability (typically assumed as greater than average) to compensate for and so control limitations. Youthful audiences, among whom both cannabis use and driving afterward is more common, could benefit from appropriate awareness-raising around the substance's impact on performance and indications that, for those in their age bracket who use and drive, the risks of crash are now comparable if not above that liability for peers who drink and drive (Fergusson et al., 2008; cf. Mann et al., 2010). The advisability of a 3-4 hour wait before driving after ingestion of cannabis is an item that could well afford to gain greater public awareness and appreciation (Sewell et al., 2009; Fischer et al., 2011).

In view of the accepted status of pharmaceuticals and in keeping with the relative lack of research around them in conjunction with driving, there is likely to be less persuasion of danger in combining use of prescribed drugs and driving an automobile.

FACTORS INFLUENCING YOUTH TO DRIVE IMPAIRED

In short, a diverse range of influences are conducive to or contribute to substance-impaired driving and need to be variously addressed in acting comprehensively to reduce this hazardous behaviour. This will include efforts that seek to improve the relational climate for youth in ways that reduce marginalization and also relativize the social role of alcohol.

One helpful classification of factors that bear on common teen risky driving behaviour (e.g., speeding, tailgating, unsafe lane changing, weaving in order to pass, failure to yield or stop as directed by regulations and signage, impaired driving, fatigue, distraction, lack of seatbelt use and impaired driving) distinguishes seven sorts of influence: driving ability, developmental factors, behavioural factors, personality factors, demographic factors, perceived environment factors, and driving environment (physical and social) features (Shope & Bingham, 2008; cf. Shope, 2006; Shope et al., 2009). The formulators of these categories recognize that some factor types (e.g., ability, behavioural factors, perceived environment, driving environment) are more modifiable than others (such as developmental, personality, demographic) and that policy level changes may well prove more effective than individual-based approaches in bringing about change. Given greater proclivity for risk-taking as a natural feature of the adolescent phase of cognitive development indicated by social neuroscience, regulations that limit opportunities for immature decision-making are a sensible response (Steinberg, 2008). At the same time, systematic improvement of driver training programs could enhance ability on a larger scale, and graduated driver licensing has already brought about more opportunity to develop skills before exposure to riskier situations.

Among perceived environment features predicting youthful impaired driving are found such tokens as surrounding support for drinking and drink driving, less parental monitoring of adolescents, parents being overly permissive, and less perceived risk for the practice of driving after drinking. Parents accordingly become natural candidates for assistance, as do peers and partners likewise constitute a fitting target for efforts to promote safer practices among them. Messaging to communities needs to be clear concerning risk and responsibility in regard to driving after drinking, but a commitment to active enforcement of safety-serving regulations is an integral part of this issue (Nygaard & Grube, 2005; Nygaard et al., 2003). Progress in regulation and utilization of the media (including advertisement, entertainment and branding) remains another important piece in this area, given the manifold promotional appeal the alcohol industry generates (see Chester et al., 2010; THCU, 2010).

Among personality factors, teens with more tolerance of deviance, less family connectedness and parental orientation, more vulnerability to peer pressure, more of a bent to take risks (or seek sensation), and more disposition toward hostility and aggression are more likely to engage in impaired driving. Enhanced parental involvement, initiatives that seek to encourage and support less hazardous alternative behaviours, and inclusive interventions that aim to ameliorate antisocial inclinations is all called for, most of which requires patient, persistent effort to mitigate fairly entrenched orientation and tendencies resistant to change.

In the behavioural grouping, besides expressions of risk-taking propensity, alienation from others and poor grades in school, many measures of substance use (e.g., early onset, increasing trajectory, greater use of other drugs) feature prominently along with more delinquent conduct and aggressiveness in driving as predictors of impaired driving. Again, emphases that raise risk perception, commend harm reduction and build connectedness, thus supporting personal development and social adjustment, are appropriate responses at the individual, family, school and community levels (Shope et al., 2009; Shope and Bingham, 2008; Shope, 2006; cf. Sabel et al., 2004; Vassallo et al., 2007, 2008).

It is not surprising that established drug use patterns, especially more frequent and heavier alcohol use, are associated with substance-impaired driving (e.g., van Beurden et al., 2005; Walker et al., 2005). But other correlates such as access to a vehicle and use of it, whether to get to and from social events, place oneself in situations apart from parental or other monitoring and also figure into the picture and deserve attention in the adolescent stage of life, particularly with regard to occurrence of drink driving and of riding in such situations (Lewis et al., 2005). Attractive transportation alternatives (or relative lack thereof, e.g., in more rural environments) is a significant issue not only for drivers but also for potential passengers of impaired drivers (Cartwright & Asbridge, 2011; Poulin et al., 2007; Walker et al., 2005).

EFFECTIVE RESPONSES TO IMPAIRED DRIVING

In short, a socio-ecological approach is the most appropriate framework within which to promote healthier thinking and safer practice in regard to the relationship between use of drugs and driving. A socio-ecological approach will plan to act strategically in a concerted way at different levels and points where people are affected by their situation and surroundings and so address different avenues of influence on them. The aim will be to change not just individual behaviours but also environmental features that encourage substance impaired driving. Key community contexts of opportunity include schools, other locations where youth have interaction with their peers and fellow citizens (e.g., sports and recreation associations, cultural and religious faith communities, health and social services), and where relationships with parents can be influenced. Settings that are connected with driving or are associated with substance use also can serve as sites for action. Regulatory measures are critical components, but program initiatives that shape the ethos of a community and interventions that aid individuals and targeted groups also contribute to the cause. This report highlights some prime locations for and some relevant forms of action.

Productive regulatory responses to drinking and driving

The literature is clear that the most effective instruments of response in reducing rates of alcohol impaired driving and harms ensuing from such behaviour are broad-based regulatory policy initiatives rigorously implemented. Such solid application involves consistent conspicuous enforcement, that is, routine execution accompanied by publicity that underscores likelihood of offenders being detected with unwelcome sanctions being promptly imposed. While penalties need to be of sufficient severity, the probability of being caught and the immediacy of adverse impact will serve as stronger deterrents than punitive harshness in discouraging people from non-compliance with the regulations.

In regard to alcohol, such regulatory measures include, firstly, policies that indirectly bear on the phenomenon of drinking and driving by decreasing availability of alcohol via higher pricing, restricted density of outlets, confined hours of service, and limited alcohol-allowed public events. While provincial positions are especially determinative here (as on minimum legal drinking age and minimum legal driving age), municipal stances can strengthen exercise of such demands. A second area of proximate influence would be efforts to ensure safer drinking environments in the community, whether improving promotion, service standards, physical features and social conditions at standing venues (e.g., bars, clubs), or better managing special public occasions where alcohol use is permitted. Again, while provincial dictates and programs can help with some of these aspects (such as mandatory responsible beverage service and violence prevention training for management and staff), local ordinances and monitoring can also enhance prospects for safer operations.

More directly applying are assorted pieces such as:

- *per se* laws specifying a low enough blood alcohol concentration (BAC) level at and above which a driver is considered unacceptably impaired in ability to safely operate a vehicle
- conducting routine frequent surveillance of drivers for possible impairment, involving either selective sobriety checkpoints or preferably random breath-testing
- a package of penalties for impaired driving infractions that will be practically effective in application, uncongenial to offenders, and readily administered by enforcement officials (candidates for consideration include incarceration, fines, licence suspension/revocation, vehicle impoundment, imposition of an interlock device [to require passing of an in-car breathalyser test before the vehicle will permit mobility or continued operation])
- mandated remedial treatment for repeat offenders to combat recidivism
- special restrictions on novice drivers (e.g., low or even zero tolerance on BAC, graduated licensing with limits on night-time hours, number, age and status of passengers allowed)
- alternative transportation arrangements or programs from drinking venues

Again, while higher jurisdictional authority will mostly be responsible for enacting policies in these areas, local agency can support implementation and promotion of such measures and be particularly active in facilitating safer ride options.

Forceful polices as mentioned above are critical and unrivalled for optimal declines in harms stemming from alcohol-impaired driving. For maximal impact, they can and should be complemented and strengthened by awareness endeavours that not only alert communities to (or remind them of) the presence of such measures but also situate, explain and commend these regulatory initiatives as crucial contributors to public health. Such promotion presents them as well worthy of endorsement and adherence by fellow citizens in the interest of mutual well-being that requires joint obligation to some behavioural constraints for the common good (Howat et al., 2004; Grube & Stewart, 2004; Shults et al., 2001, 2009; Babor et al., 2010; Global Road Safety Partnership, 2007).

Regulatory responses to driving after use of other drugs

Legal prohibition of various substances has occasioned questions around the effectiveness of this strategy as a means of limiting availability and reducing use (including before driving). The illegal status of various drugs rules out various options for regulating them in other ways that could indirectly lower the prevalence of driving under their influence. Direct regulations around other drug-impaired driving are in place in Canada. While technology does not yet permit the equally prompt and precise determination of impairment as do breath-testing devices for BAC level, procedures currently in place in Canada involve administration to suspects of (a) a short standardized field sobriety test, in which a failing roadside result leads directly to (b) a fuller drug evaluation and classification (DEC) procedure at a police station by officers specially trained to recognize substance impairment. The DEC protocol includes collection of a bodily fluid sample for analysis. Inability to pass the assessment (or refusal to comply with the process) leaves the driver in question subject to stiff legal penalties for substance impaired driving considered a danger to the public (Beirness et al., 2007, 2009; Beirness & Porath-Waller, 2009; Porath-Waller et al., 2009; Porath-Waller & Beirness, 2010). In the absence of random drug testing exercises and frequent sobriety checkpoints, educational discussion around enforcement can usefully refer to the rigour and inconvenience of the testing process suspected drivers will be required to undergo and the severity of sanctions that can be applied. Graduated licensing programs can bear on the matter of driving in conjunction with use of substances other than alcohol too.

The impact of conventional educational initiatives

Public education will achieve minimal impact when carried out in whatever context as a merely informative enterprise that essentially addresses itself to individuals. The shortcoming is not only with a

formal approach that intends to be instructional or didactic without trying to be engaging, but also attaches to any authoritarian agenda that shows little interest in the complexity of life situations in a social milieu. Education can make headway via social marketing campaigns or other mechanisms that reflect appreciation for interpersonal considerations and wider connections. In their most robust forms (and especially when strategically coupled with complementary initiatives to influence an environment), such vehicles become substantial contributions toward building literacy, enhancing connectedness and collective resilience, and so would become means of health promotion.

Social marketing

Social marketing endeavours fall within the larger orb of health promotion as one useful way in which to pursue it. These initiatives tend to be directed towards the need for behavioural change within a certain targeted audience rather than aiming to mitigate large-scale structural or other environmental factors that precipitate health problems (although an appeal to people in a position directly to decide or indirectly to advocate for action on a policy matter could well take the form of a social marketing approach). Social marketing is distinguished by application of private sector commercial marketing ideas and tools for a different sort of profit: health benefit for the public instead of monetary gain for the private business enterprise. While viewed early on with suspicion by some for the associations of its roots (with, e.g., self-serving exploitation, manipulation) and doubts about the transferability of primarily purveyor values to the endeavour of serving the well-being of the audience, the core elements of effectively commending a good have been positively appropriated in the interest of social welfare (Andreason, 2004; Cugelman, n.d.; Story et al., 2008).

Social marketing draws upon commercial marketing's attention to components such as product, price, place and promotion (the famous 4 Ps) and the notion of exchange (persuasion of the audience to buy into what is offered rather than hold onto a present situation without it or opt for some other alternative). However, it resituates and recasts such elements to suit its own higher purpose. Social marketing seizes on them to help analyze, plan, execute and evaluate programs designed to influence the voluntary behaviour of target audiences in order to improve their personal and public welfare (Andreason, 2004; Stead et al., 2007; Smith, 2006; Story et al., 2008; Zimmerman, 1997).

Distinguished benchmarks of a full-fledged social marketing approach are:

- behavioural change as a bottom line measurable objective
- use of audience research to understand their experiences, values and needs, to pre-test intervention elements and monitor response to implementation
- segmentation of target audience in order to tailor a thrust to their particularities and so also enhance efficiency and effectiveness in use of outreach resources
- attempt to maximize marketing mix by creating an attractive benefit package (product) at minimal cost (price) possible, making the exchange as convenient and easy as it can be (place), conveying an appeal that will prove pertinent and powerful to the audience (promotion), rather than just doing advertising alone
- strategic offer of an attractive exchange that aligns with the audience's motivation
- continued attention to competing behaviours in order to minimize their appeal relative to the one being commended (Andreason, 2004; Stead et al., 2007; cf. Story et al., 2008)

Elements considered crucial in the customer-centred process are a lot of attentive listening in formative research, careful planning to provide a most attractive offer (in a well-defined and organized delivery), pretesting to get an advance handle on what responses are elicited, strongly managed implementation (e.g., assignment of responsibility, performance deadlines), watchful monitoring of reception, and reworking as required by unforeseen developments. One leading proponent sees advantage in

integrating stages of change considerations (from Prochaska and DiClemente) into appeal strategies and emphases relative to benefits, costs and self-efficacy. A major challenge is to remain customer-oriented (rather than centred around one's own organization and its perception of what makes the behaviour on offer so desirable) and thus respectfully and patiently pursue what is required to reach the audience and prove compelling to them (Andreason, 2004).

Social norms marketing campaigns

Social norms marketing, when applied in particular to substance impaired driving, aims to correct typical overestimations of others' engagement in and acceptance of impaired driving that would leave the misperceivers themselves more liable to participate in it or be complacent about it. The counter tactic is messaging that clarifies the actual minority status of this behaviour and of tolerance for it, but does so by consciously accentuating and positively depicting the majority stance as predominant in its broad appeal. This way of undermining a misimpression by setting the record straight in a manner welcoming endorsement of a different orientation is expected to prompt people towards personal rejection of impaired driving and disapproval of the practice for others.

Though primarily undertaken thus far in postsecondary campus contexts, the use of social norms marketing in communities beyond schools seems promising, and the strategy has been used with evident impact in a state-wide context (Perkins et al., 2010; Linkenbach & Perkins, 2005). This strategy requires a repeated high-profile dosage of affirmative and implicitly inviting messaging to ensure exposure and absorption if it is going to shift identifications (or reinforce those for people already adopting the safer conduct and more protective attitudes). Even in the confined setting of campus applications, social norms marketing has had greater punch where its thrust has been bolstered by environmental measures such as restriction on alcohol outlet density in proximity to collegiate grounds. This serves as a reminder of the added clout of complementary initiatives within a comprehensive social-ecological approach to address substance impaired driving (Scribner et al., 2011).

School-based initiatives

School-based initiatives can serve as an appropriate vehicle for reduction of substance impaired driving among adolescents. Drug education programs that have focused only on providing information or building esteem have proved insufficient (in part because of not adequately appreciating how various external factors affect decision-making). However, endeavours that are based on a more extended account (attentive to social influences) of how people learn, relate to their stage of development, seek to equip students with skills for management of a range of intra- and interpersonal challenges, and attempt to do so using more participatory, interactive, engaging methods to enhance self, social and cultural competence, have achieved better results and offer greater prospects for success (McBride, 2003; Midford, 2007, 2009; Griffin et al., 2004; Shope et al., 2001; King et al., 2008). A constructivist approach to learning is desirable. Such an approach raises questions and offers a framework for investigation and reflection in order to facilitate a more intentional and critical process of forming persuasions on issues (Mallick & Watts, 2007). In a broader reach than curricular focus, efforts that make the larger school milieu a more inclusive climate that promotes meaningful, positive relationships among students and between them and staff will serve to help reduce substance use problems among these youth, including in connection with driving (CARBC, n.d.).

The school setting provides a publicly recognized strategic venue for health promotion initiatives as a locus that not only gives direct access to youth in a group context, but can serve as a channel for involving parents in collective dialogue and mutual support. Not only can parents be enabled to model for and communicate more constructively with their children and relate more helpfully among themselves, they become better positioned to engage in concerted action on a community basis.

Parents can contribute to reduction in likelihood of their youth being involved in driving crashes from a variety of factors, including substance use, by taking a more active role in supplementing driver education and graduated licensing, with supervised practice and setting limits that reinforce the unsuitability of driving under conditions of elevated risk (Simons-Morton, 2007; Simons-Morton & Ouimet, 2006). While experience gained under such additional coaching and monitoring could enable novice drivers to be better prepared to handle some of those conditions on their own, it could, with motivational encouragement, also serve to dissuade youth from participation in substance impaired driving (cf. Chen et al., 2008).

Health and social services interventions

Certain use patterns, including early age of onset, frequent and heavier volume use and development of dependency, are associated with uptake of driving after use and riding in such impaired situations. Given these correlates or risk factors, evidence-informed interventions for individuals or groups of such persons in regard to the use issues and related concerns can have benefit toward deterring such behaviours (Jones et al., 2005, 2006, 2007). Whether brief interventions or more extended and intensive treatment programs are required, opportunity can be present to educate, explore and equip around challenges related to impaired driving (D'Amico & Fromme, 2000, 2002). Motivational enhancement will be critical, along with skills training, for a beneficial impact. The shorter, more compact initiatives of this sort can be conducted in a variety of contexts beyond primary healthcare settings.

Community initiatives

Effective community endeavours (ideally within a thoughtfully deliberated and collectively adopted comprehensive integrated strategy, but at least from some measure of shared vision with common goals) will attempt to foster and nurture collaborative efforts that complement each other in working to cultivate a community of care. Assorted components referred to above can be incorporated into such an inclusive thrust with a view to pursuing mutual well-being. The undertaking becomes one in which community members support one another in building and sustaining a wholesome environment with conditions that allow residents to flourish, in part through less vulnerability to harm associated with alcohol and other drugs (Howat et al., 2004; Shults et al., 2009).

CONCLUSION

Though not a majority practice, substance impaired driving poses a serious health and safety threat to drivers who engage in it, to other occupants in their vehicle and in other automobiles sharing the road with them, plus cyclists and pedestrians. It also imposes significant costs on extended families and the larger community. This behaviour, which runs contrary to the social contract around mutual responsibility to fellow users of roadways (and thus is also sanctioned by legal measures), is indeed an issue that needs to be addressed by broad-based efforts using various forms of action. There are grounds for encouragement that, when the behaviour is addressed in a holistic approach, consistently attending to influences from the environment as well as individual facilitators, further progress may be made in reducing its occurrence and the harms that can ensue from such incidents.

APPENDIX

Means and media strategies

The most far-reaching means of lowering the prevalence of substance impaired driving involve large-scale initiatives to effectively reduce availability of substances, ensure safer use environments, and

systematically execute legal stipulations and sanctions around driving under the effects of drugs. The best attested aspects of a multi-component health promotion effort to reduce harms associated with substance impaired driving are those evaluated in connection with driving under the influence of alcohol. Aptness of a comparable, even integrated approach for driving after use of other substances is readily apparent.

Consciousness and responsibility raising initiatives need to persuade the public that

a) impairment from use before driving does indeed compromise performance and raise liability to serious injury to self and others too much to justify the behaviour,
b) while it is the behaviour of a decided minority, and some progress has been made in countering it, impaired driving is still widely enough distributed to produce an overall burden of harm of such magnitude as to require concerted action,
c) the most broadly effective ways of reducing the prevalence of this behaviour and so protect the community are consistently enforced robust regulatory measures and joint collective commitment to enhance connectedness and resilience, and
d) individuals can contribute to changing the culture of attitude and practice on the question of impaired driving by their own personal behaviour and their involvement, together with those around them, in cultivating a more caring, inclusive and supportive social environment.

Campaigns which can most reasonably hope to succeed in fostering attitudinal and behavioural change need to operate from a solid foundation with

a) sound theoretical underpinning regarding dynamics of social persuasion, recognizing a long-term timeframe for significant collective shifts in outlook and the need for sustained initiative,
b) commitment to continuing research and evaluation on issues, as well as monitoring and assessing broad public and particular subgroup sentiments about such issues and their response to communications the campaign delivers,
c) a strategic plan (clear objectives, targeted actions, identified audiences and tailored messaging, appropriate interventions) and effective organization (mobilizing people with management practices that encourage collaborative contribution and action), and
d) a thrust which endorses and lends weight to pertinent regulations and their ongoing administration.

Campaigns need to capture and retain attention. Utilization of a range of media popular with the target audiences is critical, as is a communication stream that, while continuing unified in its consistently clear and coherent emphases, shows freshness in sequential complementary presentation of particular points. Use of specialists in marketing who can apply strong theory on learning and change to the exploitation of new technologies enhances prospects for making an impact. Promotion will ideally include much more than traditional advertising and so seize on suitable branding opportunities as well.

Readiness to use new media is necessitated not only by its attractiveness to youth, but also by the fact that the alcohol industry is already heavily invested in it, with proportionally quite limited allusion to alcohol-related harms and attempted dissuasion from impaired driving. Beyond providing an instrument for transmitting information, various social media tools of interpersonal interaction facilitate formation and/or influencing of social networks to foster change. Principles of inclusion, integrity, positive thrust and modelling, engagement, motivation and empowerment all apply as much in this domain as in more conventional vehicles of messaging.

Broad messaging considerations in addressing substance impaired driving (SID)

Efforts that focus on relating more directly to people about issues should reflect recognition that decisions and actions are significantly affected by alterable conditions in the social environment these people inhabit rather than just the interpersonal context and intrapersonal dynamics that are particular to individuals. The larger goal should be not just to build up personal resilience but also to enhance connectedness, cultivating a climate of mutual concern and responsibility for collective well-being.

Messaging can usefully situate the issue of SID within the larger domain of driving as an established, often pleasurable, yet challenging and demanding (e.g., alertness, knowledge, judgment, skill and energy), privileged, public rather than private activity. Its social conventions and regulations serve to reinforce what is required and expected of each (e.g., attention, consideration, caution, control) in order that all, including passengers and pedestrians, can benefit from the driving (and riding) experience rather than be harmed by it.

Messaging should not unwittingly reinforce misperceived social norms (overestimations of the extent to which others, especially peers, are involved in substance use and driving under the influence) but rather serve to undermine and correct such exaggerated impressions. Rather than just broadly pointing to the persuasions of the general public as a consensus toward which youth can gravitate, efforts of this sort need to be attentive to the impact of relevant reference groups to whose actions and attitudes youth will especially relate. Alertness to how perceptions are formed and transmitted within such circles will also aid communication. With sensitivity to such dynamics, initiatives to clarify and commend healthier social norms can be expected to encourage more identification with and adoption of safer practices.

Messaging should have a thrust to it of reducing likelihood of experiencing harm though SID rather than of simply abstaining from substance use altogether. While not wanting to fuel excessive estimations of involvement, there needs to be candid acknowledgment that some engage in substance use for understandable reasons but also at real risk (that ought not to be fabricated, embellished, downplayed or ignored). There also needs to be persuasion on the part of communicators that (notwithstanding notions of invulnerability and attraction to risk) youth are capable of relating to questions of potential injury and making appropriate choices, realizing also that they tend to reject simplistic imposition of artificial advice (such as “Just say ‘No’”) and may be more receptive to suggestions on harm reduction strategies.

Messaging should aim to be more affective and engaging than simply didactic or merely informative on risk. Young people are not reached by a method that just passes on allegedly authoritative content for them to accept, but require instead interactive communication that presents opportunity for them to explore, examine, discuss and formulate answers. A constructivist approach to learning is preferable, with its provision of a framework for a more intentional and critical process of reflectively investigating and making judgments on matters.

Rather than strictly playing on fear, messaging should be productive in encouraging individuals and groups in regard to their ability to be agents of change. While appeal should be emotional and not only rational, attempts that focus on scare tactics regarding harm generally have at most short-term shelf life in terms of dissuading impact (initial intimidation), and tend in the longer term to wear thin, often arousing suspicions of an exploitive ploy and leading to erosion of credibility. Resultant scepticism can then unfortunately cause abrupt dismissal of more honest and justified warnings which ought in any event to be carefully issued.

There needs to be a tone that avoids negative moralizing, thus not impugning, stigmatizing and ostracizing those who have engaged in SID. The thrust instead should be to reach out to, include in dialogue and motivate individuals and groups that have so far been in varying degrees prepared to

practice it or unwilling to call it into question. In countering advocacy for the behaviour of or receptiveness to SID, sensitive caution and creativity can seek to positively provoke reconsideration and avert offence, perhaps even employing humour at points as a tool of attraction (without allowing it to distract, discredit, trivialize or alienate).

Rather than just focusing on personal well-being and individual capacity to pursue and acquire it, messaging should also acknowledge interdependence and promote healthy connectedness, attending to opportunity for development of a wholesome support circle and network. Youth need to see benefit in seeking assistance as needed and be helped to build social consciousness with a sense of responsibility to aid others and contribute to collective welfare in confidence that they can already make a difference for the better in their community.

Messaging should seize on social priorities for youth and pursue expectations for good friends in a way that challenges unhealthy pressures to conform and capitalizes on assumptions that closer relationships spell greater obligation of care. This avenue needs to trade on language of mutual respect and express reciprocity in informal ways that are used by youth and are gender-specific (e.g., “good guys have their buddies’ backs” for males, with reservation of more sensitive language like “close friends do not let each other…” for females).

Messaging in regard to the substances and impairment

Messaging should relate befittingly to the question of impairment and elevated risk for serious injury. Orientation in methods utilized in testing and analyzing such impact (laboratory cognitive studies, experimental driver assessment using simulator, closed course or road testing, and epidemiological field studies on drivers involved in accidents for effects of drug consumption) could be helpful toward persuasion on formal claims. The extent and exactness of what can be affirmed will vary among substances and be subject to conditions of use. Accent on respective substances should indicate particular and contrasting effects, acknowledging pertinent limitations of knowledge relative to the substance in question.

Messaging also must speak somewhat to the issue of and procedures for legal determinations of impairment, possibility of detection, and application of enforcement sanctions. This is particularly the case with respect to alcohol-impaired driving in view of effectiveness for such measures when surveillance exercises are consistently employed and penalties speedily imposed, as can be the case with respect to that substance. With regard to other substances, information can be shared on how the enforcement process is developing to overcome initial limitations (hopefully addressing this in a way that does not invite would-be offenders to dismiss prospects of being apprehended as highly unlikely and so no deterrent).

Accent on respective substances should reflect the relative prevalence of use and of driving under the influence of a particular drug, especially among the target audience. Adherence to this principle will dictate primary attention to alcohol and cannabis impaired driving, with lesser reference to substances such as ecstasy, cocaine and unauthorized use of prescription drugs, and little mention necessary of methamphetamine (under the more general rubric of stimulant effects).

Re alcohol

Alcohol-impaired driving merits prominent attention in view of the drug’s popularity and substantial rates at which drinking and driving still occurs, especially the number of cases where BAC exceeds legal limits and where the impaired driver is an older adolescent or young adult. Messaging can refer candidly to the elevated risk of injury and fatality for young adults in such scenarios, quite disproportionate to that age bracket’s relative representation within the overall population. It is worth debunking the

common notion that the problem of driving under the influence has largely if not almost entirely to do with severely dependent drinkers (with whom most youth will not identify).

Messaging should underscore the well-established nature of findings regarding the adverse impact of alcohol on cognitive and motor functioning necessary for driving. Content should include allusion to the reality of impairment and increased risk in connection with driving at very modest levels of intake below the legal BAC threshold of .08%. Messaging needs also to include reference to particular adverse impairment effects of alcohol (e.g., tendency to increase speed, reduce following distance, and overtake other vehicles) that exacerbate its own debilitating influence beyond lowering attention, compromising coordination and slowing down reaction time.

Messaging should include reference to intensified or magnified impairment when alcohol is used in combination with other drugs as this is widely recognized to be a particularly dangerous mix, making matters worse whether the other substances are depressant (like alcohol itself) or stimulant in their psychoactive operation. Specific examples can elucidate this additive or multiplicative impact and underscore the scope and degree of increased hazard. This discussion should include reference to liability of alcohol in conjunction with energy drinks, given the attractiveness of the latter to youth and the capacity of such beverages to mask but not actually counter (undo/offset) the negative influence of alcohol on performance.

Messaging should address acceptable youth strategies for averting alcohol-impaired driving in view of the social appeal of drinking. Also to be taken into account when advocating for alternatives are the attractions and advantages (e.g., convenience, privacy) of using a privately owned motor vehicle and the intersection of apparent interests (e.g., freedom, opportunity to impress) involved in drinking and also in driving/riding in a car.

Re cannabis

Cannabis-impaired driving deserves particular attention in view of (a) self-reported prevalence of those engaging in it among 16-19 year olds in Canada as proportionally exceeding those in that same age bracket driving under the influence of alcohol, and (b) rates of recent cannabis use (compared to drugs other than alcohol) among youth. Messaging could refer to higher prevalence of driving soon after cannabis use among youth (without fuelling misperceived norms) relative to older age groups (where, unlike driving under the influence of alcohol, it drops off).

Messaging should affirm some genuine grounds for concern about driving under the influence of cannabis while admitting limitations in what is confirmed. Consistent indications from laboratory studies of impairment from cannabis across a broad range of functioning pertinent to driving do not translate into uniform under-performance in experimental research, though some detriment is attested. More cautionary compensating strategies (e.g., going slower, keeping greater distance) do not alleviate deficits in unconscious control (e.g., tracking or lane maintenance), reaction time and response to unexpected developments. While those accommodating tactics do reduce some liability to collisions, they are also not necessarily employed as long after use as they could afford to be, and higher doses of cannabis compromise ability further (particularly among those who have not acquired tolerance). In short, while cannabis-caused impairment is apparently not as severe as with alcohol, it is a reality and poses a threat to safety of varying degree (though epidemiological findings are suggestive rather than decisive on these dose-related odds ratios).

Although allowing for some carefully qualified nuance in its claims (as required by evidence mentioned above that is at points inconclusive), messaging can and should address common misperceptions of non-adverse impact or even advantage in cannabis use for driving. This must be done against the backdrop of broader persuasion among the public, including youth, that cannabis use is largely harmless. The

impression of the drug being essentially benign has been partly fostered by discovery of how unwarranted were earlier claims in exaggerating its hazards on various counts. Judicious efforts at encouraging some critical reflection on risks with use must avoid such a one-sided and overstated approach to the issue. Nothing exists yet for cannabis that matches the quantified specific advice relating to the wait time required after the consumption of certain standard amounts of alcohol in order for its impairing effects to disappear before one takes the wheel. Basic guidance can still advise those who choose to use cannabis to wait at least three hours or opt for alternative transportation measures (e.g., another driver) in the meanwhile.

Messaging should address cannabis use in conjunction with alcohol and how augmented impairment resulting from that mix, even in small doses of each, constitutes a substantially worse threat to safety than either substance used alone. Alcohol's influence in fuelling driver aggressiveness runs contrary to any cautionary tendency cannabis users might exercise and it affects cognitive control tasks more, while cannabis can compromise automatic functioning. Both drugs slow reactions and hinder proper response to emergency; aggregate effects on such counts leave drivers jeopardized. Though chronic cannabis users may not be so vulnerable to the impairing effects of alcohol, heavier ingestion of cannabis is on its own deleterious for driving.

Messaging can usefully take into consideration various recognized risk factors for driving under the influence of cannabis among youth, attentive to how some of these correlates will be distinct from those associated with drink driving.

REFERENCES

Adlaf, E., Mann, R.E. & Paglia, A. (2003). Drinking, cannabis use and driving among Ontario students. *Canadian Medical Association Journal*, 168(5), 565-566.

Aitken, C., Kerger, M. & Crofts, N. (2000). Drivers who use illicit drugs: behaviour and perceived risks. *Drugs: education, prevention and policy*, 7(1), 39-50.

Arcuri, A. (2009). *Driving under the influence of cannabis: a brief review of the literature*. National Cannabis Prevention and Information Centre (NCPIC). http://ncpic.org.au/ncpic/publications/research-briefs/pdf/driving-under-the-influence-of-cannabis-a-brief-review-of-the-literature.

Andreason, A. R. (2004). A social marketing approach to changing mental health practices directed at youth and adolescents. *Health Marketing Quarterly*, 21(4), 51-75.

Asbridge, M., Poulin, C. & Donato, A. (2005). Motor vehicle collision risk and driving under the influence of cannabis: Evidence from adolescents in Atlantic Canada. *Accident Analysis and Prevention*, 37(6), 1025-1034.

Ashton, H. (2001). Pharmacology and the effects of cannabis: a brief review. *British Journal of Psychiatry*, 178(2), 101-106.

Babor, T., Caetano, R., Caswell, C., Edwards, G., Giesbrecht, N., Graham, K. et al. (2010). *Alcohol: no ordinary commodity: Research and public policy*. Oxford, UK: Oxford University Press. (Second edition)

Barker, J.C. & Kosoho, H. (2008). Hazardous use of gamma hydroxybutyrate: driving under the influence. *Substance Use and Misuse*, 43(11), 1495-1508.

Beasley, E.E., Beirness, D.J. & Porath-Waller, A.J. (2011). A comparison of drug- and alcohol-involved motor vehicle driver fatalities. Ottawa, ON: Canadian Centre on Substance Abuse.

Bédard, M., Dubois, S. & Weaver, B. (2007). The impact of cannabis on driving. *Canadian Journal of Public Health*, 98(1), 6-11.

Beirness, D.J. & Beasley, E.E. (2011). *Alcohol and drug use among drivers: British Columbia Roadside Survey 2010*. Ottawa, ON: Canadian Centre on Substance Abuse.

Beirness, D.J. & Davis, C.G. (2008). Driving after drinking in Canada: Analysis drawn from the 2004 Canadian Addiction Survey. http://www.ccsa.ca/2008%20CCSA%20Documents2/ccsa0115282008.pdf

Beirness, D.J. & Davis, C.G. (2007). Driving after drinking in Canada: Findings from the Canadian Addiction Survey. *Canadian Journal of Public Health*, 98(6), 476-480.

Beirness, D.J. & Davis, C.G. (2006). Driving under the influence of cannabis: Analysis drawn from the 2004 Canadian Addiction Survey. http://www.ccsa.ca/2006%20CCSA%20Documents/ccsa-011481-2006.pdf

Beirness, D.J., Beasley, E. & LeCavalier, J. (2009). The accuracy of evaluations by Drug Recognition Experts in Canada. *Canadian Society of Forensic Science Journal*, 42(1), 75-79.

Beirness, D.J , LeCavalier, J. & Singhal, D. (2007). Evaluation of the Drug Evaluation and Classification Program: a critical review of the evidence. *Traffic Injury Prevention*, 8(4), 368-376.

Beirness, D.J. & Porath-Waller, A.J. (2009). *Clearing the smoke on cannabis 3: Cannabis use and driving*. Ottawa, ON : Canadian Centre on Substance Abuse.

Beirness, D.J., Simpson, H.M. & Williams, A.F. (2006). Role of cannabis and benzodiazepines in motor vehicle crashes. In *Drugs and traffic: A symposium* (pp. 12-21). Transportation Research Circular, Number E-C096. Washington, DC: Transportation Research Board.

Berghaus, G., Scheer, N. & Schmidt, P. (1995). Effects of cannabis on psychomotor skills and driving performance – a metaanalysis of experimental studies. In Kloeden, C. & McLean, A. (Eds.). *Alcohol, drugs and traffic safety* (pp. 403-409). Adelaide, AU: University of Adelaide.

Bingham, C.R., Shope, J.T., Parow, J.E., Raghunathan, T.E. (2009). Crash types: Markers of increased risk of alcohol-involved crashes among teen drivers. *Journal of Studies on Alcohol and Drugs,* 70(4), 528-353.

Blomberg, R.D., Peck, R.C., Moskowitz, H., Burns, M. & Fiorentino, D. (2005). *Crash risk of alcohol-involved driving: A case-control study. Final Report*. Stanford, CT: Dunlap and Associates.

Breitmeier, D., Seeland-Schulze, I., Hecker, H. & Schneider, U. (2007). CLINICAL STUDY: The influence of blood alcohol concentrations of around 0.03% on neuropsychological functions—a double-blind, placebo-controlled investigation. *Addiction Biology*, 12(2), 183-189.

Cartwright, J. & Asbridge, M. (2011). Passengers' decisions to ride with a driver under the influence of either alcohol or cannabis. *Journal of Studies on Alcohol and Drugs*, 72(1), 86-95.

Centre for Addictions Research of BC (CARBC) (n.d.). Helping schools. http://www.carbc.ca/HelpingSchools.aspx.

Chamberlain, E.A.L. & Solomon, R.M. (2008). Minimizing impairment-related youth traffic deaths: The need for comprehensive provincial action. *Canadian Journal of Public Health*, 99(4), 267-270.

Chen, M-J., Grube, J.W., Nygaard, P. & Miller, B.A. (2008). Identifying social mechanisms for the prevention of adolescent drinking and driving. *Accident Analysis and Prevention*, 40(2), 576-585.

Chester, J., Montgomery, K. & Dorfman, L. (2010). Alcohol marketing in the digital age. Center for Digital Democracy and Berkeley Media Studies Group. http://www.digitalads.org/alcohol.php.

Couper, F.J. & Logan, B.K. (2004a). Addicted to driving under the influence—a GHB/GBL case report. *Journal of Analytical Toxicology*, 28(6), 512-515.

Couper, F.J. & Logan, B.K. (2004b). *Drugs and human performance fact sheets*. Washington, DC: National Highway Traffic Safety Administration. Technical Report No. DOT HS 809 725.

Couper, F.J. & Logan, B.K. (2001). GHB and driving impairment. *Journal of Forensic Sciences*, 46(4), 919-923.

Cugelman, B. (n.d.). Online social marketing. A brief history of social marketing and the internet. http://www.cugelman.com/campaigns/a-brief-history-of-social-marketing-and-the-internet.htm.

D'Amico, E.J. & Fromme, K. (2002). Brief prevention for adolescent risk-taking behavior. *Addiction*, 97(5), 563-574.

D'Amico, E.J. & Fromme, K. (2000). Implementation of the Risk Skills Training Program: A brief intervention targeting adolescent participation in risk behaviors. *Cognitive and Behavioral Practice*, 7(1), 101-117.

Danton, K., Misselke, L., Bacon, R. & Done, J. (2003). Attitudes of young people toward driving after smoking cannabis or after drinking alcohol. *Health Education Journal*, 62(1), 50-60.

Davey, J.D., Davey, T. & Obst, P.L. (2005a). Drug and drink driving by university students: An exploration of the influence of attitudes. *Traffic Injury Prevention*, 6(1), 44-52.

Davey, J., Davies, A., French, N., Williams, C. & Lang, C.P. (2005b). Drug driving from a user's perspective. *Drugs: education, prevention and policy*, 12(1), 61-70).

Drummer, O.H., Gerostamoulos, J., Batziris, H., Chu, M., Caplehorn, J., Robertson, M.D. & Swann, P. (2004). The involvement of drugs in drivers of motor vehicles killed in Australian road traffic crashes. *Accident Analysis and Prevention*, 36(2), 239-248.

Dubois, S., Bédard, M. & Weaver, B. (2008). The impact of benzodiazepines on safe driving. *Traffic Injury Prevention*, 9(5), 404-413.

Fergusson, D.M., Horwood, L.J. & Boden, J.M. (2008). Is driving under the influence of cannabis becoming a greater risk to driver safety than drink driving? Findings from a longitudinal study. *Accident Analysis and Prevention*, 40(4), 1345-1350.

Ferreira, S.E., de Mello, M.T., Pompéia, S. & de Souza-Formigoni, M.L.O. (2006). Effects of energy drink ingestion on alcohol intoxication. *Alcoholism: Clinical & Experimental Research*, 30(4), 598-605.

Ferreira, S.E., de Mello, M.T., Rossi, M.V. & Souza-Formigoni, M.L.O. (2004). Does an energy drink modify the effects of alcohol in a maximal effort test? *Alcoholism: Clinical & Experimental Research*, 28(9), 1408-1412.

Fillmore, M.T., Roach, E.L. & Rice, J.T. (2002). Does caffeine counteract alcohol-induced impairment? The ironic effects of expectancy. *Journal of Studies on Alcohol*, 63(6), 745-754.

Fischer, B., Jeffries, V., Hall, W., Room, R., Goldner, E. & Rehm, J. (2011). Lower risk cannabis use guidelines for Canada (LRCUG): A narrative review of evidence and recommendations. *Canadian Journal of Public Health*, 102(5), 324-327.

Fischer, B., Rodopoulos, J., Rehm, J. & Ivsins, A. (2006). Toking and driving: Characteristics of Canadian university students who drive after cannabis use—an exploratory pilot study. *Drugs: education, prevention and policy*, 13(2), 179-187.

Global Road Safety Partnership (2007). *Drinking and driving: A road safety manual for decision-makers and practitioners*.

Griffin, K.W., Botvin, G.J. & Nichols, T.R. (2004). Long-term follow-up effects of a school-based drug abuse prevention program on adolescent risky driving. *Prevention Science*, 5(3), 207-212.

Grotenhermen,, F., Leson, G., Berghaus, G., Drummer, O.H., Krüger, H-P., Longo, M. et al. (2007). Developing limits for driving under cannabis. *Addiction*, 102(12), 1910-1917.

Grube, J.W. & Stewart, K. (2004). Preventing impaired driving using alcohol policy. *Traffic Injury Prevention*, 5(3), 199-207.

Hammond, K. (2009). *Drug driving in New Zealand: a survey of community attitudes, experience and understanding*. New Zealand Drug Foundation. http://www.nzdf.org.nz/files/File/Drug%20Driving%20in%20New%20Zealand,%20full%20research%20report,%20August%202009.pdf.

Howat, P., Sleet, D., Elder, R. & Maycock, B. (2004). Preventing alcohol-related traffic injury: A health promotion approach. *Traffic Injury Prevention*, 5(3), 208-215.

Howland, J., Rohsenow, D.J., Arnedt, J.T., Bliss, C.A., Hunt, S.K., Calise, T.V. et al. (2011a). The acute effects of caffeinated versus non-caffeinated alcoholic beverage on driving performance and attention/reaction time. *Addiction*, 106(2), 335-341.

Howland, J., Rohsenow, D.J., Calise, T.V., MacKillop, J. & Metrik, J. (2011b). Caffeinated alcoholic beverages: An emerging public health problem. *American Journal of Preventive Medicine*, 40(2), 268-271.

Jones, A.W., Holmgren, H. & Kugelberg, F.C. (2008). Driving under the influence of gamma-hydroxybutrate (GHB). *Forensic Science, Medicine and Pathology*, 4(4), 205-211.

Jones, C.G.A., Donnelly, N.J., Swift, W. & Weatherburn, D.J. (2007). Correlates of driving under the influence of cannabis. *Drug and Alcohol Dependence*, 88(1), 83-86.

Jones, C., Donnelly, N., Swift, W. & Weatherburn, D. (2006). Preventing cannabis users from driving under the influence of cannabis. *Accident Analysis and Prevention*, 38(5), 854-861.

Jones, C., Donnelly, N., Swift, W. & Weatherburn, D. (2005). Driving under the influence of cannabis: The problem and potential countermeasures. *Crime and Justice Bulletin*, 87.

Kelly, E., Darke, S. & Ross, J. (2004). A review of drug use and driving: epidemiology, impairment, risk factors and risk perceptions. *Drug and Alcohol Review*, 23(3), 319-344.

King, K.A., Vidourek, R.A., Love, J., Wegley, S. & Alles-White, M. (2008). Teaching adolescents safe driving and passenger behaviors: Effectiveness of the You Hold the Key teen driving countermeasure. *Journal of Safety Research*, 39(1), 19-24.

Kuypers, K.P.C., Wingen, M., Samyn, N., Limbert, N. & Ramaekers, J.G. (2007). Acute effects of nocturnal doses of MDMA on measures of impulsivity and psychomotor performance throughout the night. *Psychopharmacology*, 192(1), 111-119.

Kuypers, K.P.C., Samyn, N. & Ramaekers, J.G. (2006).MDMA and alcohol effects, combined and alone, on objective and subjective measures of actual driving performance and psychomotor function. *Psychopharmacology*, 187(4), 467-475.

Lenné, M., Triggs, T. & Regan, M. (2004). *Cannabis and road safety: A review of recent epidemiological, driver impairment, and drug screening literature*. Australia: Monash University Accident Research Centre. http://www.monash.edu.au/miri/research/reports/muarc231.pdf.

Lewis, T.F., Thombs, D.L. & Olds, S. (2005). Profiles of alcohol- and marijuana-impaired adolescent drivers. *Addiction Research and Theory*, 13(2), 145-154.

Linkenbach, J. & Perkins, H.W. (2005). *Montana's MOST of Us Don't Drink and Drive campaign: A social norm strategy to reduce impaired driving among 21-34-year-olds*. Washington, DC: National Highway Traffic Safety Administration.

Mallick, J., Johnston, J., Goren, N. & Kennedy, V. (2007). *Drugs and driving in Australia: a survey of community attitudes, experience and understanding*. Melbourne, AU: Australian Drug Foundation. http://www.druginfo.adf.org.au/downloads/External_Reports/Drugs_and_Driving_in_Australia_fullreport.pdf.

Mallick, J. & Watts, M. (2007). Personal construct theory and constructivist drug education. *Drug and Alcohol Review*, 26(6), 595-603.

Mann, R.E., Stoduto, G., Ialomiteanu, A., Asbridge, M., Smart, R.G. & Wickens, C.M. (2010). Self-reported collision risk associated with cannabis use and driving after cannabis use among Ontario adults. *Traffic Injury Prevention*, 11(2), 115-122.

Mann, R.E., Adlaf, E., Zhao, J., Stoduto, G., Ialomiteanu, A., Smart, R.G. & Asbridge, M. (2007). Cannabis use and self-reported collisions in a representative sample of adult drivers. *Journal of Safety Research*, 38(6), 669-674.

Marczinski, C.A., Fillmore, M.T., Bardgett, M.E. & Howard, M.A. (2011). Effects of energy drinks mixed with alcohol on behavioral control: risks for college students consuming trendy cocktails. *Alcoholism: Clinical and Experimental Research*, 35(7), 1282-1292.

Marczinski, C. A. & Fillmore, M.T. (2006). Clubgoers and their trendy cocktails: Implications of mixing caffeine into alcohol on information processing and subjective reports of intoxication. *Experimental and Clinical Psychopharmacology*, 14(4), 450-458.

Marczinski, C.A. & Fillmore, M.T. (2003). Dissociative antagonistic effects of caffeine on alcohol-induced impairment of behavioral control. *Experimental and Clinical Psychopharmacology*, 11(3), 228-236.

McBride, N. (2003). A systematic review of school drug education. *Health Education Research*, 18(6), 729-742.

McCarthy, D.M., Lynch, A.M. & Pedersen, S.L. (2007). Driving after use of alcohol and marijuana in college students. *Psychology of Addictive Behaviors*, 21(3), 425-430.

McIntosh, J., O'Brien, T. & McKegney, N. (2008). Drug driving and the management of risk: The perspectives and practices of a sample of problem drug users. *International Journal of Drug Policy*, 19(3), 248-254.

Midford, R. (2009). Drug prevention programmes for young people: where have we been and where should we be going? *Addiction*, 105(10), 1688-1695.

Midford, R. (2007). Drug education and other prevention programmes for students. *Drug and Alcohol Review*, 26(6), 573-575.

Moskowitz, H. & Fiorentino, D. (2000). *A review of the literature on the effects of low doses of alcohol on driving-related skills*. Washington, DC: National Highway Traffic Safety Administration. DOT HS 809 028.

National Highway Traffic Safety Administration (NHTSA)(2000). Marijuana and alcohol combined severely impede driving performance. *Annals of Emergency Medicine*, 35(4), 398-400.

Nygaard, P. & Grube, J.W. (2005). Mixed messages: Contributions to adolescent drinking and driving. *Addiction Research and Theory*, 13(5), 411-426.

Nygaard, P., Waiters, E.D., Grube, J.W. & Keefe, D. (2003). Why do they do it? A qualitative study of adolescent drinking and driving. *Substance Use and Misuse*, 38(7), 835-863.

O'Brien, M.C., McCoy, T.P., Rhodes, S.D., Wagoner, A. & Wolfson, M. (2008). Caffeinated cocktails: energy drink consumption, high-risk drinking, and alcohol-related consequences among college students. *Academic Emergency Medicine*, 15(5), 453-460.

Ogden, E.J.D. & Moskowitz, H. (2004). Effects of alcohol and other drugs on driver performance. *Traffic Injury Prevention*, 5(3), 185-198.

O'Kane, C.J., Tutt, D.C. & Bauer, L.A. (2002). Cannabis and driving: A new perspective. *Emergency Medicine*, 14(3), 296-303.

Paglia-Boak, A., Mann, R.E., Adlaf, E.M. & Rehm, J. (2009). Drug use among Ontario students, 1977-2009: OSDUHS highlights. CAMH Research Document Series No. 28. Toronto, ON: Centre for Addiction and Mental Health.

Papafotiou, K., Carter, J.D. & Stough, C. (2005). The relationship between performance on the standardised field sobriety tests, driving performance and the level of Δ9-tetrahydrocannabinol (THC) in blood. *Forensic Science International*, 155(2-3), 172-178.

Peck, R.C., Gebers, M.A., Voas, R.B. & Romano, E. (2008). The relationship between blood alcohol concentration (BAC), age, and crash risk. *Journal of Safety Research,* 39(3), 311-319.

Perkins, H.W., Linkenbach, J.W., Lewis, M.A. & Neighbors, C. (2010). Effectiveness of social norms media in reducing drinking and driving: A statewide campaign. *Addictive Behaviors*, 35(10), 866-874.

Phillips, D.P. & Brewer, K.M. (2011). The relationship between serious injury and blood alcohol concentration (BAC) in fatal motor vehicle accidents: BAC = 0.01% is associated with significantly more dangerous accidents than BAC = 0.00%. *Addiction*, 106(9), 1614-1622.

Porath-Waller, A.J. & Beirness, D.J. (2010). Simplifying the process for identifying drug combinations by drug recognition experts. *Traffic Injury Prevention*, 11(5), 453-459.

Porath-Waller, A.J., Beirness, D.J. & Beasley, E.E. (2009). Toward a more parsimonious approach to drug recognition expert evaluations. *Traffic Injury Prevention*, 10(6), 513-518.

Poulin, C., Boudreau, B. & Asbridge, M. (2007). Adolescent passengers of drunk drivers: a multi-level exploration into the inequities of risk and safety. *Addiction*, 102(1), 51-61.

Price, S.R., Hilchey, C.A., Darredeau, C., Fulton, H.G. & Barrett, S.P. (2010). Energy drink co-administration is associated with increased reported alcohol ingestion. *Drug and Alcohol Review*, 29(3), 331-333.

Ramaekers, J.G., Moeller, M.R., van Ruitenbeck, P., Theunissen, E.L., Schneider, E. & Kauert, G. (2006). Cognition and motor control as a function of Δ^9 - THC concentration in serum and oral fluid: Limits of impairment. *Drug and Alcohol Dependence*, 85(2), 114-122.

Ramaekers, J.G., Berghaus, G., van Laar, M. & Drummer, O.H. (2004). Dose related risk of motor vehicle crashes after cannabis use. *Drug and Alcohol Dependence*, 73(2), 109-119.

Ramaekers, J.G., Robbe, H.W.J. & O'Hanlon, J.F. (2000). Marijuana, alcohol and actual driving performance. *Human Psychopharmacology*, 15(7), 551-558.

Ramaekers, J.G. & Kuypers, K.P.C. (2006). Acute effects of 3,4-methylenedioxymethamphetamine (MDMA) on behavioral measures of impulsivity: Alone and in combination with alcohol. *Neuropsychopharmacology*, 31(5), 1048-1055.

Ronen, A., Gershon, P., Drobiner, H., Rabinovich, A., Bar-Hamburger, R., Mechoulam, R. et al. (2008). Effects of THC on driving performance, physiological state and subjective feelings relative to alcohol. *Accident Analysis and Prevention*, 40(3), 926-934.

Sabel, J.C., Bensley, L.S. & van Eenwyk, J. (2004). Associations between adolescent drinking and driving involvement and self-reported risk and protective factors in students in public schools in Washington state. *Journal of Studies on Alcohol*, 65(2), 213-216.

Scribner, R.A., Theall, K.P., Mason, K., Simonsen, N., Schneider, S.K., Towvim, L.G. & DeJong, W. (2011). Alcohol prevention on college campuses: The moderating effect of the alcohol environment on the

effectiveness of social norms marketing campaigns. *Journal of Studies on Alcohol and Drugs*, 72(2), 232-239.

Sewell, R.A., Poling, J. & Sofuoglu, M. (2009). The effect of cannabis compared with alcohol on driving. *American Journal on Addictions*, 18(3), 185-193.

Shope, J.T. (2006). Influences on youthful driving behavior and their potential for guiding interventions to reduce crashes. *Injury Prevention*, 12(Suppl 1), i9-i14.

Shope, J.T. & Bingham, C.R. (2008). Teen driving: Motor-vehicle crashes and factors that contribute. *American Journal of Preventive Medicine*, 35(3S), S261-S271.

Shope, J.T., Bingham, C.R. & Zakrajsek, J.S. (2009). Psychosocial and behavioral factors that predict impaired and other risky drinking: Findings from a longitudinal study. In *Young impaired drivers: The nature of the problem and possible solutions* (pp. 59-72). Transportation Research Circular, Number E-C132. Washington, DC: Transportation Research Board.

Shope, J.T., Elliott, M.R., Raghunathan, T.E. & Waller, P.F. (2001). Long-term follow-up of a high school alcohol misuse prevention program's effect on students' subsequent driving. *Alcoholism: Clinical and Experimental Research*, 25(3), 403-410.

Shults, R.A., Elder, R.W., Nichols, J.L., Sleet, D.A., Compton, R., Chattopadhyay, S.K. et al. (2009). Effectiveness of multicomponent programs with community mobilization for reducing alcohol-impaired driving. *American Journal of Preventive Medicine*, 37(4), 360-371.

Shults, R.A., Elder, R.W., Sleet, D.A., Nichols, J.L., Alao, M.O., Carande-Kulis, V.G. et al. (2001). Reviews of evidence regarding interventions to reduce alcohol-impaired driving. *American Journal of Preventive Medicine*, 21(4S), 66-88.

Smith, W.A. (2006). Social marketing: an overview of approach and effects. *Injury Prevention*, 12(Suppl 1): i38-i43.

Simons-Morton, B. (2007). Parent involvement in novice teen driving: Rationale, evidence of effects, and potential for enhancing graduated driver licensing effectiveness. *Journal of Safety Research*, 38(2), 193-202.

Simons-Morton, B. & Ouimet, M.C. (2006). Parent involvement in novice teen driving: a review of hte literature. *Injury Prevention*, 12(Suppl 1), i30-i37.

Solomon, R., Organ, J., Abdoullaeva, M., Gwyer, L. & Chiodo, S. (2009). *Alcohol, trauma and impaired driving, 4th edition*. Toronto, ON: CAMH. http://www.camh.net/About_Addiction_Mental_Health/Drug_and_Addiction_Information/alcohol_trauma_impaired_driving09.pdf.

Solomon, R. & Chamberlain, E. (2006). *Youth and impaired driving in Canada: Opportunities for progress*. MADD Canada. http://www.madd.ca/english/research/youth_and_impaired_driving_may_2006.pdf.

Stead, M., Gordon, R., Angus, K. & McDermott, L. (2007). A systematic review of social marketing effectiveness. *Health Education*, 107(2), 126-191.

Steinberg, L. (2008). A social neuroscience perspective on adolescent risk-taking. *Developmental Review*, 28(1), 78-106.

Story, J.D., Saffitz, G.B. & Rimón, J.G. (2008). Social marketing. In Glanz, K., Rimer, B.K. & Viswanath, K. (Eds.), *Health behavior and health education: Theory, research, and practice* (pp. 435-464). San Francisco, CA: Jossey-Bass, 4th edition.

Stough, C. & King, R. (2010). The role of alcohol and other drugs in road deaths and serious injuries. Prevention Research Quarterly, Issues Paper No. 12, March 2010. Australian Drug Foundation. www.druginfo.adf.org.au/downloads/Prevention_Research_Quarterly/IP_Mar10_driving.pdf.

Swann, P. (2000). The real risk of being killed when driving whilst impaired by cannabis. *Proceedings of the 15th International Council on Alcohol, Drugs and Traffic Safety; 22-26 May 2000* (pp. 542-548). Stockholm SW: Economy Press.

Terry, P. & & Wright, K.A. (2005). Self-reported driving behaviour and attitudes towards driving under the influence of cannabis among three different user groups in England. *Addictive Behaviors*, 30(3), 619-626.

The Health Communication Unit (THCU) (2010). Social media overview. Ontario Health Promotion E-Bulletin, 10 September 2010 – OHPE Bulletin 676, Volume 2010, No. 676.

Thombs, D.L., O'Mara, R.J., Tsukamoto, M., Rossheim, M.E., Weiler, R.M., Merves, M.L. & Goldberger B.A. (2010). Event-level analyses of energy drink consumption and alcohol intoxication in bar patrons. *Addictive Behaviors*, 35(4), 325-330.

Traffic Injury Research Foundation (TIRF) (2011a). *Alcohol-crash problem in Canada: 2009*. http://www.ccmta.ca/english/committees/rsrp/strid/pdf/alcohol_crash09_e.PDF.

Traffic Injury Research Foundation (TIRF) (2011b). *The Road Safety Monitor 2010: Youth drinking and driving*. http://www.tirf.ca/publications/PDF_publications/RSM_2010_Young_Drivers_4.pdf.

Traffic Injury Research Foundation (TIRF) (2010a). *Alcohol-crash problem in Canada: 2008*. Ottawa: Canadian Council of Motor Transport Administrators and Transport Canada. http://www.ccmta.ca/english/committees/rsrp/strid/pdf/alcohol_crash08_e.PDF.

Traffic Injury Research Foundation (TIRF) (2010b). *The Road Safety Monitor 2010: Drinking and driving in Canada*. http://www.tirf.ca/publications/PDF_publications/rsm_2010_DD_web.pdf.

Traffic Injury Research Foundation (TIRF) (2009a). *Alcohol-crash problem in Canada: 2007*. Ottawa: Canadian Council of Motor Transport Administrators and Transport Canada.

http://www.ccmta.ca/english/committees/rsrp/strid/pdf/alcohol_crash07_e.PDF.

van Beurden, E., Zask, A., Brooks, L. & Dight, R. (2005). Heavy episodic drinking and sensation seeking in adolescents as predictors of harmful driving and celebrating behaviours: implications for prevention. *Journal of Adolescent Health*, 37(1), 37-43.

Vassallo, S., Smart, D., Sanson, A., Cockfield, S., Harris, A., McIntyre, A. & Harrison, W. (2008). Risky driving among young Australian drivers II: Co-occurrence with other problem behaviours. *Accident Analysis and Prevention*, 40(1), 376-386.

Vassallo, S., Smart, D., Sanson, A., Harrison, W., Harris, A., Cockfield, S. & McIntyre, A. (2007). Risky driving among young Australian drivers: Tends, precursors and correlates. *Accident Analysis and Prevention*, 39(3), 444-458.

Vingilis, E. & Macdonald, S. (2002). Review: Drugs and traffic collisions. *Traffic Injury Prevention*, 3(1), 1-11.

Walker, S., Waiters, E., Grube, J.W. & Chen, M-J. (2005). Young people driving after drinking and riding with drinking drivers: Drinking locations—what do they tell us? *Traffic Injury Prevention*, 6(3), 212-218.

Walsh, J.M., De Gier, J.J., Christopherson, A.S. & Verstraete, A.G. (2004). Drugs and driving. *Traffic Injury Prevention*, 5(3), 241-253.

Zimmerman, R. (1997). *Social marketing strategies for campus prevention of alcohol and other drug problems*. Newton, MA: Higher Education Center for Alcohol and Other Drug Prevention.