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Motor vehicle collision risk and driving under the influence of cannabis: Evidence from adolescents in Atlantic Canada

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Abstract

Objective: Employing a sample of 6087 senior students in Atlantic Canada, this paper examines the relationship between driving under the influence of cannabis (DUIC) and motor vehicle collision (MVC) risk. A series of models were analyzed adjusting for demographic characteristics, driver experience, and substance use.

Methods: Participants were drawn from the 2002/2003 *Student Drug Use Survey in the Atlantic Provinces*, an anonymous cross-sectional survey of adolescent students in the Atlantic provinces of Canada. Logistic regression techniques were employed in the analysis of unadjusted and adjusted models.

Results: Among senior students, the prevalence of DUIC in the past year was 15.1% while the prevalence of MVCs was 8.1%. The predictors of DUIC were gender, driver experience, use of a fake ID, and driving under the influence of alcohol (DUIA). The predictors of MVC were gender, driver experience, DUIC, and DUIA.

Conclusions: These findings extend our knowledge of DUIC as a socio-legal and public health issue with implications on road safety. Effort must be placed on educating new drivers about cannabis use in the context of driving.

1. Introduction

Motor vehicle collisions (MVCs) remain a major source of morbidity and mortality, and a main public health concern (Beirness et al., 2003; National Cancer Institute of Canada, 2001; Scallan et al., 2004). In 1997, MVCs were the seventh leading cause of potential years of life lost in Canada, and third among children aged 0–19 (National Cancer Institute of Canada, 2001). While a number of factors contribute to a MVC (weather, traffic density, vehicle type, etc.), arguably the most important influence is the driver. Driver influences include the age and experience of the driver, driver fatigue, and driving while impaired (Lam, 2002; Movig et al., 2004; Norris et al., 2000; Pack et al., 1995; Turner and McClure, 2004; Whitlock et al., 2003; Peden et al., 2004). Impaired driving is the single leading criminal cause of death in many Western nations and almost half of all traffic fatalities involve someone who is impaired (Romelsjö, 1995; Ross, 1984; Soper, 1990).

We know a considerable amount about the role of alcohol in MVCs (Connor et al., 2004; Mayhew et al., 2002; Movig et al., 2004; O'Malley and Johnston, 2003; Romelsjö, 1995; Single et al., 1998, 1999; Skog, 2001, 2003; Solomon and Usprich, 1990; Soper, 1990). However, as Mann et al. (2003) note, we know less about the effects of drug use on driving ability and traffic safety. Over the past decade, drug impaired driving has emerged as a serious public health issue in many Western Nations. This has resulted in the publication of a number of governmental reports on drugs and driving in Canada (Mann et al., 2003), the United States (U.S. Department of Transportation, 2003), England (Department of Environment, 1998; UK Department for Transport, 2000), Scotland (Ingram et al., 2000), Australia (Parliamentary Travelsafe Committee, 1999), and other nations in the European Union (De Gier, 1995; European Monitoring Centre for Drugs and Drug Addiction, 1999).

After alcohol, the psychoactive substance most widely researched with respect to driving is cannabis (Bates and

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Blakely, 1999; Mann et al., 2003; Mcdonald et al., 2002). Despite being regulated by Canada's Controlled Drugs and Substances Act, cannabis is the most widely used psychoactive substance after alcohol (Mann et al., 2003; Macdonald et al., 2003). A survey of Canadians aged 15 and older found that over one-third of respondents reported using cannabis at some point in their lives, with almost 1 in 10 using cannabis in the previous year (Ogborne and Smart, 2000). Recent surveys of Canadian adolescents from four provinces (New Brunswick, Nova Scotia, Ontario, and Prince Edward Island) found the prevalence of cannabis use among high school students to range from 23.7% to 36.5% (Adlaf et al., 2003; Poulin and Wilbur, 2002). The primary psychoactive component in cannabis is THC (Δ^9 tetrahydrocannabinol), which typically produces euphoria, relaxation, and changes in perception at low doses, and at higher doses, deficits in attention span and memory, and pain relief. Given the psychoactive effects of cannabis, concern has been expressed about the potential deleterious effect of cannabis consumption on driving skills (Macdonald et al., 2003; Strang et al., 2000).

Two questions are of importance to the issue of cannabis, driving, and MVCs: Is there an increased risk of a MVC among people who drive under the influence of cannabis and does cannabis impair driving performance? In regards to the latter question, there is a substantial body of research assessing the effects of cannabis on human performance (i.e. Bates and Blakely, 1999; Ramaekers et al., 2004). One conclusion drawn from this body of research is that moderate or greater doses of cannabis (>300 μg/kg) may produce impairment in the motor and perceptual skills that are necessary for safe driving. Laboratory tests have shown that cannabis produces impaired performance on driving-related tasks (Berghaus and Guo, 1995; Low et al., 1973; Moskowitz, 1985; Smiley, 1998), while studies conducted on closed road courses find a correlation between cannabis dose and poor driver performance (Peck et al., 1986; Robbe and O'Hanlon, 1993).

In answering the former question, epidemiological research on collisions has pointed to the role of cannabis on the risk of MVCs. These studies typically focus on specific sub-populations, including fatally injured drivers, clinical samples of drivers in collisions who have been admitted to hospital, or individuals involved in drug treatment. Fatality studies find that after alcohol, cannabis is the drug most often found in drivers who are fatally injured in a MVC (Dussault et al., 2002; Jeffery et al., 1995; Stoduto et al., 1993). For instance, Stoduto et al. (1993) found that 32% of motor vehicle collision victims admitted to a regional trauma unit had a positive BAC, while 13.9% of collision victims tested positive for cannabis. A large proportion of fatally injured drivers who test positive for cannabis also test positive for elevated blood alcohol levels (Cimbura et al., 1990; Drummer, 1995). This suggests that the influence of cannabis on driving skills may be further exaggerated when consumed in combination with alcohol (Peck et al., 1986; Perez-Reyes et al., 1988). Some recent culpability studies have found that cannabis increases the risk of MVC and death among culpable versus non-culpable drivers (Drummer et al., 2004). Meanwhile, research on impaired drivers in treatment programs have noted that many individuals involved in driving under the influence of alcohol also test positive for cannabis and other drugs (Brookoff et al., 1994; Chipman et al., 2003; Soderstrom et al., 1994).

Not all studies, however, find that the consumption of cannabis alone increases the risk of a MVC (Movig et al., 2004; Terhune, 1983). In fact, some studies suggest that those driving under the influence of cannabis may be less at risk for a MVC than are drug-free drivers as cannabis users tend to recognize their impairment and compensate by driving more slowly (Robbe and O'Hanlon, 1993). Some of the discrepancy as to whether cannabis is a risk factor for MVCs results from our inability to isolate active cannabis metabolites among drivers involved in collisions (Bates and Blakely, 1999; Begg et al., 2003; Ramaekers et al., 2004).

Fewer studies have looked at the relationship between cannabis consumption and the risk of MVCs in non-clinical samples from the general population (Fergusson and Horwood, 2001; Hingson et al., 1982; Movig et al., 2004). The difficulty in studying the role of cannabis in MVCs in non-clinical samples is, in part, due to ethical issues associated with obtaining blood or urine samples from the general driving population (Macdonald et al., 2003). The illegal status of cannabis generates further difficulty for researchers trying to recruit subjects to comprise a control sample (Bates and Blakely, 1999; Ramaekers et al., 2004). As such, researchers wishing to explore the relationship between cannabis use and MVCs in a representative sample from the general population often rely on self-report data.

In the early 1970s, Smart (1974) studied self-reported cannabis use and the probability of MVC among college students. He found that cannabis users had almost as many MVCs under the influence of cannabis as they did when under the influence of alcohol. Based on a telephone survey of 6000 adolescents between the ages of 16 and 19 years of age, Hingson et al. (1982) found MVC involvement to be related to the frequency of driving under the influence of cannabis. The risk of collision increased substantially among those young people who more frequently drove under the influence of cannabis compared to people who drove under the influence occasionally or not at all. More recently, Fergusson and Horwood (2001) uncovered a significant relationship between individuals' reported annual cannabis use and annual MVC rates. Individuals who consumed cannabis 50 times or more per year were involved in 1.6 times the number of MVCs as non-users. However, the direct effect of cannabis on MVC risk was non-significant once driver characteristics (i.e. whether respondents reported drinking and driving and whether they scored high on a risky driving scale) were controlled for.

The current study extends this body of research by exploring MVC risk in a non-clinical sample of senior students in Atlantic Canada who reported driving within an hour of

using cannabis. MVCs are disproportionately experienced by young drivers, as is the propensity to drive under the influence of drugs or alcohol (Grube and Voas, 1996). Two questions are addressed. First, we look at the risk factors associated with driving under the influence of cannabis among senior students. Research on impaired driving has documented a number of risk factors that are correlated with adolescent involvement in driving under the influence of alcohol, including demographic indicators, risk-taking, and substance use (Begg et al., 2003; Bingham and Shope, 2004; Donovan, 1993; Fahrenkrug and Rehm, 1994; Jelalian et al., 2000; Macdonald and Mann, 1996; Shope and Zakrajsek, 2004; Wells-Parker et al., 1986; Wilson and Jonah, 1985). The current study looks to explore the extent to which some of these same risk factors are important predictors of driving under the influence of cannabis. Second, controlling for DUIA, driver experience, demographic indicators, and substance use, we look at MVC risk among those adolescents who drove under the influence of cannabis, those who used cannabis but did not drive under the influence, and those who did neither.

2. Methods

2.1. Setting

Canada's Atlantic region includes the provinces of Nova Scotia (NS), New Brunswick (NB), Newfoundland and Labrador (NL), and Prince Edward Island (PE). As of 2002, the region had a total population of approximately 2.34 million (Statistics Canada, 2004). The region's population is comprised mostly of European descendants. As of 2001, Aboriginals made up approximately 1.0–3.7% of the population in each province and other visible minorities made up another 0.9–3.8% of the population in each province (Statistics Canada, 2004).

As with alcohol, drug-impaired driving is prohibited by the Canadian Criminal Code. Under paragraph 253(a) of the Criminal Code, it is an offence for anyone to operate a motor vehicle, vessel, aircraft, or railway equipment while his or her ability to operate it is impaired by alcohol or a drug. Currently, the police have neither authority under the Criminal Code to demand physical sobriety tests or bodily fluid samples for impaired driving investigations, nor is there a "legal limit" offence for drugs as there is for alcohol. Additionally, most provincial governments have enacted graduated licensing programs for new drivers. Graduated licensing programs specify that the new license holder maintain a zero BAC for the first 2 years, along with restrictions on night driving and the stipulation that the license holder drive under the supervision of an experienced driver. Failure to comply with these regulations results in strict penalties that include a loss of license. Nowhere in the graduated licensing legislation is drug-impaired driving mentioned.

2.2. Participants

Participants were drawn from the 2002/2003 *Student Drug Use Survey in the Atlantic Provinces* (SDUSAP), the third iteration of an anonymous cross-sectional survey of adolescent students in the Atlantic provinces of Canada including Nova Scotia (Poulin and Wilbur, 2002), New Brunswick (Liu et al., 2003), Prince Edward Island (Van Til and Poulin, 2002), and Newfoundland and Labrador (Martin and Poulin, in press). The survey was standardized in 1994 (Poulin et al., 1995) and implemented in 1996 and 1998 (Poulin et al., 1999; Poulin and Graham, 2001). The sample design was a single-stage cluster sample of randomly selected classes stratified by grade and either health region (in NS and NL) or school district or board (in NB and PE). The total sample was 12990 students in grades 7, 9, 10, and 12 in the four Atlantic provinces of Canada, with a response rate of 97%. The average age of participants was 14.9 years and 50% of respondents were male.

This sample was further refined for the current analysis to include only those students in grades 10 and 12. The driver's licensing age in Canada is 16, and given that driving under the influence is, in part, conditioned on being of driving age, the analysis was restricted to older adolescents. This led to a sample of 6087 senior students. The median age of students in grade 10 and 12 was 16 and 18 years, respectively.

2.3. Instrument

The 2002/2003 *SDUSAP* is a self-reported questionnaire comprising 100 items requesting information about demographics, social environment, substance use, gambling, school rules, mental health, and help-seeking. The methods to assess validity and reliability of the overall survey have been replicated at each implementation of the survey (Poulin et al., 1993). Evidence that the standardized survey is valid, reliable, and minimizes under-reporting includes a low rate of non-coverage of the student population, the safeguarding of anonymity and confidentiality, drug use estimates consistent with those of similar surveys, low non-response rates for the drug use items, high rates of logical consistency between selected items, and a test–retest was performed on a subsample of respondents.

2.4. Variables

The present study investigated the predictors of driving under the influence of cannabis (DUIC) and the predictors of being a driver in a MVC. The DUIC question asked, "In the past 12 months, how many times have you driven a motor vehicle within an hour of using cannabis?" As a precondition, respondents had to have used cannabis at least once in the preceding 12 months, based on the question, "In the past 12 months, how often did you use cannabis (marijuana, grass, weed, pot, hash, hash oil)?" The cannabis variable was combined with the DUIC variable to create a variable with

three levels: no use of cannabis in the past 12 months, use of cannabis in the past 12 months but no DUIC, and use of cannabis in the past 12 months and DUIC, with analyses comparing adolescents who engaged in DUIC and those who had not. The MVC question asked, "In the past 12 months, have you been in a motor vehicle accident with you as the driver?" Responses were a dichotomy of those who endorsed being the driver involved in a MVC and those who did not.

The independent variables included demographic measures, use of a fake ID to get alcohol, driver experience, and driving under the influence of alcohol (DUIA). Furthermore, DUIC was included as an independent variable when predicting MVC. Gender, grade level, and urban/rural residence were included as demographic measures. Urban/rural residence was based on a Census Canada definition using the first three digits of the respondent's postal code (Canada Post, 2004). Use of fake ID was based on the question, "In the past 12 months, have you used a fake identification or lied about your age in order to get alcohol" with responses dichotomised into use or no use of a fake identification to get alcohol. Driver experience was based on the question, "How long have you had a license to drive a car or a motorcycle?" with responses regrouped into three categories (no license, beginners' license or license for less than a year, license for greater than a year). The DUIA variable was constructed in the same way as the DUIC variable, with alcohol use being a precondition of DUIA. The DUIA question asks, "In the past 12 months, how often have you driven a motor vehicle within an hour of drinking two of more drinks of alcohol?" The alcohol question asks, "In the past 12 months, how often did you drink alcohol—beer, wine, coolers, or hard liquor (rum, whisky, vodka, gin, etc.)?" The resulting DUIA measure included three levels: no drinking during the past 12 months, drank but did not DUIA, and drank and DUIA.

Test–retest results from a subsample of respondents were examined using the kappa statistic. The kappa statistic demonstrates the extent of agreement between test and retest, over and above agreement expected due to chance. Kappa values for the four key measures, DUIC, MVC, DUIA, and driver experience, were 0.46, 0.60, 0.81, and 0.68, respectively. According to Fleiss (1981), values of kappa between 0.4 and 0.75 represent fair to good agreement, and values greater than 0.75 represent excellent agreement. Descriptive statistics for all independent variables are presented in Table 1.

Table 1
Characteristics of senior high school students in the Atlantic Provinces

Variables	Senior students ($n = 6087$)		
	n	Weighted %	CI[a]
Gender			
Female	3056	50.5	2.4
Male	2959	48.4	2.3
Missing	72	1.1	0.4
Grade			
10	3279	52.1	2.6
12	2808	47.9	2.6
Location			
Urban	2110	37.7	5.8
Rural	3977	62.3	5.8
Driver experience			
Do not have a license	2812	47.3	2.2
License < 1 year	1853	30.0	1.8
License > 1 year	1402	22.3	1.9
Missing	20	0.4	0.2
Use of fake ID			
No use of a fake ID to get alcohol	5045	82.6	1.8
Used a fake ID to get alcohol	1033	17.3	1.8
Missing	9		
DUIC			
Did not use cannabis	3191	50.5	2.4
Used cannabis but no DUIC	1964	33.6	2.0
DUIC	878	15.1	1.6
Missing	54	0.8	0.3
DUIA			
Did not use alcohol	1566	24.9	1.9
Used alcohol but no DUIA	3762	62.6	2.0
DUIA	719	11.7	1.4
Missing	40	0.8	0.3
MVC			
No	5568	91.4	1.0
Yes	494	8.1	1.0
Missing	25	0.5	0.3

[a] 99% Confidence interval.

2.5. Statistical analysis

All prevalence estimates and statistical tests accounted for the stratified disproportionate cluster sample design and probability weights. Non-response to any given predictor variable was coded as a separate dummy category and included in the analysis. As age in years (16–18) and grade (10 and 12) were highly collinear (Pearson's correlation coefficient = 0.95), grade was used for prevalence estimates and in the multivariate models.

Overall proportions were investigated in the sample to obtain general descriptive statistics and prevalence rates of DUIC and MVCs. Analysis occurred in two stages. In the first stage, the influence of predictor variables on DUIC was determined using logistic regression. However, given that a precondition of DUIC is having used cannabis, regression analyses were performed on a reduced sample of 2834 senior students who had used cannabis in the past year. This analysis examined the predictors of DUIC compared to cannabis users who did not DUIC. For the second stage, logistic regression was employed to predict the influence of DUIC and other variables on MVC on the full sample of 6087 senior students. All logistic regressions used maximum likelihood estimators. Maximum likelihood estimators are asymptotically efficient and normal and have good properties in large samples (Allison, 1995). Denominators for regression models did not always sum to 2834 and 6087, respectively, due to missing data.

For the analysis of DUIC, the general logistic model fitted was:

$$\log\left(\frac{\mu}{1-\mu}\right) = \alpha + \sum_{i=1}^{p} \beta_i X_i$$

where μ was the expected value of DUIC and $\sum_{i=1}^{p} \beta_i X_i$ was a set of predictor variables (e.g. gender, grade, driver experience, DUIA). For the analysis of MVC, the general logistic regression model fitted was:

$$\log\left(\frac{\mu}{1-\mu}\right) = \alpha + \sum_{i=1}^{p} \beta_i X_i + \beta_{(p+1)} X_{(p+1)}$$

where μ was the expected value of motor vehicle collisions, $\beta_{(p+1)} X_{(p+1)}$ was DUIC, and $\sum_{i=1}^{p} \beta_i X_i$ was a set of predictor variables (e.g. gender, grade, driver experience, DUIA). All analyses were conducted with the Stata 8.0 computer program (StataCorp, 2001) using the survey commands that account for intra-cluster correlation due to the sampling strategy.

3. Results

Descriptive statistics from Table 1 reveal that overall, 8.1% of senior high school students reported having been involved in a MVC, with themselves as the driver, in the 12 months prior to the survey. In terms of driver experience, slightly more than half of all senior students had a license. Of these students, 30.0% had a license for less than 1 year while 22.3% had a license for more than 1 year. Regarding substance use and impaired driving in the past year, 15.1% of students drove under the influence of cannabis while 33.6% of students used cannabis but did not DUIC. About 11.7% of senior students drove under the influence of alcohol at least once in the past year and 62.6% of students used alcohol but did not DUIA. Despite the higher prevalence of alcohol use relative to cannabis use, a lower proportion of senior students engaged in DUIA than in DUIC.

Table 2 presents logistic regression results predicting DUIC among senior students in Atlantic Canada. Unadjusted results indicate that relative to cannabis users who did not DUIC, adolescents who engaged in DUIC were more likely to be male, in grade 12, living in rural locales, to have used a fake ID to get alcohol, to have had a license (license > 1 year and license < 1 year), and to DUIA. Adjusted results from Table 2 were generally consistent with unadjusted results, with two exceptions: grade and urban/rural residence were no longer significantly related to DUIC, and the effect sizes for all variables were diminished in the adjusted model.

Table 2
Multinomial logistic regression of driving under the influence of cannabis among senior student in the Atlantic Provinces (weighted estimates with odds ratios and standard errors in parentheses)

Variables	Cannabis users ($N = 2834$)			
	n[a]	Weighted % of DUIC	Unadjusted	Adjusted
Gender				
Female	1367	23.2	1	1
Male	1427	37.6	2.03 (0.163)**	1.78 (0.169)**
Grade				
10	1368	18.1	1	1
12	1466	41.7	3.23 (0.345)**	1.18 (0.159)
Location				
Urban	1051	26.4	1	1
Rural	1783	33.3	1.40 (0.160)*	1.21 (0.149)
Use of fake ID to get alcohol				
No	2031	24.0	1	1
Yes	802	47.7	2.87 (0.285)**	1.63 (0.194)**
Driver experience				
Do not have license	1180	13.7	1	1
License < 1 year	907	30.7	2.78 (0.341)**	2.32 (0.293)**
License > 1 year	741	58.8	9.17 (1.24)**	5.71 (0.932)**
DUIA				
Did not use alcohol	151	14.5	1	1
Use alcohol but no DUIA	2117	21.6	1.53 (0.385)	1.27 (0.334)
DUIA	55	71.8	14.3 (3.89)**	7.61 (2.21)**
LR (degrees of freedom)				799.88 (11)**
Pseudo R-squared				0.23

[a] The weighted prevalence estimates are based on 2834 cases yet missing cases reduced the number of observations for certain variables.
* $p < 0.01$.
** $p < 0.001$.

Table 3
Logistic regression of MVCs among senior students in Atlantic Canada (weighted estimates and odds ratios with standard errors in parentheses)

Variables	n[a]	Weighted %	MVC (n = 494)		
			Model 1 (unadjusted)	Model 2 (adjusted)	Model 3 (adjusted with DUIA)
Gender					
Female	3049	7.0	1	1	1
Male	2942	9.4	1.39 (0.156)*	1.24 (0.145)	1.19 (0.137)
Grade					
10	3261	4.1	1	1	1
12	2801	12.5	3.35 (0.371)**	1.23 (0.182)	1.20 (0.177)
Location					
Urban	2099	7.5	1	1	1
Rural	3963	8.5	1.15 (0.142)	1.16 (0.121)	1.08 (0.113)
Use of fake ID to get alcohol					
No	5022	6.8	1	1	1
Yes	1033	14.7	2.37 (0.270)**	1.21 (0.164)	1.08 (0.147)
Driver experience					
Do not have license	2795	3.4	1	1	1
License < 1 year	1853	6.9	2.12 (0.309)**	1.74 (.259)**	1.70 (0.257)**
License > 1 year	1400	20.0	7.15 (0.907)**	4.69 (0.823)**	4.41 (0.784)**
DUIC					
Did not use cannabis	3178	5.7	1	1	1
Used cannabis but no DUIC	1957	6.6	1.18 (0.137)	1.27 (0.151)	1.14 (0.148)
DUIC	877	20.0	4.14 (0.491)**	2.39 (0.332)**	1.84 (0.277)**
DUIA					
Did not use alcohol	1558	3.9	1		1
Used alcohol but no DUIA	3750	7.4	1.93 (0.297)**		1.36 (0.233)
DUIA	717	21.3	6.61 (1.16)**		2.40 (0.533)**
LR (degrees of freedom)				389.61 (10)	416.64 (13)
Pseudo R-squared				0.11	0.12

[a] The weighted prevalence estimates are based on 6087 cases yet missing cases reduced the number of observations for certain variables.
* $p < 0.01$.
** $p < 0.001$.

Table 3 describes logistic regression results predicting MVCs among senior students in Atlantic Canada. Three models were analysed. The first model was unadjusted while models 2 and 3 were adjusted. Unadjusted estimates indicated that male students and students in grade 12 had significantly increased odds of a MVC. Meanwhile, students who had a driver's license for less than a year were twice as likely as unlicensed drivers to be in a MVC, and those who had a license for more than 1 year exhibited a seven-fold increased risk. Finally, students who drove under the influence of cannabis in the past year were over four times as likely as cannabis-free drivers to be involved in a MVC, yet those adolescents who used cannabis but did not DUIC were not at an elevated risk of a MVC. Compared to students who did not use alcohol, students who drove under the influence of alcohol, and students who drank alcohol but did not DUIA had an increased risk of a MVC.

Adjusted results revealed the following: first, once driver experience was entered into the model gender and grade differences disappeared. Second, driver experience had a consistent direct effect on the odds of a MVC, such that having a license for greater than 1 year enhanced the likelihood of being involved in a MVC. Finally, controlling for demographic characteristics and for DUIA, DUIC increased the odds of involvement in a MVC, while being a cannabis user in the absence of DUIC resulted in no significant independent effect on the likelihood of a MVC.

The explained variance was less than 25% for all models, indicating that additional explanatory variables have not been measured. Other explanatory measures might include estimated miles driven, driving history, or community level enforcement patterns for impaired driving. Earlier analyses included additional variables such as perceived family economic status, academic performance, and family structure, predicting DUIC and MVC. None of these measures demonstrated a significant relationship with either dependent variable and were removed from the analyses so that the best model was fitted. Detailed results are available upon request.

4. Discussion

The major conclusions from this paper can be summarized as follows. First, the prevalence of DUIC among senior

students was higher than that of DUIA (15.1% versus 11.7%), despite the higher prevalence of alcohol consumption relative to cannabis use. Meanwhile, 8.1% of senior students reported being involved in a MVC in the preceding year. These findings replicate results from recent studies in Canada and the U.S. (Adlaf et al., 2003; O'Malley and Johnston, 2003).

Second, the highest risk for engaging in DUIC was among male students, students who had used a fake ID to purchase alcohol, students with a driver's license, and students who had engaged in DUIA, reaffirming some of the conclusions drawn from the few studies that have explored the correlates of driving under the influence of cannabis (Adlaf et al., 2003; Walsh and Mann, 1999). The strongest relationship was exhibited between driving under the influence of cannabis and driving under the influence of alcohol, where adolescents who engaged in DUIA had a six-fold increased odds of DUIC. Alcohol consumption, not in the context of driving, had no influence on DUIC.

Third, net of driving under the influence of alcohol, driver experience, and demographic characteristics, adolescents who drove under the influence of cannabis reported an increased risk of a MVC. The risk of being involved in a collision among those who drove under the influence of cannabis was nearly two-fold relative to cannabis-free adolescents. Moreover, it was not cannabis consumption, per se, that was associated with an increased risk of MVC, but the recency of cannabis use just prior to driving. This finding is similar to earlier studies (Hingson et al., 1982; Smart, 1974) but does not support the more recent work of Fergusson and Horwood (2001), who noted a minimal effect of cannabis use on traffic accident risk. The discrepancy in findings may be due to the fact that Fergusson and Horwood (a) controlled for driver attitudes, while the current study includes only driver experience and (b) only measured the frequency of cannabis use in the past year and its association to MVC, whereas in the current study the influence of cannabis use just prior to driving was analyzed. As Ferguson and Horwood describe in their conclusion (p. 710), the inability to measure the recent use of cannabis in the context of driving may have hindered their ability to properly determine the role of cannabis on traffic accident risk. The current findings confirm that self-report studies of cannabis and road safety must rely on measures of recent cannabis use in the context of driving.

Finally, adolescents who have held a license for more than 1 year were at the greatest risk of a MVC, followed by those adolescents that had their license for less than 1 year. In an earlier study, Mayhew et al. (2003) found a curvilinear relationship between driver experience and MVC risk. Learners (drivers who recently received a license) had the lowest risk of collision, while novice drivers (drivers who have had a license for 6 months to a couple of years) had one of the highest risks of MVC. After the first year of driving had ended the risk of MVC began to significantly diminish (Mayhew et al., 2003; Williams et al., 1997). We discovered that increased driver experience was associated with an increased risk of becoming involved in a MVC. The limited time-frame employed to measure driver experience in the current study may partially explain this finding.

It is also important to point out that a number of unlicensed adolescents were involved in MVCs. Given that many of these young people were also likely to DUIC and/or DUIA, this finding reinforces the notion that there is a constellation of less desirable activities clustering within a small subgroup of young reckless drivers (Bingham and Shope, 2004; Grube and Voas, 1996; Jelalian et al., 2000; Jonah et al., 2001; Turner and McClure, 2004). While measures of risk-taking have not been included in the current study, perhaps, as Drummer et al. (2004) note, the mere use of cannabis or alcohol in the context of driving (licensed or otherwise) is a strong proxy for a risk-taking lifestyle.

Collectively, these findings speak to the graduated licensing procedures in place in Atlantic Canada. As noted, graduated licensing programs specify that new license holders maintain a zero BAC for the first 2 years of driving, along with restrictions, in the first year, on night driving and the stipulation that the license holder drive while supervised by an experienced driver. First-year license holders had an accident risk of less than 7% compared to the almost 20% among license holders in the second year and beyond. A considerable body of research has demonstrated that teenage MVCs occur, most frequently, at night (Cvijanovich et al., 2001; Phebo and Dellinger, 1998; Williams et al., 1997; Zhang et al., 1998). The fact that newly licensed drivers in their first year cannot drive at night and must drive while supervised may account for the discrepancy in collision rates.

Some of the benefit of graduated licensing in reducing collisions may be offset by the high rates of DUIC at all levels of driver experience and the failure of legislation to set explicit standards for drug-free driving. One explanation centres upon the issue of enforcement. Because impaired driving under the influence cannabis is difficult to establish, legally, and not clearly articulated in either federal law nor in the graduate licensing provisions, young people may be unafraid of either getting charged and/or convicted for drug-impaired driving (O'Malley and Johnston, 2003). As Albery et al. (2000, p. 203) note, "Educational campaigns emphasising the role of alcohol on driving performance and accident involvement. . . have been a constant theme in road safety programmes. In terms of driving after the consumption of illicit substances, this exposure has at best been limited."

Educational and policy initiatives directed at new drivers have failed to adequately inform new drivers about the potential consequences of driving under the influence of cannabis. Recent surveys suggest that young people have not taken the issue of drug use and driving seriously. Patton et al. (2001) found that 19% of students in Manitoba, Canada, thought there was "nothing wrong" with driving under the influence of cannabis, compared to only 4% who felt the same about driving under the influence of alcohol. This speaks to the role of organizations involved in health promotion and education around impaired driving who have, until recently, focused almost exclusively on the issue of drinking and driving and

paid less attention to the drug-driving issue (Berger and Marelich, 1997). As O'Malley and Johnston (2003, p. 311) note,

Because alcohol consumption is still considerably more prevalent than marijuana consumption, the fact that the use of these two substances in combination with driving has reached near parity suggests that teens are relatively less likely to drive after drinking than they are after using marijuana. This may reflect the concerted efforts in the past 20 years to deter drunk driving compared to the much more limited efforts to deter drug-impaired driving.

Our findings reconfirm O'Malley and Johnston's observation.

This study has three major limitations. First, data were cross-sectional rather than longitudinal, and therefore this study was unable to capture a potential cause-and-effect relationship between various risk factors, DUIC, and MVC. Second, involvement in a MVC in the past year was based on self-reports and may suffer from biases of under- and over-reporting. Third, the current study asked only about driving under the influence of cannabis and not driving while impaired by cannabis. Additionally, af Wåhlberg (2003) has noted some consistent biases in MVC studies including, a failure to note the reliability of predictors in collision studies, the failure to mention the time period for collecting collision data which may bias estimates, and the issue of driver culpability. The current study attempted to account for these biases in the following ways. First, as outlined in the methods section, the study design includes a test–retest component among a sub-sample of study participants to confirm the reliability of measures. Second, an explicit time period for collision data was used. MVCs were measured over the past year among a sample of young drivers, ranging in age from 14 to 19. Because respondents were young and not asked to recall lifetime involvement in collisions, errors in reporting collision involvement should be minimal. However, a measure of driver culpability was not included in this study; therefore, the results cannot confirm whether cannabis proved to be a greater risk in collisions where the driver was culpable compared to collisions with a lack of driver culpability.

In conclusion, the current study found that among the general adolescent population in Atlantic Canada, driving under the influence of cannabis has become a prevalent activity surpassing driving under the influence of alcohol, and it has played an important role in motor vehicle collision risk, independent of drinking and driving, driver experience, and other risk factors. While the current findings cannot confirm whether DUIC was directly responsible for a MVC, adolescents who used cannabis in the one hour prior to driving were more likely to be involved in MVCs. Educational efforts around impaired driving have, until recently, been directed at alcohol and driving. This study suggests that as a means to improve driving safety, graduate licensing programs and other similar programs aimed at new drivers should pay equal attention to driving under the influence of drugs. This involves educating the public about the potential risks associated with drug-impaired driving, as well as the establishment of explicit legal standards for such driving violations.

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