The Contribution of Alcohol and Other Drugs Among Fatally Injured Drivers in Quebec: Final Results

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Background

Over the last 20 years, Québec has become a groundbreaker in the war against drinking and driving. Harsher penalties and an increased police presence have contributed to reducing the number of drinking and driving deaths. Consequently, between 1991 and 1999, the percentage of drivers with a blood-alcohol level above 80mg declined 50%. Despite these statistics, impaired driving still accounts for 30% of traffic deaths, 18% of accidents causing serious injury and 5% of accidents causing minor injury.

The campaign against drinking and driving, however, must increasingly extend to the emerging trend of drug-impaired driving, which includes legal drugs, such as medication and illegal drugs like marijuana or cocaine. Considering the increased consumption of these substances among different segments of the population, particularly young adults for illegal drugs and the elderly for legal ones, larger numbers of individuals may be driving under the influence of drugs.

In Canada, an estimated 5 to 12% (1) of drivers may be driving under the influence of cannabis. Males under age 25 account for over 20%. In Québec, the number of marijuana users among 15- to 24- year-olds nearly doubled between 1992-93 and 1998, climbing from 15% to 25.9% (2). This growth is a serious concern for highway safety because drivers under age 25 account for a disproportionately higher number of road accidents. These results are corroborated by a 1999-2000 roadside survey in Québec where the presence of cannabis in urine was detected among 24.8% of drivers aged 16 to 19 and 18.9% of drivers between ages 20 to 24 (3).

It is important to underscore the fact that, in this roadside survey, cannabis was detected in the urine of drivers. Consumption, however, may not necessarily be recent, since cannabis can be detected in urine up to 2 or 3 weeks later. Consequently, not all of these drivers would be driving impaired by cannabis. An estimated 0.5 to 1% of individuals would drive shortly after consuming cannabis (4). In Canada, an Ontario survey showed that 1.9% and 2.7% of respondents (in 1999 and 2002 respectively) reported having driven after consuming cannabis at least once in the previous 12 months (5).

In 1998, Québec Health Ministry identified the elderly as a segment of the population requiring specific attention in its 1999-2001 Plan of Action on Addiction. Given our aging population and the increased consumption of psychotropic medication, this

finding is all the more significant since 27.8% of medication prescribed for the elderly involves psychotropic medication (i.e. sedatives, anxiolytics, etc.) (6). In terms of highway safety, this information must be given due consideration.

This article details the final results of the case-control analysis that was part of a broad epidemiological survey in Québec between 1999 and 2002. Preliminary results were presented during the 16th ICADTS Conference held in Montreal in August 2002 (7).

Methodology

The data comes from two sources. First, coroner, forensic laboratory and police accident records were matched for 823 (62%) of the 1,337 fatally injured drivers of passenger vehicles deceased between April 1999 and December 2002. Among those 823 matched fatally injured drivers, urine samples were obtained in 520 cases (63%). And finally, for those 520 drivers, 492 blood samples were obtained. Both blood and urine samples were sent to the laboratory for a complete toxicological analysis (screening and confirmation). It was not possible to estimate BAC for 8 of those cases. Therefore, 512 cases have been used for the analyses.

For cases where biological samples were not available, reasons for the absence of tests varied. For some cases, it was not possible to obtain a biological sample. But difficulty contacting all coroners is the principal reason many samples were not collected. Biological samples were supposed to be taken systematically, but obviously it was not the case.. There are consequently significant differences in matched records based on age, time of accident, number of vehicles involved in the accident and region of the accident.

Second, a roadside survey over two years was conducted in August 1999 and August 2000. According to a two-stage stratified sampling procedure, representative of the Quebec driving population, the survey sample was distributed proportionately to the number of fatal crashes per time of day (eight 3-hour periods) and day of the week (seven days). During both daytime and nighttime, a total of 11,952 drivers participated in the two roadside surveys among which 11,574 provided a breath sample (96.8%) and 5,931 a urine sample (49.6%).

On each site (348 sites for 1999 and 2000), a roadblock was set up and drivers were directed to an adjacent emplacement. After a brief introduction, respondents were asked to answer a brief questionnaire and to provide a breath sample, and then a urine sample. During the 1999 survey, in case of a refusal to provide a urine sample, the driver was asked to provide a saliva sample that was basically used as a control for non-response. That procedure was changed for the 2000 survey when all drivers were asked to provide breath, urine and saliva samples. Saliva sample was used again as a control for non-response, but also to compare drug presence in urine and in saliva. All urine and saliva samples were placed in small containers with icepacks. At the end of each period, the samples were transported to the lab located in Montreal and kept frozen (-15 ^{0}C) until analysis.

All analyses were performed by the same forensic laboratory. Preliminary screening (immunoassay) was performed applying the following cutoffs for urine: THC-COOH

for cannabis: 25 ng/ml, benzoylecgonine for cocaine: 300 ng/ml, opiates: 100 ng/ml, PCP: 25 ng/ml, benzodiazepines: 50 ng/ml, barbiturates: 200 ng/ml, amphetamines: 300 ng/ml. All positives were confirmed by mass spectrometry (HPLC-MS and GC/MS).

CASE-CONTROL ANALYSIS – The case-control analysis compares the presence of a drug (or drug combination) in urine samples of fatally injured drivers to the presence of a drug (or drug combination) in urine samples of drivers participating in the roadside survey (urine/urine comparison). For alcohol, the case-control analysis compares the presence of alcohol in blood samples (or vitreous humor for some cases) of fatally injured drivers for some cases to alcohol detected in breath samples of drivers stopped at the roadside (blood/breath comparison). The control sample was post-stratified in order to eliminate the voluntary over-sampling during the nighttime period. That over-sampling was performed to obtain a number of observations similar to previous alcohol nighttime surveys conducted in Quebec in 1981, 1986 and 1991.

LOGISTIC REGRESSION ANALYSIS – Use of the logistic regression analysis was necessary to adjust odds ratios for differences between case and control groups with respect to the sex and age of drivers and time and day of the week. Groups were formed as follows: for age, 16- to 24-year-olds, 25- to 44-year-olds and 45-year-olds or over; for time of day, 6:00 a.m. to 9:00 p.m. (day) and 9:00 p.m. to 6:00 a.m. (night); and for day of week, Monday to Thursday (weekdays) and Friday to Sunday (weekend).

RESPONSIBILITY ANALYSIS – The responsibility analysis is a case-case approach. Cases were split in a two by two design: drug versus drug-free cases and responsible versus non-responsible cases and odds ratios were calculated using the Terhune method (8) which is similar to the case-control method. The responsibility analysis was performed by three different judges, otherwise not involved in the study, who assessed responsibility without knowing drug presence. The determination of responsibility was established using the crash responsibility scale (9). Crash responsibility was determined for 471 of the 512 cases.

Despite precautions taken during the planning of the study, the matching of data reveals differences according to sex and age of drivers, day and time of the accident and number of vehicles involved in the accident when we compare the distributions of drivers whose samples were analyzed and deceased drivers during the study period. Hence, more samples were collected from young drivers and from men (Table 1). Moreover, slightly fewer drivers in daytime accidents were matched. Finally, it was also the case for accidents involving 3 vehicles or more (29.9%), but these ones account for only 11.5% of the 1,337 deceased drivers.

Table 1. Number of deceased drivers and matched records by age, gender and hour of crash.

Age	total	matched	%	Gender	total	matched	%	Hours	total	matched	%
16-24	359	162	45.1%	Male	1,033	416	40.3%	6am-9pm	880	293	33.3%
25-44	438	171	39.0%	Female	304	96	31.6%	9pm-6am	457	219	47.9%
45+	537	178	33.1%	Total	1,337	512	38.3%	Total	1,337	512	38.3%
Total	1,337	512	38.3%								

Therefore, proportions based on these variables vary considerably between cases and controls, as table 2 shows, even when control group is weighted to eliminate the planned over-sampling during the night for the roadside survey. Though, a logistic regression was realized to adjust odds ratios for these variables. There were no problem in matched records for day of crash, but when comparing cases and controls groups, there were a slight difference in proportions. Hence, this variable was also considered in the analysis.

Table 2. Proportions of deceased drivers (total), matched records(cases) and surveyed (controls) by age, gender, hour of crash.

Age	total	cases	controls	Gender	total	cases	controls	Hours	total	cases	controls
N	1337	512	5931	N	1337	512	5931	N	1337	512	5931
16-24	26.9%	31.6%	20.9%	Male	77.2%	81.3%	71.8%	6am-9pm	65.8%	57.2%	42.9%
25-44	32.8%	33.4%	40.6%	Female	22.8%	18.7%	28.2%	9pm-6am	34.2%	42.8%	57.1%
45+	40.2%	34.8%	38.5%								

RESULTS

FATALLY INJURED DRIVERS (CASES) – Alcohol was found in 39.8% of blood samples (204/512) with the following BAC: 20-49 mg%: 2.3% (12/512), 50-80 mg%: 2.9% (15/512) and > 80mg%: 34.6% (177/512). Alcohol alone cases accounts for 61.3% (125/204) of all alcohol cases and thus, another drug was found in 38.7% (79/204) of all alcohol cases.

Other drugs were found in 32.4% (166/512) of urine samples in the following proportions: cannabis: 19.7% (101/512), cocaine: 7.8% (40/512), benzodiazepines: 10.4% (53/512), opiates: 1.8% (9/512), PCP: 1.2% (6/512), amphetamines: 0.8% (4/512), barbiturates: 0.2% (1/512). Alcohol was also found in 47.5% (79/166) of all drug cases.

DRIVERS AT THE ROADSIDE (CONTROLS) – During both daytime and nighttime, a total of 11,952 drivers participated in two surveys among which 11,574 provided a breath sample (96.8%) and 5,931 a urine sample (49.6%). The actual participation rate for saliva is 84.6% (8,177/9,671) since saliva samples were asked after urine refusals in 1999, but systematically in 2000. Regardless of the time of the day, alcohol was found in 5.1% of breath samples (weighted results to control for nighttime over-sampling). During the nighttime (9pm-6am), alcohol was detected among 8.7% of the drivers and 1.6% had a BAC exceeding 80 mg%.

Other drugs were found in 11.8% of 5,931 urine samples obtained at the roadside (weighted results to control for nighttime over-sampling): cannabis: 6.7%, cocaine: 1.1%, benzodiazepines: 3.6%, opiates: 1.2%, PCP: 0.03%, amphetamines: 0.1%, barbiturates: 0.5%. Among controls, the concomitant use of alcohol accounts for only 5.9% of all drug cases.

Table 3 Odds ratios for different categories of drugs and combinations of drugs for case-control analysis, logistic regression (Adjusted for age, gender, hour and day) and responsibility analyses.

Drugs	**Case-Control, unadjusted**	**Logistic regression, adjusted**	**Responsibility Analysis**
Alcohol alone			
20-50 mg%	1.5 [0.8-2.9]	1.7 [0.9-3.5]	3.2 [0.4-25.8]
51-80 mg%	3.3 [1.6-6.8]	4.5 [2.1-9.5]	0.7 [0.2-2.9]
81-150 mg%	16.1 [9.5-27.4]	23.9 [13.9-41.0]	8.5 [1.1-64.6]
151-210 mg%	125.7 [49.1-322.0]	176.5 [77.8-400.6]	Infinite
>210 mg%	306.1 [73.4-1277.2]	640.0 [149.1->999.9]	Infinite
All alcohol > 80mg%	**47.4 [31.7-70.9]**	**69.9 [46.5-105.1]**	**32.6 [4.4-240.3]**
All alcohol > 20mg%	**10.8 [8.3-14.1]**	**14.1 [10.6-18.7]**	**7.6 [2.9-19.7]**
Cannabis			
Cannabis alone	**2.0 [1.4-2.9]**	**1.6 [1.1-2.4]**	**1.2 [0.5-2.9]**
Cannabis alone - low THC-COOH	1.1 [0.5-2.6]	0.9 [0.4-2.0]	0.2 [0.0-1.5]
Cannabis alone - medium THC-COOH	1.8 [1.0-3.5]	1.4 [0.7-2.7]	1.6 [0.3-7.6]
Cannabis alone - high THC-COOH	3.3 [1.9-5.9]	2.6 [1.5-4.7]	2.1 [0.5-9.8]
Cannabis + alcohol 20-80 mg%	5.2 [1.9-14.4]	4.8 [1.7-13.4]	Infinite
Cannabis + alcohol > 80 mg%	155.8 [47.1-515.3]	203.8 [73.4-565.9]	8.5 [1.1-64.6]
Cannabis + cocaine	7.0 [2.9-17.3]	5.6 [2.3-14.0]	Infinite
Cannabis + cocaine + alcohol > 80mg%	35.4 [12.2-102.9]	42.2 [15.4-115.1]	Infinite
Cannabis + benzodiazepines	20.1 [5.4-75.5]	17.6 [4.8-64.7]	Infinite
Cannabis + benzo + alcohol > 80mg%	64.4 [7.2-579.1]	99.1 [16.7-590.2]	Infinite
All cannabis cases	**5.1 [3.9-6.6]**	**4.5 [3.3-6.0]**	**3.2 [1.5-6.8]**
Cocaine			
Cocaine alone	**3.7 [1.1-13.1]**	**4.5 [1.2-16.3]**	**Infinite**
Cocaine + cannabis	7.0 [2.9-17.3]	5.6 [2.3-14.0]	Infinite
Cocaine + cannabis + alcohol > 80mg%	35.4 [12.2-102.9]	42.2 [15.4-115.1]	Infinite
Cocaine + alcohol > 80mg%	177.2 [22.8-1379.0]	500.5 [62.6->999.9]	Infinite
All cocaine cases	**15.2 [9.6-23.8]**	**17.2 [10.8-27.2]**	**Infinite**
Benzodiazepines			
Benzodiazepines alone	**3.5 [2.3-5.4]**	**3.9 [2.5-6.1]**	**2.5 [0.7-8.7]**
Benzo + cannabis	20.1 [5.4-75.5]	17.6 [4.8-64.7]	Infinite
Benzo + alcohol > 80mg%	Infinite	Infinite	Infinite
Benzo +cannabis + alcohol > 80mg%	64.4 [7.2-579.1]	99.1 [16.7-590.2]	Infinite
All benzodiazepines cases	**5.5 [3.9-7.8]**	**6.8 [4.7-9.7]**	**5.1 [1.5-17.1]**
Other drugs			
All opiates cases	**2.8 [1.4-5.9]**	**3.1 [1.5-6.5]**	**3.2 [0.4-25.8]**
All PCP cases	**32.2 [8.0-129.7]**	**31.4 [9.2-107.4]**	**Infinite**
All amphetamines cases	**12.9 [3.4-48.3]**	**11.0 [2.9-41.3]**	**1.1 [0.1-10.5]**
All barbiturates cases	**0.7 [0.1-5.0]**	**0.7 [0.1-5.3]**	**Infinite**
All drugs and alcohol			
Any drug without alcohol	**2.8 [2.1-3.6]**	**2.5 [1.9-3.3]**	**2.1 [1.0-4.2]**
Any drug + alcohol 20-80 mg%	**4.7 [2.1-10.4]**	**4.7 [2.1-10.6]**	**Infinite**
Any drug + alcohol > 80 mg%	**148.2 [68.9-318.8]**	**185.4 [96.2-357.3]**	**10.5 [2.5-44.4]**

DISCUSSION

Despite the emerging use of certain drugs within the population, primarily cannabis and benzodiazepines, alcohol remains the drug most often detected among

deceased drivers. Of all the drugs identified, alcohol continues to be the principal cause of accidents. The accident risk also increases exponentially as blood-alcohol levels rise.

There is still no consensus on the risk associated with marijuana use. Initial studies (9, 10, 11, 12) were unable to show that the effects on driving observed in laboratory studies or on a simulator were reflected in traffic accidents. Since then, a few studies have appeared to lead to more convincing results (13, 14), particularly by focusing on cases where consumption was recent. The shortcomings of responsibility analysis methods may also have contributed to the initial mixed results (12). The case-control analysis presented here is intended as a means of circumventing this problem and the 2.0 risk associated with the presence of cannabis in urine (1.6 when adjusted by logistic regression) appears to confirm this hypothesis. Risks based on THC-COOH concentration in urine, although this metabolite of cannabis is not an indicator of recent consumption, are increasing as concentrations rise.

The risk associated with benzodiazepines consumption is significant. This confirms the risks observed in many prior studies (13,15,16). Knowing the relatively large prevalence of these drugs in the ageing population, this should be of interest in the years to come. As for cannabis, presence detected in urine is not necessarily a sign of recent use, so the risk could be larger than the one estimated.

We observed few cases where cocaine was detected alone. The odds ratio estimated is associated with a relatively wide confidence interval. It is therefore difficult to accurately characterize the effect of cocaine. However, cocaine often appears to be linked to alcohol consumption and this combination shows a major risk of fatal crash.

Combined alcohol and drug use substantially increases risk, regardless of which drug is consumed. Alcohol seems to act in synergy with drugs, as shown in prior studies (9, 10, 13, 17). Many countries control only for alcohol or for any drug alone, but we should pay attention to all mixture of drugs and alcohol since there is a major problem of combining both, even at low concentrations (17).

With regard to the other categories of drugs studied, there are not enough cases available to interpret results. At first glance however, PCP and amphetamines appear to be more problematic substances than opiates and barbiturates. The relatively small number of cases (n=512) in the case-control analysis, combined to the lower prevalence of these drugs made it difficult to take apart those drugs consumed alone.

During the study's planning phase, the projection was that 700 cases would be obtained. Given the smaller number of accidents in Québec in the recent years, the difficulties encountered in matching data and, in particular, problems obtaining urine, it resulted in fewer cases being obtained than projected. The study period, first previewed to be ended in April 2001 was extended, but had to be concluded in December 2002, to avoid a too long period between cases and the collection of control samples in 1999 and 2000.

Urine was used for analysis and may, in fact, result in a certain theoretical bias in the study, since urine cannot be used to detect recent drug use, particularly in the case of cannabis. The acknowledged effect of this type of bias, however, when not differential, is that it could eliminate a significant risk, not the opposite.

The relatively small numbers of participants in the roadside survey who provided urine samples could lead to an over estimation of risks (4). While it is true that a slight under estimation on the road may result in creating a non-existent risk, it should be noted that the prevalence observed on the road appears to have a good face-value (18) and also that a higher participation rate for urine samples in the survey in 2000 (56.6%), compared to the participation rate in 1999 (41.4%) did not significantly change the prevalence. It must also be specified that the increased risk for cannabis based on the probability of recent drug use (concentration of THC-COOH) demonstrates that the ratio observed, if any, is an under estimation of the actual risk associated with driving under the influence of cannabis.

The results of the responsibility analysis are deceiving. In most cases, risks are smaller than for the case-control analysis and confidence intervals are higher. On the whole, the high level of responsibility for fatal accidents makes it difficult to ascertain differences between sober drivers and drivers in whom drugs were detected. Terhune (9) in his work estimated that between 3,400 to 5,700 cases would have to be studied in order to observe significant differences for drugs with prevalence of drugs of 3% to 5%.

Otherwise, we have to mention the hypothesis of a riskier group of drivers rather than a risk caused by consumption of the substance. In an article presented in this conference (19), we can see that individuals for whom we detected presence of drugs are in fact riskier in terms of highway convictions or criminal offences.

Despite this, it must be emphasized that the results indicate that the risk is increasing as concentrations increase, and that the magnitude of the risk is large in many cases, though it is less probable that a bias or a riskier group generate this risk. Moreover, we noticed comparable risks among different groups of people (p.ex. for different age groups and for male and female), and since the effects of drugs are present even in controlled conditions in experimental studies, it seems that drugs would be in fact a contributing factor in road crashes.

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