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

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Abstract
This study presents some preliminary results regarding the contribution of alcohol and other drugs in fatal crashes in Quebec. The data comes out of two sources. First, coroner, forensic laboratory and police accident records were matched for 482 fatally injured drivers of passenger vehicles deceased between April 1999 and November 2001. Among those 482 fatally injured drivers, both blood and urine samples were obtained in 354 cases (73.4%). Second, two roadside surveys were conducted in August 1999 and 2000. 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%), 8,177 a saliva sample (84.6% when requested: 8,177/9,671) and 5,931 a urine sample (49.6%).

The data collected allowed two different analyses: case-control (alcohol: blood/breath, other drugs: urine/urine) and responsibility (case-case approach) that compares drug cases to drug-free cases. Drugs under scrutiny included alcohol, cannabis, cocaine, benzodiazepines, opiates, barbiturates, amphetamines and PCP.

Results of case-control analyses show the following odds ratios for each drug alone [with 95% confidence intervals]: Alcohol: 51-80 mg%: 3.7 [1.6-8.3], > 80mg%: 39.2 [25.5-60.2]; Cannabis: 2.2 [1.5-3.4]; Cocaine: 4.9 [1.4-17.4]; Benzodiazepines: 2.5 [1.4-4.3]. Other drugs (opiates, barbiturates, amphetamines, PCP) were detected less frequently but significantly increased risks were calculated for all cases (regardless of the presence of another drug) for amphetamines and PCP. For all drugs including alcohol, polyusage is systematically associated with an elevated risk. Responsibility analyses corroborate those results although odds ratios are always less high and sometimes not statistically
significant, which could be explained by the limitations inherent to that methodology (lack of statistical power).

**Introduction**

Over the past century, alcohol has been identified as the most problematic drug on the road while other drugs have received little attention. As elsewhere, the contribution of alcohol to fatal crashes has substantially decreased in Quebec over the last two decades or so. That improvement on the alcohol front has raised the issue of a substitution risk, from alcohol to other drugs.

Facing that situation, the Société de l’assurance automobile du Québec (SAAQ), a Quebec government agency responsible for road safety promotion, decided to undertake a major endeavor in order to establish the role of alcohol and other drugs in traffic crashes in Quebec.

The research plan integrates the results of two different analyses. The first one uses a case-control approach which compares drug presence in fatally injured drivers to drugs detected in drivers participating in a roadside survey. The second one is a responsibility analysis (case-case approach) which compares drug cases to drug-free cases (Terhune, 1983). This paper focuses on the role of alcohol and other drugs among fatally injured drivers using the data available at the end of 2001.

**Methods**

Since April 1999, a procedure established by the Office of the Coroner-in-chief calls for the systematic collection of both blood and urine samples of all fatally injured drivers in Quebec. Coroners have routinely collected blood samples since more than a decade in order to detect alcohol presence. However, blood samples are usually not collected when death occurs more than 24 hours after the crash as the presence of alcohol has probably vanished. The call for a systematic collection of urine is a new procedure and, as reported by others (Marzuk & al., 1990), urine is not readily available at autopsy in some cases.

Both blood and urine samples were sent to the Laboratoire de sciences judiciaires et de médecine légale (Forensic laboratory of the Quebec ministry of public safety) for a complete toxicological analysis (screening and confirmation). Only drivers of passenger vehicles, deceased between April 1999 and November 2001, on whom the coroner, forensic laboratory and police accident records have been matched were considered in this study. Passenger vehicles were defined as cars, minivans, sport utility vehicles and pick-up trucks but excluded motorcycles.

The roadside survey design used a two-stage stratified sampling procedure with 348 sites representative of the Quebec driving population. The first level of stratification divided the province of Quebec into four main regions: Northeastern, Central/Eastern, Central/Western and Western. The second level involves seven categories of
municipalities starting with a 2,500 to 4,999 inhabitants cluster and up to a more than 1,000,000 inhabitants cluster. The sample was also distributed proportionately to the number of fatal crashes per time of day (eight 3-hour periods) and day of week (seven days). For obvious practical reasons – including winter conditions from November to April – it was not possible to account for monthly variations. For both 1999 and 2000 surveys, the month of August was selected for its favourable weather and availability of nursing students (interviewers).

On each site, a roadblock was set up and drivers were directed to an adjacent emplacement with enough space to simultaneously process three vehicles. In order to ensure that drivers were chosen on a random basis, police officers were instructed to intercept the first passenger vehicle that could be stopped safely when an interviewer indicates he or she is available. Interviewers were mostly students in nursing and all received four-days’ training. Seven teams of three interviewers and one supervisor were formed in 1999, and eight teams were formed in 2000. The supervisor was responsible for managing logistics and handling problems.

After a brief introduction, respondents were asked to answer a brief questionnaire and to provide a breath sample, and then a urine sample. Two well-maintained portable toilets (men/women) were available on each site. 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. 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 °C) until analysis.

All analyses were performed by the same forensic laboratory although the samples collected at the roadside were analyzed under contract for the SAAQ. Preliminary screening (immunoassay) was performed applying the following cutoffs for urine (for blood in brackets): THC-COOH for cannabis: 25 (40) ng/ml, benzoylecgonine for cocaine: 300 (100) ng/ml, opiates: 100 (50) ng/ml, PCP: 25 (10) ng/ml, benzodiazepines: 50 (25) ng/ml, barbiturates: 200 (200) ng/ml, amphetamines: 300 (200) 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 of fatally injured drivers 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 in order to obtain a number of observations similar to previous alcohol nighttime surveys conducted in 1981, 1986 and 1991.
For the purpose of the case-control analysis, the cases/controls included in the analysis were only those for which both biological specimens were obtained: blood and urine for cases, and breath and urine for controls. That procedure is necessary in order to have comparable cases/controls (blood/breath for alcohol and urine/urine for other drugs) and control simultaneously for both the presence of alcohol and other drugs. For instance, if only a blood sample is available for a case, there is no comparable control to assess drug presence since only breath and urine samples were collected at the roadside.

Data were analyzed using Statistical Analysis System (SAS) case-control standard method. Ninety-five (95%) confidence intervals around odds ratios were calculated. Case-control analyses were performed for each drug alone, most frequent drug combinations as well as all cases combined for each drug (regardless of the presence of another drug).

RESPONSIBILITY ANALYSIS – The responsibility analysis is a case-case approach. Cases with a specific characteristic are compared to similar cases but without the specific characteristic in order to identify etiological factors (Last, 1994). In this study, 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 (1983) method 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 (Terhune & al., 1992). In a separate paper (Brault & Dussault, 2002), the Terhune method was compared to Robertson & Drummer (1994) method, showing consistent results.

Results

FATALLY INJURED DRIVERS (CASES) – For the April 1999 to November 2001 period, it was possible to match coroner, forensic laboratory and police accident records for 482 fatally injured drivers of passenger vehicles. Among those 482 fatally injured drivers, both blood and urine samples were obtained in 354 cases (73.4%). Alcohol was found in 35% of blood samples (124/354) with the following BAC: 20-49 mg%: 2.0% (7/354), 50-80 mg%: 3.1% (11/354) and > 80mg%: 29.9% (106/354). Alcohol alone cases accounts for 64.5% (80/124) of all alcohol cases and thus, another drug was found in 35.5% (44/124) of all alcohol cases.

Other drugs were found in 30.2% (107/354) of urine samples in the following proportions: cannabis: 19.5% (69/354), cocaine: 6.8% (24/354), benzodiazepines: 8.5% (30/354), opiates: 1.4% (5/354), PCP: 1.1% (4/354), amphetamines: 0.8% (3/354), barbiturates: 0.3% (1/354). Alcohol was also found in 41.1% (44/107) of all drug cases.
Figure 1: Alcohol and/or other drugs among the 354 fatally injured drivers (cases)

```
All cases (354)
  100.0%

Sober cases (167)
  47.2%

Alcohol alone (80)
  22.6%

Alcohol + drugs (44)
  12.4%

All drugs cases (107)
  30.2%

All alcohol cases (124)
  35.0%

Alcohol and/or drugs (187)
  52.8%

Drugs alone (63)
  17.8%
```

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%), 8,177 a saliva sample 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 both systematically in 2000. Regardless of the time of the day, alcohol was found in 5.1% of breath samples. During the nighttime (9PM-6AM), alcohol was detected among 8.7% of the drivers and 2.0% had a BAC exceeding 80 mg%.

Other drugs were found in 11.8% of 5,931 urine samples obtained at the roadside (weighted results): 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.

Figure 2: Alcohol and/or other drugs among the 5,931 drivers at the roadside (controls)

```
All controls
  100.0%

Sober controls
  83.8%

Alcohol and/or drugs
  16.2%

Alcohol alone
  4.4%

Alcohol + drugs
  0.7%

Drugs alone
  11.1%

All alcohol controls
  5.1%

All drugs controls
  11.8%
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CASE-CONTROL AND RESPONSIBILITY ANALYSES – Table 1 shows the results for both case-control and responsibility analyses for each drug and most common drug combinations.

**Table 1**: Results of case-control and responsibility analyses

<table>
<thead>
<tr>
<th>Drugs</th>
<th>Case-Control Analyses</th>
<th>Responsibility Analyses</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Odds Ratio [95% C.I.]</td>
<td>Odds Ratio [95% C.I.]</td>
</tr>
<tr>
<td><strong>Alcohol alone</strong></td>
<td></td>
<td></td>
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<tr>
<td>20-50 mg%</td>
<td>1.0 [0.4-2.5]</td>
<td>0.2 [0.0-0.7]</td>
</tr>
<tr>
<td>51-80 mg%</td>
<td>3.7 [1.6-8.3]</td>
<td>1.6 [0.2-1.5]</td>
</tr>
<tr>
<td>&gt; 80 mg%</td>
<td>39.2 [25.5-60.1]</td>
<td>8.1 [1.9-34.8]</td>
</tr>
<tr>
<td><strong>All alcohol &gt; 20mg%</strong></td>
<td>9.2 [6.8-12.5]</td>
<td>2.3 [1.0-5.3]</td>
</tr>
<tr>
<td><strong>Cannabis</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cannabis alone</td>
<td>2.2 [1.5-3.4]</td>
<td>1.2 [0.4-3.9]</td>
</tr>
<tr>
<td>Cannabis + cocaine</td>
<td>8.0 [3.1-20.7]</td>
<td>Infinite</td>
</tr>
<tr>
<td>Cannabis + alcohol &gt; 80 mg%</td>
<td>80.5 [28.2-230.2]</td>
<td>2.5 [0.3-20.2]</td>
</tr>
<tr>
<td>Cannabis + cocaine + alcohol &gt; 80mg%</td>
<td>85.3 [9.5-767.0]</td>
<td>Infinite</td>
</tr>
<tr>
<td>Cannabis + benzodiazepines</td>
<td>21.3 [5.3-86.0]</td>
<td>Infinite</td>
</tr>
<tr>
<td>Cannabis + benzo + alcohol &gt; 80mg%</td>
<td>63.9 [6.6-618.0]</td>
<td>Infinite</td>
</tr>
<tr>
<td><strong>All cannabis cases</strong></td>
<td>4.6 [3.4-6.2]</td>
<td>2.3 [0.9-6.3]</td>
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<tr>
<td><strong>Cocaine</strong></td>
<td></td>
<td></td>
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<tr>
<td>Cocaine alone</td>
<td>4.9 [1.4-17.4]</td>
<td>Infinite</td>
</tr>
<tr>
<td>Cocaine + cannabis</td>
<td>8.0 [3.1-20.7]</td>
<td>Infinite</td>
</tr>
<tr>
<td>Cocaine + cannabis + alcohol &gt; 80mg%</td>
<td>85.3 [9.5-767.0]</td>
<td>Infinite</td>
</tr>
<tr>
<td>Cocaine + alcohol &gt; 80mg%</td>
<td>170.5 [21.2-1371.2]</td>
<td>Infinite</td>
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<tr>
<td><strong>All cocaine cases</strong></td>
<td>12.2 [7.2-20.6]</td>
<td>Infinite</td>
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<tr>
<td><strong>Benzodiazepines</strong></td>
<td></td>
<td></td>
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<tr>
<td>Benzodiazepines alone</td>
<td>2.5 [1.4-4.3]</td>
<td>3.6 [0.5-28.2]</td>
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<tr>
<td>Benzo + cannabis</td>
<td>21.3 [5.3-86.0]</td>
<td>Infinite</td>
</tr>
<tr>
<td>Benzo + alcohol &gt; 80mg%</td>
<td>63.9 [6.6-618.0]</td>
<td>Infinite</td>
</tr>
<tr>
<td><strong>All benzodiazepines cases</strong></td>
<td>4.2 [2.7-6.3]</td>
<td>5.8 [0.7-44.4]</td>
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<tr>
<td><strong>Other drugs</strong></td>
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<tr>
<td>All opiates cases</td>
<td>2.1 [0.8-5.3]</td>
<td>Infinite</td>
</tr>
<tr>
<td>All PCP cases</td>
<td>28.4 [6.3-128.0]</td>
<td>Infinite</td>
</tr>
<tr>
<td>All amphetamines cases</td>
<td>12.8 [3.0-54.0]</td>
<td>Infinite</td>
</tr>
<tr>
<td>All barbiturates cases</td>
<td>0.9 [0.1-6.6]</td>
<td>Infinite</td>
</tr>
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</table>
Discussion

There are several findings that can be drawn from those preliminary results. The first and obvious one is that alcohol remains the #1 problematic drug. A blood alcohol concentration (BAC) above 80 mg% was detected in 29.9% of fatally injured drivers and both case/control analysis (O.R. = 39.2) and responsibility analysis (O.R. = 8.1) reveal a significantly increased risk. Accounting for 3.1% of all cases, a BAC between 50 mg% and 80 mg% is also associated with an increased risk.

Regarding other drugs, three drugs emerged as being more frequently detected among urine samples of fatally injured drivers, namely cannabis (19.5%), benzodiazepines (8.5%) and cocaine (6.8%). Although drug presence in urine does not equate impairment, the case/control (urine/urine) analysis shows an elevated crash risk for those three drugs. The results for cocaine (O.R. = 4.9) appear more convincing since they are confirmed by the responsibility analysis. All 24 cases cocaine cases were judged as responsible for the crash causation. As observed in earlier studies, cocaine – a central nervous system (CNS) stimulant – is often accompanied by a “calming” substance like alcohol, cannabis and less frequently a benzodiazepine (Marzuk & al., 1990; Terhune & al., 1992; Dussault & al., 2001).

The role of cannabis in traffic crashes is often controversial and subject to an increasing number of studies. Based on the case-control analysis, this study suggests that cannabis use is associated with twice the risk of being fatally injured (O.R. = 2.2). However, the responsibility analysis for cannabis is not conclusive as observed in many other studies using that methodology (Bates & Blakely, 1999). Benzodiazepines are also associated with an increased risk (O.R. = 2.5) corroborated by the responsibility analysis. Another study conducted in Quebec with a completely different methodology (matching driver records and health insurance files) has shown an increased risk for long-life benzodiazepines among elderly drivers (Hemmelgarn & al., 1997).

Other drugs (opiates, PCP, amphetamines, barbiturates) were detected occasionally in urine samples of fatally injured drivers (<1.5% for each drug). However, PCP (a hallucinatory substance) and amphetamines (CNS stimulants like cocaine) usage appear to prompt significant risks. For all drugs including alcohol, there is one consistent pattern: polyusage increases the risk, the more different drugs are involved, the higher the risk.

There are limitations to this study that must be presented. The first one is that results are preliminary. While the roadside part (controls) of the study is completed, only 482 fatally injured driver records (cases) have been matched. Some coroner reports (mostly for 2001 crashes) are soon expected and the computerized matching of coroner, forensic laboratory and police accidents records has not been fully successful (further matching will require more labor expensive techniques). When completed, the expected number of cases should be around 700.
The presence of a drug in urine is more indicative of exposure to the drug than impairment itself (Lillesunde, 1997). When establishing the risk, the case/control comparison is made with the same biological specimen and thus, the same bias for both cases and controls. Usually, such a misclassification bias would lead to an underestimation of the real odds ratio.

On the contrary, the participation rate among controls (49.6% for urine samples) may suggest a possible selection bias, which could inflate odds ratios. With a participating rate of 84.6%, saliva samples were basically used as a control for non-response. In all likelihood, if the motive for refusing to provide a urine sample was the fear of being detected, the driver would normally also refuse to provide a saliva sample. The most compelling argument against the selection bias is the face value of the results (Dussault & al., 2000). For instance, the fact that 24.3% of 16-19 year-old drivers (n=333) and 22.4% of 20-24 year-old drivers (n=636) were positive for cannabis during the nighttime suggests that young cannabis users were rather collaborative with the roadside survey.

This study offers the first direct comparison between a case-control analysis and a responsibility analysis by using the same set of data for the cases. In the study design, the responsibility analysis serves to validate the results of the case-control analysis. When both concur – like for alcohol and cocaine - the results appear robust. When there is a divergence – like for cannabis – a debate may arise.

Responsibility analysis generally has two main limitations. One, the fact that some cases can be misjudged on the real responsibility might cause a misclassification bias, which leads to an underestimation of the real relative risk (Bates & Blakely, 1999). Second, fatally injured driver samples have generally very high responsibility rates (including drug-free drivers), which requires extremely high responsibility rates for a drug in order to have a statistically significant effect (Terhune & al., 1992). The results obtained in this study for alcohol clearly support that responsibility analysis might run short of sensibility. On the methodological front, there is certainly a need to compare directly case-control and responsibility analyses in other studies.

References


