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Presence of Psychoactive Substances in Biological Samples From Drivers Fatally Injured in Québec From 2002 to 2013

SURVEILLANCE REPORT

Québec

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Key messages

Since 2002, the number of road traffic deaths in Québec has been falling steadily, even though the number of motor vehicles on the road – automobiles, in particular – has increased considerably. Nevertheless, the use of alcohol, drugs and medications is frequently cited as a cause of road traffic accidents by public authorities, since these psychoactive substances have the potential to impair driving.

The aim of this study is to present a profile of the psychoactive substances (i.e. alcohol, drugs and medications) examined and detected among motor vehicle and motorcycle drivers aged 16 years and over who were killed in road traffic accidents in Québec from 2002 to 2013.

The main findings are as follows:

- The presence of psychoactive substances in the drivers of motor vehicles figured among the circumstances of death, but no assessment of a causal link between this presence and road traffic accidents was made.
- The proportion of fatally injured drivers who tested positive for at least one of the psychoactive substances studied increased from 2002 to 2013, although the variation was not significant. That being said, an increase was observed among drivers aged 16 to 34 years and 55 to 64 years. The figures for drivers aged 35 to 54 years remained fairly stable. Finally, the only decrease noted concerns the group of drivers aged 65 years and over.
- Alcohol and drugs were detected among men in the majority of cases, whereas a greater proportion of women than men tested positive for at least one medication. In particular, the combination of alcohol and drugs was encountered more often among drivers aged 34 years and under, in contrast with the combination of alcohol and medications, which was higher among women drivers aged 35 years and over.
- Alcohol, alone or in combination with other substances, was the psychoactive substance most often encountered in positive toxicology tests. All the same, a downward trend was observed in the number of fatally injured drivers who tested positive for high blood alcohol concentrations. However, among fatally injured drivers who tested positive, 80% posted a blood alcohol level over the legal limit set for Québec (80 mg/100 ml of blood, or 0.08%).
- A slight increase was noted in the proportion of fatally injured drivers who tested positive for at least one drug. More than 90% of that number presented positive toxicology results for cannabis, cocaine, or a combination of both drugs. A statistically significant increase was also observed for methamphetamine. Furthermore, a majority of fatally injured drivers who tested positive for methamphetamine or cocaine presented blood concentrations that could have altered their driving performance, based on comparisons with the concentrations reported in the scientific literature.
- The proportion of fatally injured drivers who tested positive for at least one drug was highest among people aged 16 to 24 years (47%). This share then declined with age, in contrast with the proportion of drivers who tested positive for at least one medication, which tended to increase with age.
- A statistically significant increase in the proportion of fatally injured drivers who tested positive for antidepressants was noted. In contrast, the proportion of drivers who tested positive for anti-anxiety medication was seen to decrease. Both classes of drugs were often encountered among fatally injured drivers aged 35 years and over who tested positive for at least one medication. More than a quarter (28%) of fatally injured drivers aged 65 years and over used at least one psychoactive medication.

Summary

Introduction

Since 2002, the number of road traffic deaths in Québec has been falling steadily, even though the number of motor vehicles on the road has increased considerably. Despite a number of awareness campaigns, driving under the influence of alcohol is still frequently involved in fatal road traffic accidents. The idea of including drugs in advertising is relatively recent and efforts to focus campaigns on medications are still very rare. It nevertheless remains that driving can be impaired by these psychoactive substances.

Several studies from around the world report data concerning the presence of various psychoactive substances in drivers fatally injured in road traffic accidents. The present study provides a profile of the situation in Québec.

Methodology

This study is based on a retrospective descriptive analysis as well as on a statistical analysis with a view to identifying temporal variations or trends.

To conduct this study, we linked data from the Bureau du coroner du Québec (BCQ), the Centre de toxicologie du Québec (CTQ) and the Laboratoire de sciences judiciaires et de médecine légale (LSJML) concerning motor vehicle drivers killed in road traffic accidents from 2002 to 2013. Only those data complying with the following criteria were selected:

- Drivers fatally injured in accidents that occurred on or off public roads;
- Fatally injured drivers aged 16 years and over;
- Drivers of motor vehicles, motorcycles or mopeds;
- Drivers for whom toxicology tests were performed on post-mortem biological samples (i.e. blood, urine and vitreous [eye] fluid).

Once the study population was identified, it was divided into two groups: drivers with positive toxicology test results, meaning drivers for whom the presence of a psychoactive substance (i.e. alcohol, drugs and medications that act on the central nervous system) had been confirmed, and drivers with negative toxicology test results.

Results

Despite the decrease in the number of road traffic deaths in Québec since 2002, the proportion of drivers who tested positive for at least one psychoactive substance has increased slightly (+ 0.8% per year on average). While this variation is not significant, it is observable among drivers aged 16 to 24 years and 55 to 64 years. The figures pertaining to the group of drivers aged 35 to 54 have remained fairly stable. The only observable decrease concerns the group of drivers aged 65 years and over. The most strongly affected age group remains that of drivers aged 25 to 34 years, with close to 7 out of 10 drivers testing positive for at least one psychoactive substance.

Alcohol

The number of fatally injured drivers who tested positive for alcohol decreased over time (- 1% per year on average for levels above the legal limit). Nevertheless, alcohol remained the psychoactive substance most often found in positive toxicology tests. More than 70% of fatally injured drivers who tested positive for at least one psychoactive substance presented a positive blood alcohol level.

The blood alcohol level observed in fatally injured drivers was very often higher than the legal limit. From 2002 to 2013, 8 out of 10 fatally injured drivers who tested positive for alcohol presented a blood alcohol level over that of Québec's legal limit of 80 mg/100 ml of blood (0.08%).

The proportion of fatally injured drivers who tested positive for alcohol was highest among those aged 25 to 34 years (53%), and then declined with age. In proportion, men were most often concerned: 76% of men who tested positive for at least one psychoactive substance also had a positive blood alcohol level, compared to 53% of women.

Drugs

The proportion of fatally injured drivers who tested positive for at least one drug trended upward slightly from 2002 to 2013 (+ 2.2% per year on average). A statistically significant increase was observed among

drivers who tested positive for methamphetamine (+ 12.9% per year on average). Figures for cannabis rose slightly (+ 1.3% per year on average).

Cannabis and cocaine were the drugs most often identified in this study. As such, 92% of fatally injured drivers who tested positive for at least one drug presented positive toxicology results for cannabis or cocaine or a combination of both. The group of drivers most affected were aged 16 to 24 years (47%), with this trend falling as age increased. In proportion, men were most often concerned by the presence of drugs in their biological samples: 37% of men who tested positive for at least one psychoactive substance presented positive toxicology results for at least one drug, compared to 26% of women.

Based on comparisons with the threshold values established in the scientific literature, the majority (93%) of fatally injured drivers who tested positive for cocaine or methamphetamine in this study presented blood concentrations that could have impaired their driving ability.

Medications

The proportion of fatally injured drivers who tested positive for at least one medication held fairly stable from 2002 to 2013 (- 0.1% per year on average). However, a statistically significant increase was observed among the share of fatally injured drivers who tested positive for antidepressants (+ 12.8% per year on average). This same period was also witness to a significant decrease in the proportion of fatally injured drivers who tested positive for benzodiazepines (- 5.9% per year on average).

Both of these drug classes were frequently observed among fatally injured drivers who tested positive for at least one medication. Among such drivers aged 35 years and older, 74% presented positive toxicology results in relation to a benzodiazepine or an antidepressant or a combination of both. In addition, this proportion increased with age. More than a quarter (28%) of the analyses of people aged 65 years and over showed the presence of at least one psychoactive medication.

Whereas a greater proportion of men tested positive for drugs or alcohol, fatally injured women drivers tested positive for at least one medication to a greater extent than men. Specifically, at least 52% of women who tested positive for at least one psychoactive substance had positive toxicology results for one or more medications, compared to 23% of men.

Combinations of substances

The combination of alcohol and drugs was more often encountered among drivers under the age of 35. The proportion of fatally injured drivers who tested positive for both alcohol and at least one drug was higher among people aged 16 to 34 years (26%) than among adults aged 45 to 64 (13%). Men accounted for this combination to a greater extent than women (23% vs. 12%).

The combination of alcohol and medications was higher among people aged 35 years and over, occurring at a rate of 17% among those aged 35 to 54 years, versus 6% for those aged 16 to 34. This combination was higher among women than among men (15% vs. 10%).

Conclusion

Despite a decrease in the number of deaths caused by road traffic accidents in Québec from 2002 to 2013, an increase can be seen in the proportion of fatally injured drivers who tested positive for psychoactive substances. This report has brought out a number of trends in that regard. A greater proportion of male drivers under the age of 35 years test positive for alcohol and drugs. In contrast, medications are more often encountered among drivers aged 35 years and over and particularly among older people and women.

1 Introduction

Since 2002, the number of road traffic deaths in Québec has been falling steadily, even though the number of motor vehicles has increased (1-2). These encouraging results are due, in part, to the progress accomplished in several fields, such as vehicle safety, road infrastructure, road user behaviour and traumatology services (3-5). Despite the efforts of the Québec government to reduce driving impaired by alcohol or other substances, this problem continues to be a source of road traffic deaths.

In 2002, during a survey of road safety conducted among Canadians aged 16 years and over, 17.7% of respondents stated they had driven after taking some type of potentially impairing substance at least once during the previous 12 months (6). In addition, a sizeable portion of young adults under the age of 25 – an over-represented group among fatally injured drivers in Québec – used illicit drugs (7). Furthermore, as of spring 2017, the federal government launched a process designed to legalize and regulate the non-medical use of cannabis (8), a development that may modify use profiles in the future.

An increase in drug seizures by police forces has been occurring in Québec. Since 2010, methamphetamine has become the second substance most often seized, after cannabis and before cocaine (9). This synthetic drug is increasingly encountered in arrests for driving under the influence (10).

In Canada, the percentage of people using medications increases with age, with people aged 65 years and over constituting the group most concerned by polypharmacy (i.e. the taking of several prescription medications concurrently) (11). The use of certain drug classes, such as benzodiazepines[I] (12), is associated with a greater risk of road traffic accidents among older drivers on account of their potential for altering the cognitive functions essential for safe driving.

Driving under the influence of psychoactive substances is a global phenomenon that has not spared Québec. Several studies from around the world report data concerning the presence of various psychoactive substances in fatally injured drivers (13-16). In Québec, the most recent epidemiological study on the subject was conducted in the early 2000s (17). The present study thus serves to acquire more specific, current knowledge about this phenomenon and to offer useful insights for road safety prevention efforts. It provides an up-to-date profile of the various psychoactive substances identified in drivers killed in road traffic accidents in Québec between 2002 and 2013.

The main aims of this report are to:

- present the various psychoactive substances found in drivers killed in road traffic accidents in Québec from 2002 to 2013;
- describe the temporal trends involving these psychoactive substances by age and sex, as well as the combinations of substances most frequently encountered;
- present the blood concentrations of alcohol, methamphetamine or cocaine found in fatally injured drivers in order to determine whether such concentrations could have been compatible with driving under the influence's reference values.

What is a psychoactive substance?

A psychoactive (or "psychotropic") substance acts on the central nervous system. Alcohol, certain illicit drugs and certain classes of medications fall into this category. Depending on its properties, a psychoactive substance can act on pain, sleep disorders, anxiety, mood and various other physical and psychological functions.

[I] A class of drugs used to treat sleep disorders, anxiety and seizure disorders.

2 Methodology

2.1 Type of study

This study is based on a retrospective descriptive analysis of data from the Bureau du coroner du Québec (BCQ). The data concern motor vehicle drivers who were killed in road traffic accidents in Québec from 2002 to 2013 and who were tested for the presence of psychoactive substances using toxicology tests of biological samples.

2.2 Data sources

The data were derived from the following databases:

- Bureau du coroner du Québec, 2002-2013;
- Centre de toxicologie du Québec, 2006-2013;
- Laboratoire de sciences judiciaires et de médecine légale, 2006-2013.

2.3 Study population

The study population was defined on the basis of the following inclusion criteria:

- Drivers fatally injured in accidents that occurred on or off public roads;
- Fatally injured drivers aged 16 years and over;[II]
- Drivers of motor vehicles, motorcycles or mopeds;
- Drivers for whom toxicology tests were performed on post-mortem biological samples (i.e. blood, urine and vitreous [eye] fluid).[III]

The study population was then divided into two groups:

- The first group consisted of drivers whose toxicology tests were positive. A positive toxicology test is one where the presence of psychoactive substances in biological samples from a fatally injured driver is confirmed. A list of all the substances detected and identified by the BCQ in all of the cases studied was analyzed in order to classify the substances in the following categories: alcohol, illicit drugs or medications that act on the central nervous system. Substances that did not fall into any of these categories were excluded (e.g. acetaminophen, ibuprofen).
- The second group consisted of drivers whose toxicology tests were negative.

Toxicology tests can be positively skewed by the presence of psychoactive substances administered after a road traffic accident when victims are in pre-hospital or hospital care. To ensure that the fatally injured drivers included in this study were assigned to the right group, midazolam was selected as an indicator. This is an injectable form of benzodiazepine, which is encountered almost exclusively in hospital settings and is often used to intubate patients who are in respiratory distress, are overly agitated or are having convulsions. Road traffic accident victims may have already received this medication by the time toxicology tests are performed. Therefore, all coroners' reports containing the indicator "midazolam" were consulted for the purposes of this study, making it possible to determine whether midazolam was used before or after the accident. Consequently, if a toxicology report showed that a driver tested positive for midazolam alone or for midazolam combined with one or more drug substances administered after the accident while he or she was in peri-hospital care, the driver was considered to have a negative toxicology report and was transferred to the group with negative toxicology results.

On the other hand, if the tests revealed the presence of midazolam and one or more psychoactive substances taken prior to the accident, the driver was assigned to the group with positive toxicology results.

2.4 Thresholds for dangerous driving

Positive toxicology results confirmed by a blood test for alcohol, cocaine or methamphetamine were compared with the legal limits for those substances, i.e. the limits above which driving becomes dangerous, as reported in the scientific literature. Since the blood tests for other psychoactive substances were random and not

[II] Given the limited number of drivers under the age of 15 represented in the available data, these drivers were excluded.

[III] Toxicology tests were requested for over two thirds (69.8%; 3502/5017) of the drivers killed in road traffic accidents in Québec from 2002 to 2013.

systematic, they were not considered for analytical purposes.

Even though the legal limit for alcohol in Québec is set at 80 mg of alcohol[IV]/100 ml of blood (0.08%), this does not mean that driving is safe below that level. In other jurisdictions, the limit is 50 mg of alcohol/100 ml of blood (0.05%). Therefore, both of these limits were used in order to draw comparisons.

According to a survey conducted by the Société française de toxicologie analytique (SFTA) in 2015, the threshold above which all amphetamines (including methamphetamine[V]) pose a risk to driving is 25 nanograms (ng)/ml of blood (18-19). For cocaine, it appears to be 10 ng/ml of blood (18, 20). The presence of benzoylecgonine, the main metabolite of cocaine, cannot alone establish a link with the potential alteration of a driver's alertness. Nevertheless, data were collected in this regard in order to assess the metabolism of cocaine.

2.5 Statistical analyses

The number and proportion of fatally injured drivers for whom the presence of a psychoactive substance had been confirmed were calculated[VI] on the basis of certain demographic characteristics (age and sex), time of death (day of the week, time of week, season year), type of vehicle driven and class of psychoactive substance detected. Log-binomial regression analyses were used to calculate the average annual percentage change (AAPC) for the purpose of characterizing temporal trends in the values generated. The AAPC is accompanied by a confidence interval (CI) of 95% in order to indicate measurement variability. This type of modelling was used because the outcome of interest examined is not rare (21). The statistical analyses were performed using SAS 9.4 software (SAS Institute, Cary, NC, USA).

3 Results

The distribution of the study population is shown in Figure 1. In all, we identified 5,017 drivers who were killed in a road traffic accident in Québec from 2002 to 2013. Toxicology tests were performed for 70% (3,502/5,017) of the drivers. From that group, only automobile and motorcycle drivers were selected for the study (2,797). Drivers under the age of 16 were excluded since it is illegal for people in that age group to drive a motor vehicle. The study population thus included 2,780 fatally injured drivers. Two groups were identified for analytical purposes, the first of which consisted of drivers whose toxicology test results were positive (1,719) and the second, of those whose toxicology test results were negative (1,061).

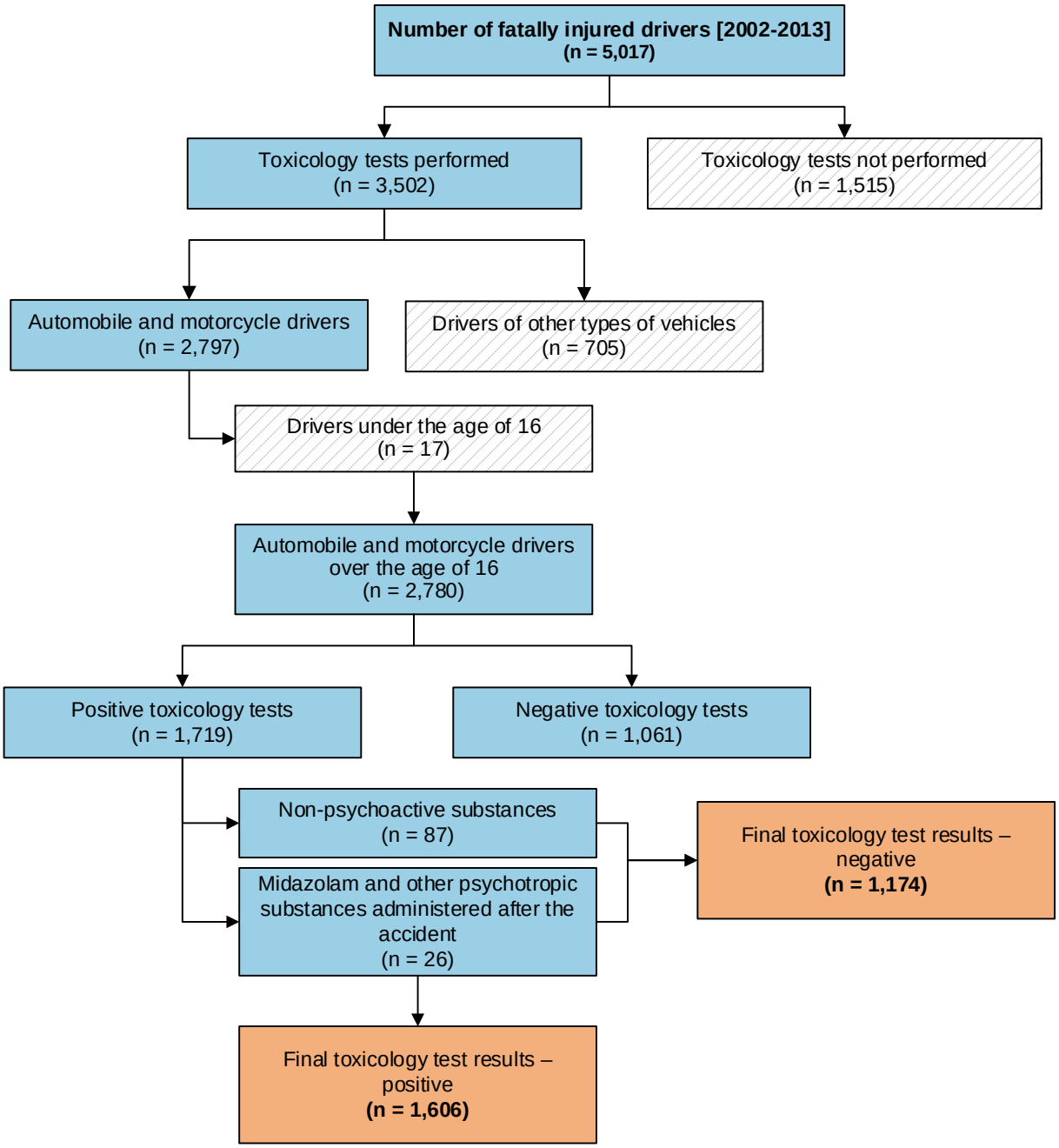
Since toxicology tests can be positive for all kinds of substances, be they psychoactive or not, the information on the study population had to be sorted to obtain a more accurate distribution of the drivers in the two groups. Drivers who had tested positive for non-psychoactive substances (n = 87) and those whose toxicology report was positive due solely to the presence of substances administered when the drivers received post-accident medical treatment (n = 26) were transferred to the group whose toxicology test results were negative. In the end, the toxicology test results of 1,606 of the 2,780 fatally injured drivers were positive.

[IV] The effects of alcohol are felt at 20 mg/100 ml of blood (0.02%). At 50 mg/100 ml (0.05%), the ability to drive carefully is altered, as reflected by reduced alertness, loss of coordination and a decrease in the ability to react to unexpected road situations). When the limit of 80 mg/100 ml (0.08%) is reached, muscle cooordination is poor and accompanied by balance and vision problems as well as increased reaction time. Greater difficulty perceivng risks can also be noted.

[V] Methamphetamine is a psychostimulant with euphoric properties. As in the case of cocaine, the euphoric effect of methamphetamine, and more generally amphetamines, is accompanied by irrational behaviour and increased risk taking. Initially, amphetamine use stimulates cognitive and psychomotor functions and thus increases awareness. Subsequently, however, when the stimulating effects of amphetamines wear off, symptoms of drowsiness, fatigue and anxiety appear.

[VI] We decided not to use rates expressed in 100,000 licence-years reflecting the number of deaths that occurred during a given year over the number of valid driver's licence holders in Québec for that year, because those rates reflected mainly the decrease in the number of deaths caused by traffic accidents (motor vehicle crash deaths).

Figure 1 **Definition and distribution of the study population according to certain criteria and toxicology test results**



Note: The boxes with crosshatching correspond to the exclusion criteria used to define the study population.

Table 1 shows the distribution of the number of fatally injured drivers in the population selected (n = 2,780), by toxicology test results (negative or positive) and certain specific characteristics. The results show that men and the general population aged 16 to 24 years account for a large proportion of road traffic deaths. In the case of the study population, automobiles were the main type of vehicle involved (86%; 2,376/2,780). The number of deaths caused by road traffic accidents was higher in summer and fall than in winter or spring. In addition, the proportion of positive toxicology tests was highest among drivers killed from Friday to Sunday, while negative tests were encountered for the most part among drivers killed at the beginning of the week.

Table 1 Distribution of fatally injured drivers [n (%)], by toxicology test results, period and certain characteristics

CHARACTERISTICS		PERIODS AND TEST RESULTS (NEGATIVE [-] OR POSITIVE [+]) n (%)								TOTAL FOR EACH CRITERION
		2002 – 2004		2005 – 2007		2008 – 2010		2011 – 2013		
		-	+	-	+	-	+	-	+	
Sex	Female	89 (27.8)	76 (17.0)	82 (21.1)	74 (16.6)	74 (29.8)	54 (13.7)	65 (29.8)	57 (17.8)	571
	Male	231 (72.2)	370 (83.0)	306 (78.9)	372 (83.4)	174 (70.2)	340 (86.3)	153 (70.2)	263 (82.2)	2,209
Age	16 – 24 years	87 (27.2)	127 (28.5)	101 (26.0)	130 (29.1)	67 (27.0)	124 (31.5)	53 (24.3)	87 (27.2)	776
	25 – 34 years	46 (14.4)	92 (20.6)	61 (15.7)	107 (24.0)	41 (16.5)	95 (24.1)	25 (11.5)	78 (24.4)	545
	35 – 44 years	53 (16.6)	84 (18.8)	54 (13.9)	69 (15.5)	32 (12.9)	51 (12.9)	30 (13.8)	43 (13.4)	416
	45 – 54 years	57 (17.8)	77 (17.3)	74 (19.1)	78 (17.5)	36 (14.5)	65 (16.5)	37 (17.0)	46 (14.4)	470
	55 – 64 years	38 (11.9)	28 (6.3)	43 (11.1)	31 (7.0)	34 (13.7)	30 (7.6)	27 (12.4)	37 (11.6)	268
	65 and over	39 (12.2)	38 (8.5)	55 (14.2)	31 (7.0)	38 (15.3)	29 (7.4)	46 (21.1)	29 (9.1)	305
Type of vehicle	Motorcycle	58 (18.1)	42 (9.4)	74 (19.1)	41 (9.2)	52 (21.0)	54 (13.7)	37 (17.0)	46 (14.4)	404
	Automobile	262 (81.9)	404 (90.6)	314 (80.9)	405 (90.8)	196 (79.0)	340 (86.3)	181 (83.0)	274 (85.6)	2,376
Season	Spring	85 (26.6)	110 (24.7)	83 (21.4)	112 (25.1)	57 (23.0)	105 (26.6)	57 (26.1)	77 (24.1)	686
	Summer	94 (29.4)	146 (32.7)	141 (36.3)	142 (31.8)	87 (35.1)	142 (36.0)	57 (26.1)	88 (27.5)	897
	Fall	78 (24.4)	130 (29.1)	88 (22.7)	114 (25.6)	63 (25.4)	89 (22.6)	50 (22.9)	103 (32.2)	715
	Winter	63 (19.7)	60 (13.5)	76 (19.6)	78 (17.5)	41 (16.5)	58 (14.7)	54 (24.8)	52 (16.3)	482
Day	Monday – Thursday	171 (53.4)	192 (43.0)	216 (55.7)	211 (47.3)	145 (58.5)	164 (41.6)	135 (61.9)	151 (47.2)	1,385
	Friday – Sunday	149 (46.6)	254 (57.0)	172 (44.3)	235 (52.7)	103 (41.5)	230 (58.4)	83 (38.1)	169 (52.8)	1,395
TOTAL POSITIVE AND NEGATIVE RESULTS		320 (100.0)	446 (100.0)	388 (100.0)	446 (100.0)	248 (100.0)	394 (100.0)	218 (100.0)	320 (100.0)	2,780
TOTAL FOR EACH PERIOD		766 (100.0)		834 (100.0)		642 (100.0)		538 (100.0)		

Figure 2 shows the distribution of fatally injured drivers who tested positive for at least one of the psychoactive substances included in the study (n = 1,606), by sex and identified substance. Alcohol was the most commonly detected psychoactive substance. In addition, alcoholand drugs were the most frequent combination for both sexes combined, as well as for men, while alcohol and medications were the main combination encountered for women.

Figure 2 **Distribution of fatally injured drivers who tested positive for at least one psychoactive substance [n (%)], by sex and substance**

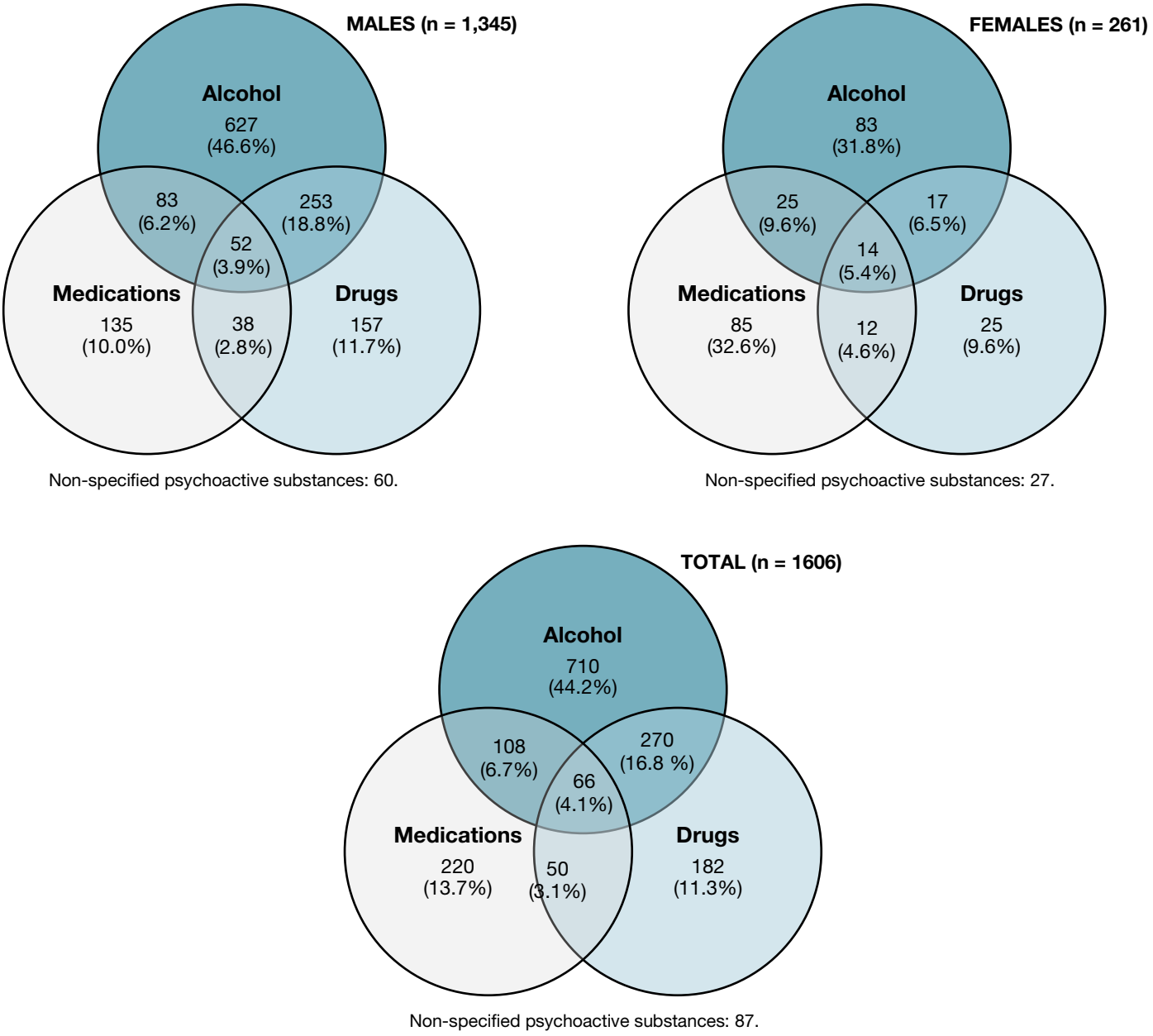


Figure 3 shows the temporal variation in the proportion of fatally injured drivers who tested positive for at least one psychoactive substance, by age group. An upward trend can be observed among drivers aged 25 to 34 years, as well as among those aged 55 to 64 years.

The trend for drivers aged 16 to 24 years, 35 to 44 years and 45 to 54 years was fairly stable over time. Nevertheless, a slight decrease can be observed among drivers aged 65 years and over.

Figure 3 **Average annual percentage change among fatally injured drivers who tested positive for the presence of psychoactive substances, by age group**

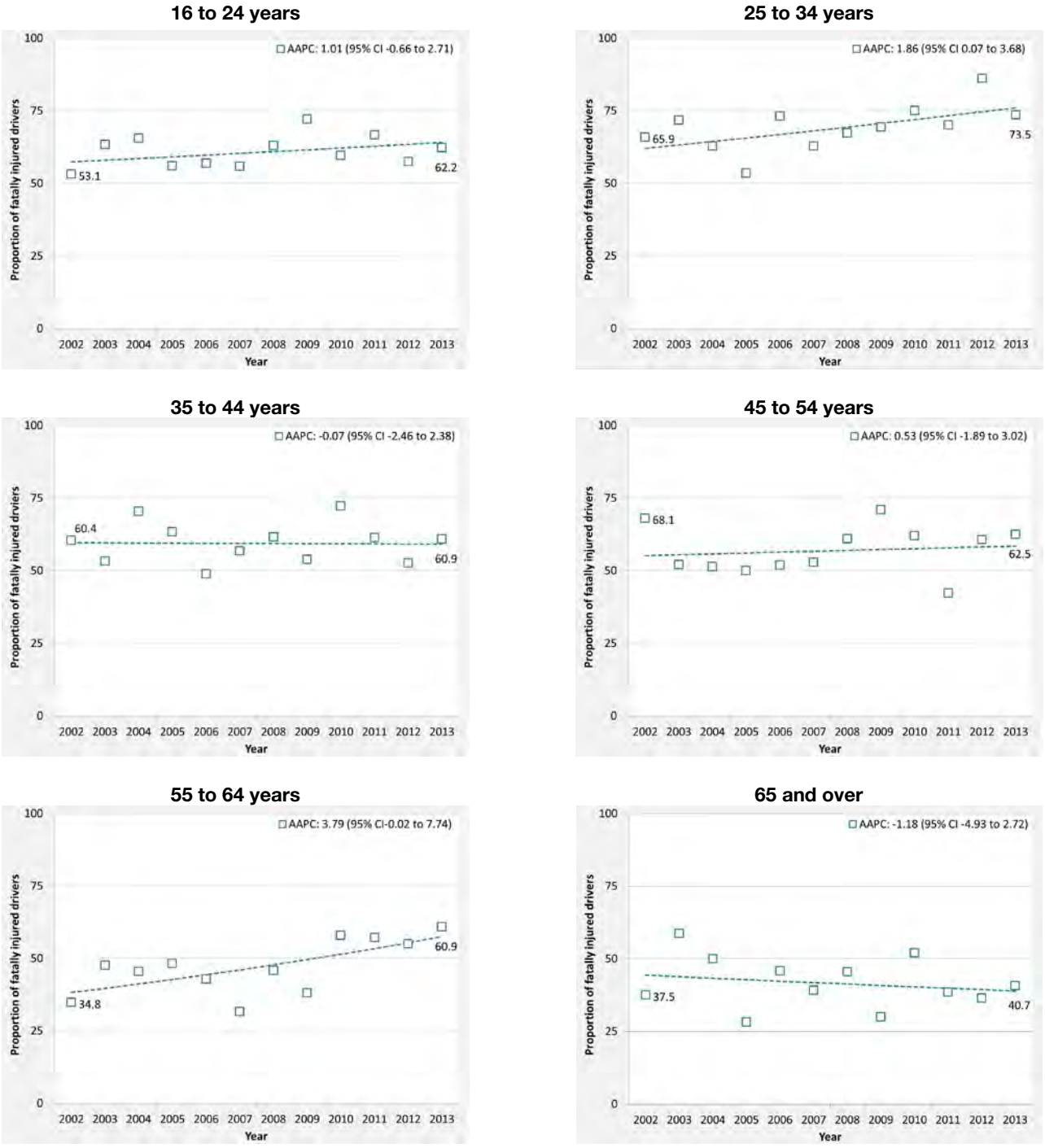


Figure 4 shows the temporal variation in the proportion of fatally injured drivers who tested positive for at least one psychoactive substance, by sex.

A slight upward trend can be observed among drivers in general and particularly among men, while the trend among women was fairly stable over time.

Figure 4 Average annual percentage change among drivers who tested positive for the presence of psychoactive substances, by sex

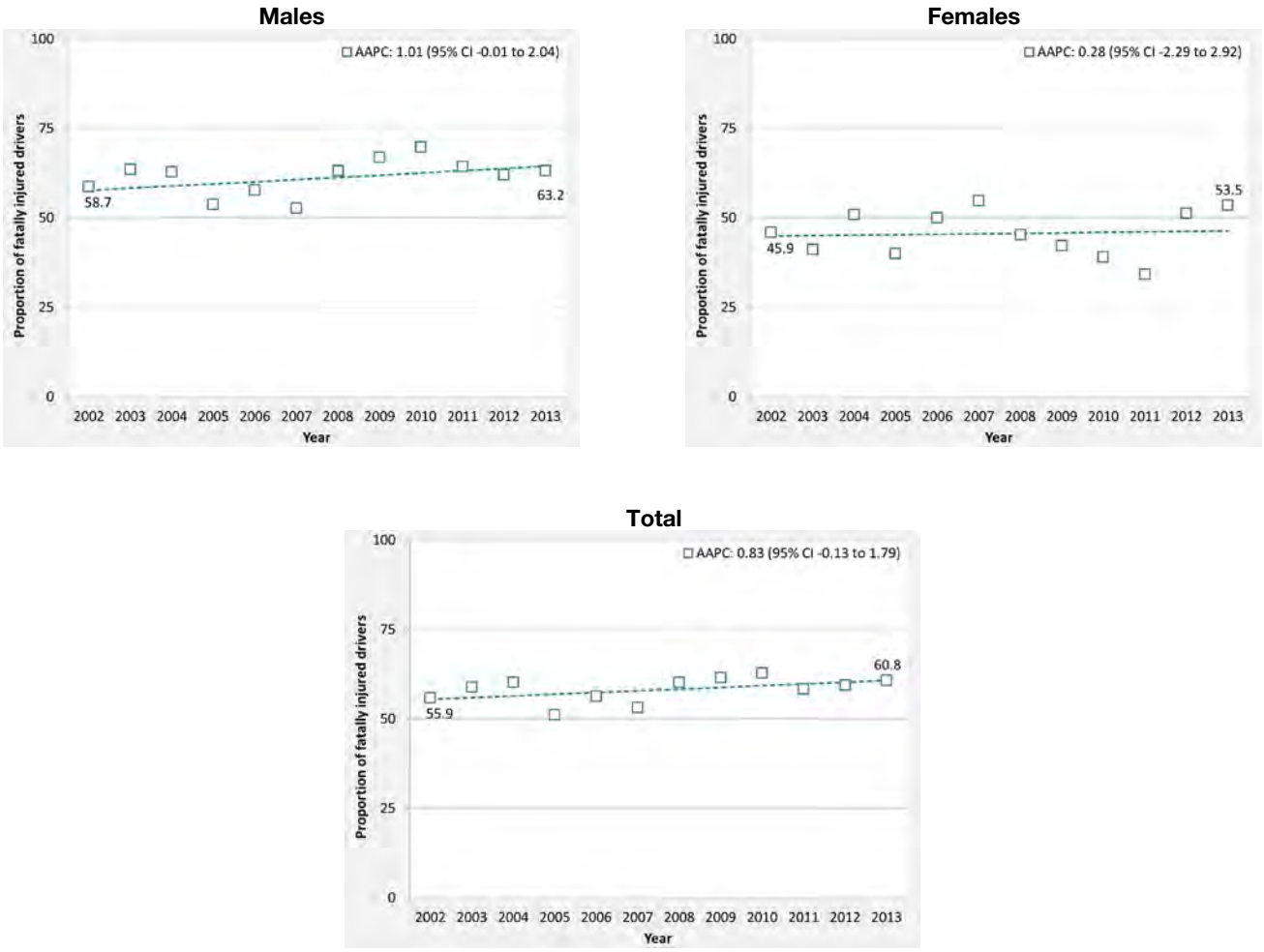


Table 2 shows the number and proportion of fatally injured drivers who tested positive for at least one psychoactive substance, by substance concerned and period. It also shows the average annual percentage change for each psychoactive substance and its various categories.

In the case of alcohol, a decrease in the proportion of fatally injured drivers who tested positive for this psychoactive substance can be observed over time with regard to the highest concentrations, i.e. over 50 mg of alcohol/100 ml of blood. The opposite trend can be seen in the case of drugs, for which drivers tested positive more and more frequently over time.

This is particularly true for methamphetamine, for which the proportion of drivers with positive test results rose from 2.5% in 2002 to 8.8% in 2013, which corresponds to a statistically significant average annual increase of over 12.9%. Even though the rates for medications were relatively stable, notable variations occurred for certain types. For example, the proportion of fatally injured drivers who tested positive for benzodiazepines was 16.8% from 2002 to 2004; however, the proportion fell to 10.9% from 2011 to 2013, for an average annual decrease of 5.9%. In contrast, antidepressants showed an average annual increase of more than 12.8% for the same periods, climbing from 4.5% to 13.4%.

Table 2 Distribution of fatally injured drivers who tested positive for at least one psychoactive substance, by substance concerned and period, and annual change in proportion

POSITIVE TOXICOLOGY TESTS						n (%)	ANNUAL CHANGE IN PROPORTION (%)			
Psychoactive substance \ Period		2002 – 2004	2005 – 2007	2008 – 2010	2011 – 2013		2002	2013	AAPC	95% CI
Alcohol (blood alcohol level[a])	**1 to 49 mg/100 ml**	45 (10.1)	47 (10.5)	42 (10.7)	34 (10.6)		9.0	12.1	+ 1.1	(- 3.1 to + 5.5)
	50 to 79 mg/100 ml	16 (3.6)	18 (4.0)	14 (3.6)	6 (1.9)		1.3	1.9	- 2.7	(- 10.1 to + 5.2)
	≥ 80 mg/100 ml	270 (60.5)	248 (55.6)	240 (60.9)	174 (54.4)		59.0	48.6	- 1.0	(- 2.2 to + 0.2)
Drugs	**Cannabis**	99 (22.2)	97 (21.7)	92 (23.4)	84 (26.3)		30.1	29.0	+ 1.3	(- 1.4 to + 4.0)
	Cocaine	55 (12.3)	65 (14.6)	61 (15.5)	39 (12.2)		14.1	12.1	- 0.1	(- 3.7 to + 3.6)
	Methamphetamine	11 (2.5)	27 (6.1)	30 (7.6)	28 (8.8)		1.9	8.4	**+ 12.9**	(+ 6.6 to + 19.6)
	All drugs[b]	138 (30.9)	154 (34.5)	153 (38.8)	123 (38.4)		38.5	37.4	**+ 2.2**	(+ 0.2 to + 4.2)
Medications	**Benzodiazepines**	75 (16.8)	55 (12.3)	32 (8.1)	35 (10.9)		18.6	13.1	**- 5.9**	(- 9.6 to - 2.0)
	Antidepressants	20 (4.5)	33 (7.4)	49 (12.4)	43 (13.4)		5.8	17.8	**+ 12.8**	(+ 7.7 to + 18.2)
	Opioids	23 (5.2)	23 (5.2)	11 (2.8)	16 (5.0)		3.8	4.7	- 0.8	(- 7.2 to + 6.0)
	Antihistamines	10 (2.2)	12 (2.7)	6 (1.5)	10 (3.1)		1.9	1.9	+ 2.2	(- 6.8 to + 12.2)
	All medications[c]	135 (30.3)	116 (26.0)	101 (25.6)	92 (28.8)		32.1	33.6	- 0.1	(- 2.5 to + 2.3)
TOTAL FOR EACH PERIOD		**446 (100.0)**	**446 (100.0)**	**394 (100.0)**	**320 (100.0)**					

Note: The values in bold are statistically significant.

[a] The limit of quantification for the analytical technique used was 0.1 mg/decilitre.

[b] The following drugs were included in the study: cannabis, cocaine, amphetamine, methamphetamine, MDMA (ecstasy), GHB, ketamine and phencyclidine (PCP). It should be noted that certain prescription drugs contain amphetamine or metabolize into amphetamine.

[c] The following classes of medications were included in the study: benzodiazepines, antidepressants, opioids, antihistamines, antipsychotic drugs, barbiturates, anticonvulsants, anaesthetics, muscle relaxants, decongestants and antitussives.

Figure 5 shows the proportion of fatally injured drivers by number of detected substances[VII] and age group. Regardless of age group, positive results were obtained more frequently for just one psychoactive substance than for combinations of several substances. For the 2002-2013 period, the largest proportion of drivers who tested positive for one or more psychoactive substances was found in the 25-34 age group.

Figure 5 **Proportion of fatally injured drivers, by number of detected substances and age group (%)**

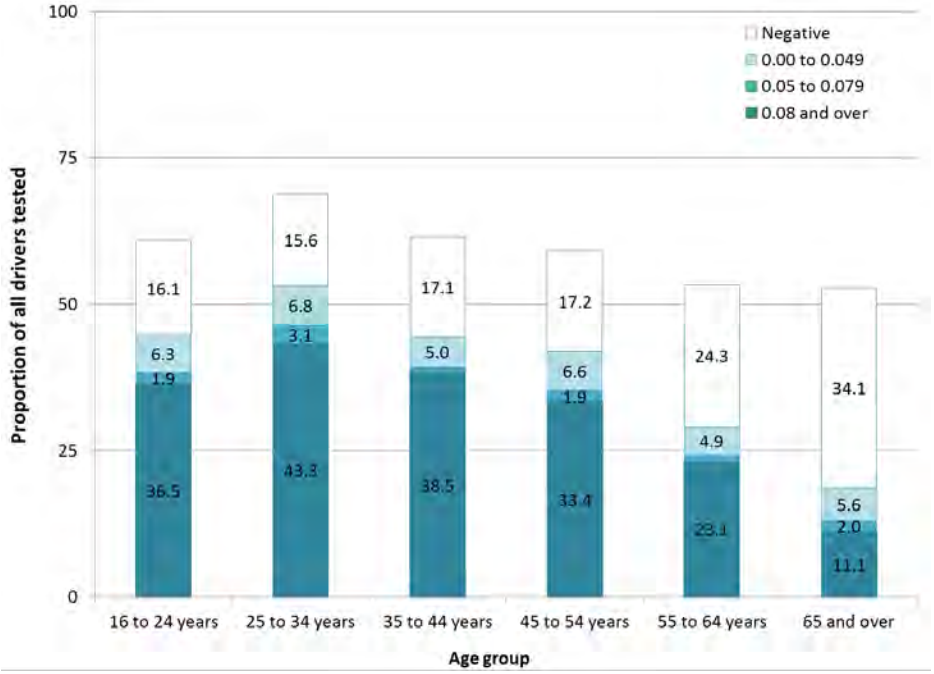
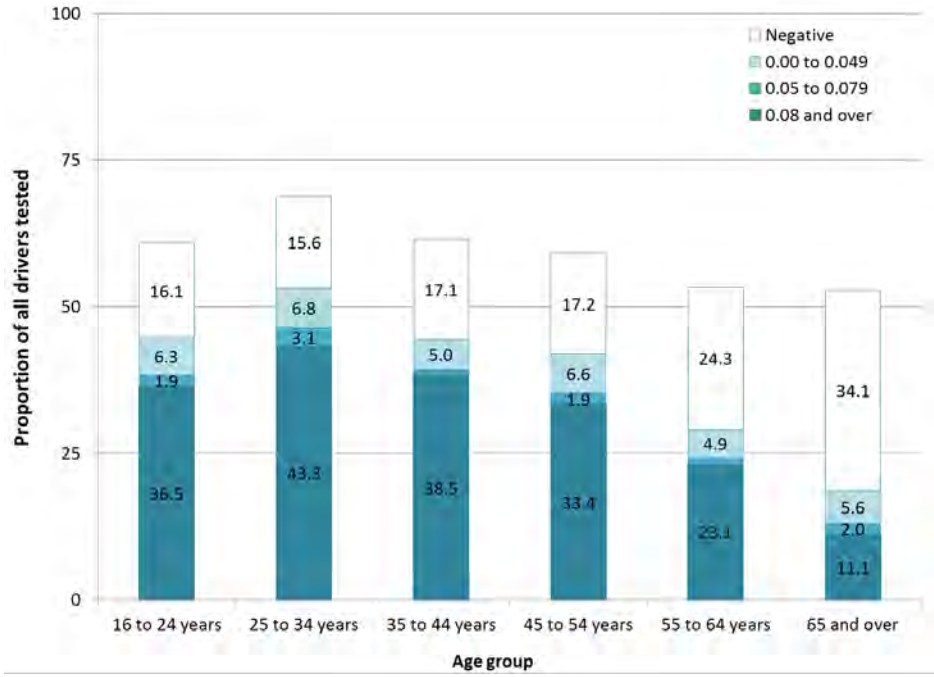


Figure 6 shows the proportion of fatally injured drivers who underwent blood alcohol tests, by concentration and age. The chart reveals that, irrespective of age group, the blood alcohol level of fatally injured drivers who tested positive for alcohol was often above the legal limit set in Québec. In addition, the proportion of drivers who tested positive for alcohol, all levels combined, was highest in the 25-34 age group. It then decreased with age, with drivers aged 65 years and over posting the largest proportion of negative blood alcohol tests.

Figure 6 **Proportion of fatally injured drivers, by blood alcohol concentration and age group (%)**



[VII] The term “detected substance” refers to one of the illicit drugs or medications studied, or to a positive blood alcohol level.

Figure 7 shows the proportion of fatally injured drivers who tested positive for at least one drug, by substance and age group. The proportion was highest among drivers aged 16 to 24 years, and tended to decline with age. Cannabis and cocaine were encountered most often among fatally injured drivers who tested positive for at least one drug, regardless of age group.

Figure 7 **Proportion of fatally injured drivers who tested positive for at least one drug, by age group (%)**

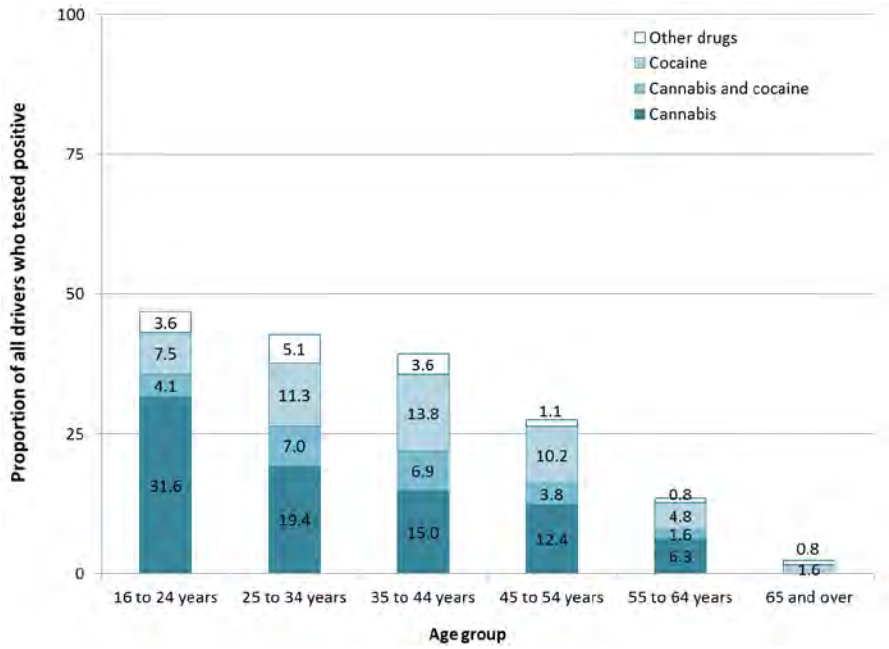


Figure 8 shows the proportion of fatally injured drivers who tested positive for alcohol and at least one drug, by substance and age group. It shows that this combination was encountered most often among drivers under 35, and decreased with age.

Figure 8 **Proportion of fatally injured drivers who tested positive for alcohol and at least one drug, by age group (%)**

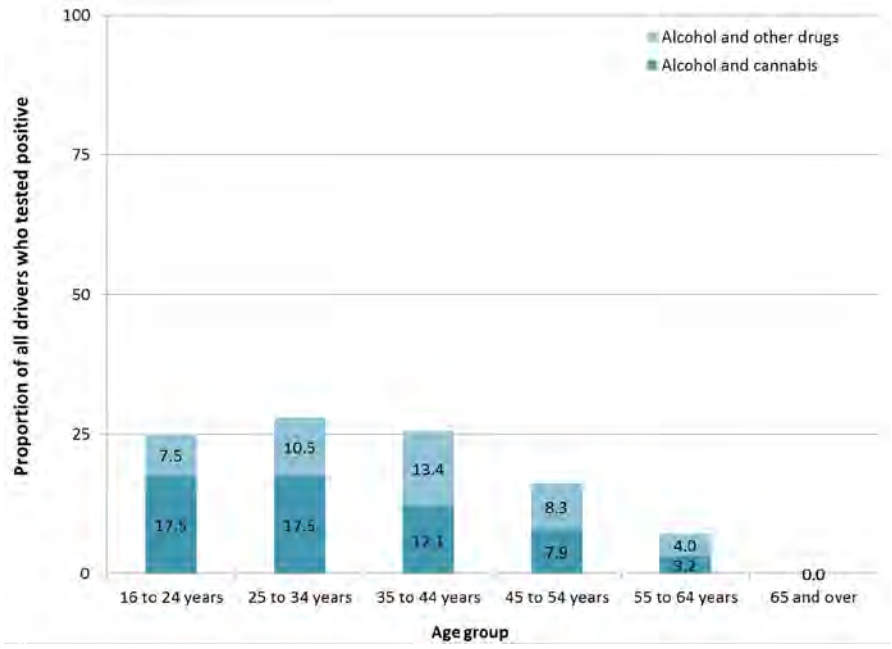


Figure 9 shows the proportion of fatally injured drivers who tested positive for at least one medication, by substance and age group. The proportion tended to increase with age. The figure also shows that benzodiazepines, antidepressants or a combination of both substances were well represented among drivers aged 35 years and over.

Figure 9 **Proportion of fatally injured drivers who tested positive for at least one medication, by age group (%)**

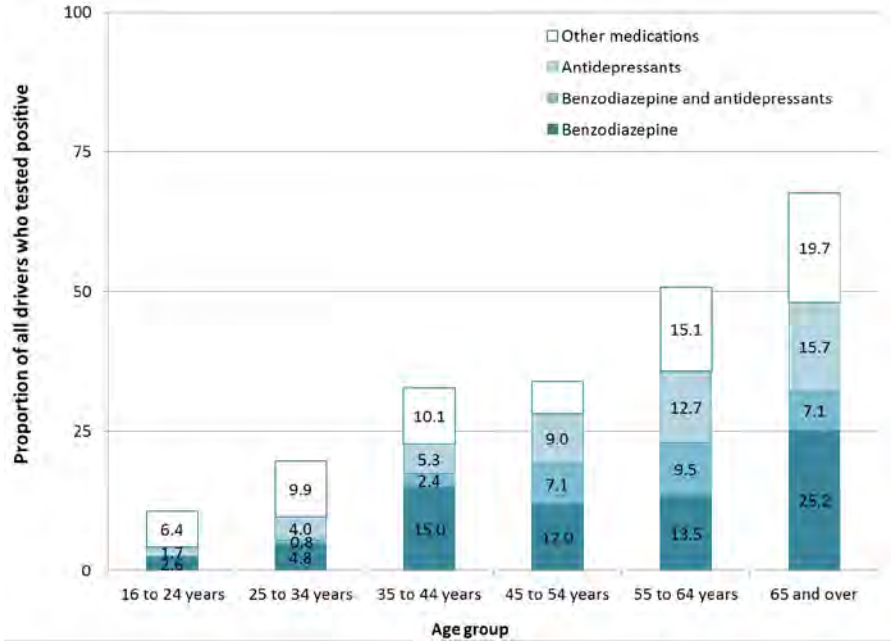


Figure 10 shows the proportion of fatally injured drivers who tested positive for alcohol and at least one medication, by substance and age group. This combination was observed most frequently among drivers aged 35 years and over.

Figure 10 **Proportion of fatally injured drivers who tested positive for alcohol and at least one medication, by age group (%)**

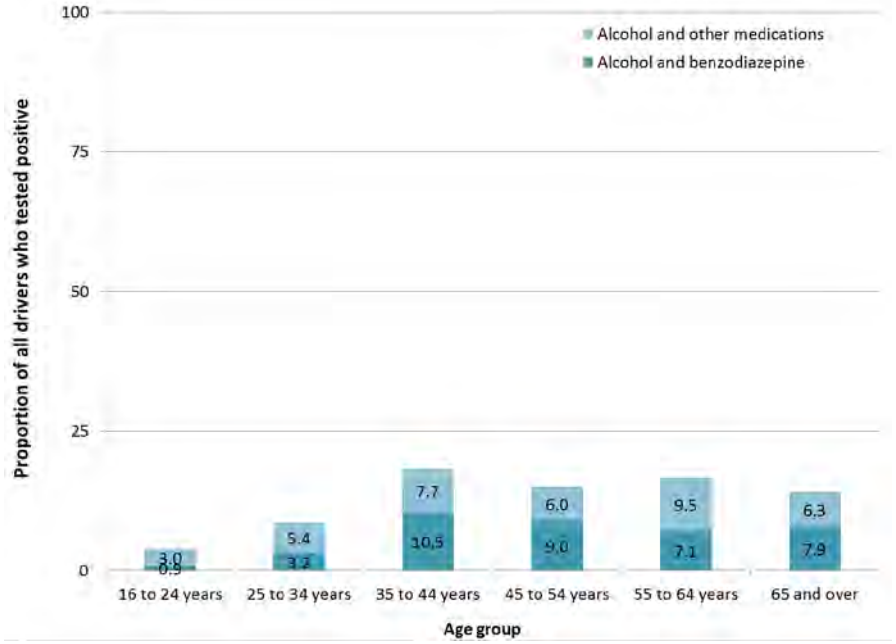


Table 3 shows the number of fatally injured drivers who tested positive for methamphetamine from 2006 to 2013, by measured blood concentrations. Almost all of these drivers (92.5%; 62/67) had a blood methamphetamine concentration above 25 ng/ml, i.e. above the threshold for dangerous driving set by the SFTA. These figures do not include cases where blood methamphetamine concentrations were not available (n = 24).

Table 3 Number of fatally injured drivers who tested positive for methamphetamine, by measured blood concentrations and period

Concentration \ Period	2006 – 2007	2008 – 2009	2010 – 2011	2012 – 2013	TOTAL
Not available*	9	9	6	0	**24**
> 0 – 25 ng/ml	1	1	1	2	**5**
> 25 ng/ml	13	10	20	19	**62**
TOTAL	**23**	**20**	**27**	**21**	**91**

* This could correspond to tests that were not performed by the CTQ, positive urine tests, negative blood tests or blood tests that were not performed.

Table 4 shows the number of fatally injured drivers who tested positive for cocaine or benzoylecgonine from 2006 to 2013, by measured blood concentrations. The majority of these drivers (93.5%; 72/77) had a blood cocaine concentration of over 10 ng/ml, i.e. above the threshold for dangerous driving set by the SFTA. These figures do not include cases where blood cocaine concentrations were not available (n = 81).

Table 4 Number of fatally injured drivers who tested positive for cocaine or benzoylecgonine, by measured blood concentrations

Benzoylecgonine \ Cocaine	Concentration not available*	> 0 – 10 ng/ml	> 10 ng/ml	TOTAL
Concentration not available*	37	0	3	**40**
> 0 – 50 ng/ml	7	2	1	**10**
> 50 ng/ml	37	3	68	**108**
TOTAL	**81**	**5**	**72**	**158**

* This could correspond to tests that were not performed by the CTQ, positive urine tests, negative blood tests or blood tests that were not performed.

4 Discussion

From 2002 to 2013, 57.8% of toxicology tests performed on 2,780 drivers aged 16 years and over who were killed in road traffic accidents in Québec were positive for the substances studied. Nearly three quarters (71.9%) of the fatally injured drivers who tested positive for at least one psychoactive substance had positive blood alcohol levels, while more than one third (35.4%) tested positive for one drug. In addition, over one quarter (27.6%) of the fatally injured drivers who tested positive for one psychoactive substance had taken a medication.

Despite the reported decrease in the number of road traffic deaths in Québec (1), the proportion of fatally injured drivers who tested positive for at least one psychoactive substance remained stable from 2002 to 2013. On the one hand, the proportion of fatally injured drivers with a blood alcohol level equal to or above 80 mg/100 ml appeared to decline during the study period (- 1.0% per year on average). On the other hand, the proportion of fatally injured drivers who tested positive for at least one drug rose (+ 2.2% per year on average), owing to the increase in the number of deaths where the presence of methamphetamine was noted (+ 12.9% per year on average). With regard to medications, the proportion of fatally injured drivers who tested positive for such substances remained stable from 2002 to 2013 (- 0.1% per year on average). However, this apparent stability masks a number of diverging trends. While the proportion of fatally injured drivers who tested positive for antidepressants grew (+ 12.8% per year on average), the proportion of those who tested positive for benzodiazepines fell (- 5.9% per year on average).

The results of this study show that alcohol nonetheless remains the psychoactive substance most frequently detected among drivers killed in road traffic accidents. In its road safety record for 2014, the Société de l'assurance automobile du Québec reported that 31.4% of drivers fatally injured on Québec roads in 2013 had a blood alcohol level of over 80 mg/100 ml of blood (1). This finding is particularly important given that drivers with a blood alcohol level above that limit are 13 times more likely to be involved in a fatal accident than drivers who did not consume alcohol (22). What is more, the risk increases considerably when alcohol is used in combination with drugs (23). In the present study, alcohol and drugs were the most common combination of psychoactive substances observed among Québec drivers killed in road traffic accidents (20.9%).

Cannabis, cocaine and methamphetamine were the drugs most frequently identified among fatally injured drivers who underwent toxicology tests in Québec from 2002 to 2013. The blood cocaine and methamphetamine concentrations encountered in these drivers almost always exceeded the threshold for dangerous driving set by the SFTA (18). That being said, there is no consensus at the international level on the thresholds above which drug consumption may be dangerous for driving. The LSJML reported that, in 2015, methamphetamine was the substance most commonly detected before cannabis among impaired drivers in Québec (10). In addition, Québec is the province with the most methamphetamine seizures by police forces in Canada (9).

The increase in the number of road traffic deaths involving the confirmed presence of methamphetamine may reflect growing use of this drug in Québec. Certain studies conducted outside Québec have also mentioned that amphetamines are frequently detected in drivers killed in road traffic accidents (16, 24, 25). This is the case in Norway (24), where researchers demonstrated that methamphetamine was the drug most commonly detected in fatally injured drivers[VIII] who tested positive for at least one psychoactive substance from 2005 to 2010. However, it is important to bear in mind that some prescription drugs contain amphetamines or metabolize into amphetamine. Since the source of the amphetamines is generally not mentioned, it is also necessary to consider the possibility that the drug detected in the fatally injured drivers was taken in a therapeutic context.

The results of the present study suggest that the proportion of fatally injured drivers who tested positive for cannabis remained stable over the study period. However, it is impossible to determine whether or not the cannabis had been consumed shortly before the accidents concerned. Recent use of cannabis, the drug most commonly used in Canada (7), has the potential to

[VIII] Drivers for whom the probable cause of death was speeding or driving unbelted.

alter the cognitive and motor functions required to drive a motor vehicle safely (26-27). In fact, recent cannabis consumption is associated with a heightened risk of fatal collisions (28-30).

In the United States, the proportion of fatally injured drivers who tested positive for cannabis trended upward following the implementation of a bill on the legalization of medical cannabis in Colorado (31). In California and the state of Washington, the implementation of a bill on the legalization of medical cannabis led to an increase in the percentage of drivers involved in a fatal road traffic accident who had recently used cannabis (32). That being said, the introduction of laws legalizing medical cannabis use from 1992 to 2009 has been associated with growing cannabis consumption among drivers in only 3 (California, Hawaii and Washington) of the 12 U.S. states that have adopted similar laws (33). However, it is impossible apparently to determine a *per se* limit for THC, the main psychoactive component of cannabis, in situations involving impaired driving (34).

In addition, changes in use patterns for psychoactive substances are reflected in the profiles of fatally injured drivers who test positive for these substances. Prescription drugs are detected more and more often in drivers killed in road traffic accidents. In the United States, the proportion of fatally injured drivers who tested positive for opioid medications or benzodiazepines increased significantly from 1999 to 2010, while the share of illicit drugs apparently declined (35-36).

Obviously, a number of medications are not compatible with safe driving, depending on the circumstances. In this study, benzodiazepines and antidepressants were often found in fatally injured drivers in Québec who tested positive for at least one medication. The wide prevalence of these substances was particularly noticeable among drivers aged 35 years and over who had tested positive for at least one medication. In fact, 73.8% (237/321) of the drivers had positive toxicology results for benzodiazepine, one antidepressant or a combination of the two.

The proportion of fatally injured female drivers who tested positive for at least one medication was greater than the proportion of fatally injured male drivers with similar test results. This is contrary to the trend observed for drugs and alcohol. Indeed, 52.1% (136/261) of the women who tested positive for at least one psychoactive substance had positive toxicology results for one or more medications, compared to 22.9% (308/1,345) of men.

It should also be noted that, contrary to the trend observed with drugs, the proportion of fatally injured drivers who tested positive for at least one medication increased with age. From 2002 to 2013, more than one quarter (28.2%; 86/305) of drivers aged 65 years and over had at least one psychoactive medication in their post-mortem biological samples. In comparison, the proportion among drivers aged 16 to 24 years dropped to 6.4% (50/776) over that same period.

These results are comparable to those obtained by the Canadian Institute for Health Information (CIHI). From 2001 to 2010, CIHI observed an increase in the use of antidepressants among drivers aged 65 years and over, as well as a slight decrease in the use of benzodiazepines in that age group. In addition, a Québec study of drivers aged 66 to 84 years revealed a heightened risk of road traffic accidents among people who had recently begun treatment with antidepressants, compared to those whose treatment had begun 4 to 8 months earlier (37). In addition, work by the Institut national de la santé et de la recherche médicale in France showed that antidepressant use significantly raised the risk of road traffic accidents. The risk was highest when treatment was first initiated or when it was modified (38).

That being said, any medication that acts on the central nervous system has the potential to alter driving ability (39). This is particularly the case of hypnotic drugs, commonly known as “sleeping pills”, which are used to treat sleep disorders (39). For example, opioids and anxiolytics,[IX] such as benzodiazepines, are likely to cause drowsiness and psychomotor retardation (39). Several epidemiological studies have shown that the risk of road traffic accidents increases following the

[IX] Medication designed to reduce anxiety.

consumption of benzodiazepines (40). Few studies have been conducted on other classes of medications.

It is difficult to establish, for each medication, a blood concentration level above which the medication would have an impact on driving. This can be explained by the fact that people may develop a certain tolerance to a medication when they use it regularly for treatment purposes. In addition, specific blood concentration levels for medications are no longer applicable when the medications are used in combination with other psychoactive substances that can affect driving. This is not to mention the fact that older people are sometimes more sensitive to the undesirable effects of certain medications (41). In fact, concomitant use of psychoactive substances is likely to amplify their adverse effects (drowsiness, slower reflexes, reduced motor skills, etc.) (41).

Limitations and strengths of the study

This study has several limitations that must not be overlooked if the results are to be placed in their proper perspective.

First of all, it may have involved a selection bias stemming from the fact that it does not always request toxicology tests for each of the deaths it investigates. Indeed, no toxicology tests were requested for 30% of the drivers killed in road traffic accidents in Québec from 2002 to 2013. This can be explained by various factors encountered in the context of such accidents. For example, no tests may be requested when a driver temporarily survives his or her injuries and is being treated in hospital, or when police forces have already obtained the information they need to explain the circumstances of a collision. It is also important to note that the data available in this study could not be used to identify suicides and natural deaths (i.e. deaths where drivers have had a medical problem before being involved in an accident). Therefore, suicides and natural deaths were not included in the study.

A number of information biases must also be considered. The toxicology tests were performed in several different laboratories that did not all use the same technologies and procedures. Moreover, the analytical capabilities of each laboratory did not cover the entire range of psychoactive substances. Therefore, it is possible that a new synthetic drug was present in a biological sample but was not detected by the laboratory that was doing the toxicology tests. In addition, the analytical methods of the different laboratories were not updated on an ongoing basis and may have been modified during the study period. Furthermore, from 2002 to 2013, the analytical capability and sensitivity of instruments improved significantly, with the result that substances that were impossible to identify in 2002 may have been detectable later on.

Certain information that could have been used to assess the impact of psychoactive substance use on the risk of being involved in a road traffic accident remains unknown (doses, time since consumption). Even though the presence of psychoactive substances may be one of the circumstances of death in a road traffic accident, it is not necessarily the cause of death. The presence of a substance in biological samples collected from fatally injured drivers is not enough to establish a causal link. This is especially true with urine samples. It should also be pointed out that some people may develop a tolerance to alcohol, drugs and medications. In such cases, the threshold above which blood concentration levels could pose a risk to driving cannot be generalized. Contrary to alcohol and drugs, numerous medications are not systematically screened for and measured in biological samples from fatally injured drivers.

The data used in this study did not shed light on all of the circumstances surrounding the deaths that had occurred and particularly on whether or not the deaths took place after victims had been taken to hospital. Some substances, like midazolam and other benzodiazepines, opioids or anticonvulsants, may have been administered in a hospital setting. Substances taken after the accidents concerned could have been excluded by analyzing each BCQ file, as was done in the case of the fatally injured drivers who had tested positive for midazolam.

Despite these limitations, this study has several strengths.

In Québec, the Act respecting the determination of the causes and circumstances of death requires that the coroner conduct an investigation to determine the causes and circumstances of deaths caused by trauma, including those caused by motor vehicle collisions (42-43). BCQ data, which are available for

research and surveillance purposes, provide information on circumstances of death, as well as on blood alcohol levels and the substances detected in toxicology tests. Therefore, in this study, it was possible to access preliminary data on all road traffic deaths that had occurred in Québec during the study period. In addition, by using midazolam as an indicator for the administration of medications during medical treatment and subsequently consulting the coroners' reports associated with that indicator, it was possible to exclude cases where victims would have been considered positive based on consultation of the database alone.

5 Conclusion

This study has presented an up-to-date profile of the psychoactive substances found in biological samples from drivers killed in road traffic accidents in Québec from 2002 to 2013. Despite a decline in the number of deaths over that period, the study revealed an increase in the proportion of fatally injured drivers who tested positive for psychoactive substances, mainly alcohol, drugs or medications, used alone or in combination with each other.

The results of this report have brought out a number of trends. Of the three main types of psychoactive substances studied, alcohol is the only one for which a decrease has been observed over time in the number of fatally injured drivers who tested positive for that substance. In addition, alcohol and drugs are detected more frequently among young male drivers under age 35. In contrast, medications are more often encountered among drivers aged 35 and over and particularly among older people and women.

In conclusion, health professionals and organizations working in prevention should be informed of these findings to enable them to optimize their interventions and, ultimately, reduce the number of deaths that occur in road traffic accidents following the consumption of psychoactive substances.

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