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Alcohol and drugs in seriously injured drivers in six European countries

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The objective of this study was to determine the presence of alcohol and drugs in drivers severely injured in traffic crashes in six European countries. Data were collected from 2492 seriously injured drivers of cars and vans in Belgium, Denmark, Finland, Italy, Lithuania, and the Netherlands, between 2007 and 2010. Toxicological analysis was performed with chromatographic techniques on whole blood for 23 substances. The percentage of drivers positive for at least one psychoactive substance ranged between 28% (Lithuania) and 53% (Belgium). Alcohol (≥0.1 g/L) was the most common finding with the highest percentage in Belgium (42.5%). Among the alcohol-positive drivers, 90.5% had a blood alcohol count (BAC) ≥0.5 g/L and 65.7% had a BAC ≥1.3 g/L. Benzodiazepines (0.0–10.2%) and medicinal opioids (0.5–7.8%) were the most prevailing medicinal drugs, but half of the concentrations were lower than therapeutic. Cannabis (0.5–7.6%) was the most prevailing illicit drug. Alcohol was found in combination with drugs in 2.3-13.2% of the drivers. Drug combinations were found in 0.5–4.3% of the drivers. This study confirms the high prevalence of psychoactive substances in injured drivers, but we observed large differences between the participating countries. Alcohol was the most common finding, followed by cannabis and benzodiazepines. Notable are the many drivers having a BAC ≥ 1.3 g/L. The majority of the substances were found in combination with another psychoactive substance, mostly alcohol. The high prevalence of high BACs and combinations (compared to roadside surveys) suggest that those drivers are most at risk and that preventive actions should target them preferentially. Copyright © 2012 John Wiley & Sons, Ltd.

Keywords: prevalence alcohol/psychoactive substance; injured drivers; Europe

Introduction

Driving under the influence of drugs other than alcohol is a significant problem all over the world.[1] Both illicit and licit drugs that affect the central nervous system have a high potential to increase crash risk.[2–8] The prevalence of alcohol and drugs among injured drivers is well documented in the literature.[4–6,8–18] However, epidemiological studies are difficult to compare with each other because of differences in study design. For example, the sampled population can differ in socio-demographical factors such as age and gender.[19] Some studies only included drivers of a car[3,20] while other studies included drivers of different types of vehicles (e.g. motorcycles and bicycles).[21,22] Some studies were performed 24/7 while other were conducted only during the weekend.[23] Different types of biological samples have been used (urine, blood, saliva). The use of urine samples may lead to an overestimation of the prevalence of psychoactive substances since drugs (and metabolites) can be detected for a relatively long period after consumption. All these factors influence the outcome of these studies and consequently make it difficult to compare the results.

The objective of the present study was to assess the presence of alcohol and other psychoactive substances in drivers of cars and vans who have been injured in traffic crashes in various European

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countries by means of analysis of blood samples of injured drivers. Including several European countries allowed for the assessment of differences in prevalence of psychoactive substances between the countries.

A uniform study design[24] minimized the problem of comparability of data, which is also a problem underlined by, for example, the European Monitoring Center for Drugs and Drug Addiction (EMCDDA) and the Working Group on Illegal Drugs & Driving (ICADTS).[25–27] This uniformed study design and an extensive data collection of nearly 2500 seriously injured drivers distinguish the present epidemiological study from previous studies. This study was performed in the framework of the EU research project Driving under the Influence of Drugs, Alcohol and Medicines (DRUID).

Materials and methods

Study setting and population

The study was conducted in different European countries between October 2007 and April 2010. We tried to include countries from all parts of Europe. Because of difficulties in organizing previous similar studies, some countries decided not to participate. Sweden and Hungary had to withdraw due to difficulties in collecting enough samples. Eventually six countries were included: Belgium (BE), Denmark (DK), Finland (FI), Italy (IT), Lithuania (LT), and the Netherlands (NL). The study population consisted of 2492 samples (BE: 348; DK: 840; FI: 54; IT: 676; LT:387; NL:187).

The study population was selected by multistage clustering sampling. First a selection of hospitals was made in each country based on willingness to cooperate, geographical distribution, and influx of injured drivers. There were five hospitals in each country (Belgium and Denmark), one in Finland, four in Italy and Lithuania, and three in the Netherlands. The study population consisted of seriously injured drivers who were admitted to the emergency department (ED) of a hospital in the six countries involved. Only drivers of cars and vans were included. The interval between crash and sampling had to be less than 3 h. Cases with a longer interval were not included because the drug concentrations are less representative of those at the time of the crash. Only drivers aged 18 and above and with a Maximum Abbreviated Injury Scale (MAIS) ≥2 were included.[28,29] The MAIS scale runs from 1–6, with a score of 1 indicating minor injury and 6 indicating death; with four in-betweenstages: moderate, severe, serious and critical injury.[28] The MAIS score was not available in Denmark and Italy, but other national criteria were used to guarantee inclusion of patients with an injury severity equivalent to MAIS score 2 or higher.

Data sources

Two sources of data were used. Standardized patient information (age, gender, time and date of sampling, medication/fluids administered prior to blood sampling, and MAIS score) and crash data (time and date, type of vehicle, type of crash (single/multivehicle), road type and seat-belt use) were gathered through means of a questionnaire that was filled in by the hospital staff. Information about the use of a seat belt was only collected in Belgium and the Netherlands. Furthermore, a blood sample was collected. Eight substance groups were chosen for analysis based on their prevalence of use and the likelihood of them playing a role in road crashes: alcohol, amphetamines, cocaine, cannabinoids (THC), benzodiazepines, illicit and medicinal opioids, and Z-drugs (zolpidemand zolpiclone).

Toxicological analyses

The toxicological analyses were performed on whole blood. Five to ten ml of whole blood was collected in grey-top vacuum tubes containing sodium fluoride and potassium oxalate. The conditions of sample transportation and storage as well as the analytical methods have been described in detail elsewhere.[24,30,31] The target substances as well as the analytical cut-off values are listed in Table 1, which also shows the mean and median concentrations. The samples from all countries have been pooled. For analysis of the toxicological findings, drugs were grouped according to their pharmacological characteristics. Samples positive for medicinal drugs administered before the blood sample was taken were considered negative for these substances. Substances of the same type were combined in substance groups. A case was positive for cannabinoids when THC was found. Thus a case where only the inactive metabolite THCCOOH was detected, was considered negative. A driver was considered positive for cocaine when cocaine alone or in combination with benzoylecgonine was measured.

Statistical analyses

Chi-square analysis was used to search for differences between countries. SPSS statistics 17 (IBM, Somers NY, USA) was used for statistical analysis. The level of significance was set at $p < 0.05$. Confidence intervals were calculated with the Wilson method.[32] Multiple regression was used to correct for age and gender. The Kruskall Wallis one-way ANOVA test was used to make pairwise comparisons between groups of drivers. The Bonferroni correction was applied to calculate adjusted significance values.

Ethical approval

To guarantee confidentiality no references were made in the medical record about the inclusion of a patient in the study. All forms and samples were given a unique and anonymous code. The study protocol complied with recognized standards of human subjects protection. Ethical approval was obtained in Belgium, Finland, Lithuania, and the Netherlands. No ethical approval was needed in Denmark and Italy. In three out of the six countries, an informed consent form had to be signed by the respondent or relative (BE, FI, IT).

Results

Description of the studied population

A description of the studied population can be found in Table 2. Significant differences between countries were found ($p < 0.01$) for age and gender, crash type, distribution by time of the week and time of the day and injury severity. There were relatively more male drivers injured in the Netherlands and Italy than in the other countries. The age group 18–24 was less present in Belgium and Italy. For the age group 25–34 a higher proportion was seen in Italy. There were more weekday traffic crashes in Denmark and Lithuania compared to the other four countries. A significant difference in MAIS scores (2 and 3) was found ($p < 0.01$) between Belgium and the Netherlands, with more MAIS 2 cases in Belgium.

Table 1. Distribution of concentrations. All concentrations in μg/L except for ethanol: g/L

Substance	Substance groups	DRUID cut-off (ng/ml)	Number of samples screened	Concentrations at or above DRUID cut-off		
				n Positive	Mean	Median
Ethanol	Alcohol	0.1 g/L	2486	609	1.59 g/L	1.60 g/L
6-acetylmorphine	Illicit opioids*	10	2484	1	12.4	12.4
Amphetamine	Amphetamines	20	2485	45	215	102
Methamphetamine		20	2485	11	112	125
MDA		20	2485	1	43.1	43.4
MDEA		20	2485	0	N.A.	N.A.
MDMA		20	2485	5	199	93.9
Alprazolam	Benzodiazepines	10	2484	6	52.3	44.5
Clonazepam		10	2484	30	45.8	40.2
Diazepam		20	2480	41	234	112
Lorazepam		10	2483	13	37.7	25.6
Flunitrazepam		2	2480	4	8.5	8.0
Nordiazepam		20	2481	46	223	138
Oxazepam		50	2483	14	303	174
Cocaine	Cocaine**	10	2484	36	59.5	35.5
Codeine	Medicinal opioids	10	2484	18	27.1	20.5
Methadone		10	2483	29	140	72.0
Morphine		10	2470	58	65.3	31.5
THC	Cannabis***	1	2481	68	3.0	2.3
Zolpidem	Z-drugs	20	2484	11	238	131
Zopiclone		10	2484	8	103	59.6

* Illicit opioids: 6-acetylmorphine or (morphine + codeine and morphine concentration ≥ codeine concentration). Concentrations of 6-acetylmorphine and/or codeine, when present, were taken into consideration even when below the DRUID cut-off.

** Cocaine: Cocaine + Benzoylecgonine or cocaine.

*** Cannabis: THC or THC + THCCOOH.

N.A.: Not applicable.

The non-response rate ranged from 0% (IT and LT) up to 8.5% (FI) (Table 2). Reasons for not participating were: not willing to give an extra blood sample, severe injuries or time pressure. Moreover, subjects not fulfilling the above mentioned inclusion criteria (e.g. because they were not driving a car) were excluded (in BE: 730; DK: 16; FI: 271; IT: 14; LT:37; NL:10).

Prevalence of alcohol and drugs in injured drivers

Prevalence of drug and alcohol-positive drivers

The highest percentage of drivers positive for one or more substances was found in Belgium (52.6%), which was significantly higher than in Denmark, Italy, Lithuania, and the Netherlands ($p < .05$) (Table 3). In these four countries, the percentage of alcohol or drug-positive drivers was approximately 30%. Male drivers were more often positive for alcohol and drugs than female drivers with the highest percentage found in Belgium (59.1%). In all six countries, the prevalence of drugs and alcohol was higher in drivers younger than 35 years.

Alcohol

The percentage of drivers positive for alcohol alone (BAC ≥ 0.1 g/L) ranged between 14.4% and 29.9% and for alcohol in combination with other substances between 2.3 and 13.2% (Table 3). In Belgium, significantly more injured drivers tested positive for alcohol compared to Denmark, Italy, Lithuania, and the Netherlands ($p < .05$). Even after correction for age and gender, the significant difference between Belgium and the four other countries persisted. The percentage of drivers testing positive for alcohol (BAC ≥ 0.5 g/L) – the legal limit in most countries involved – ranged between approximately 16 and 38%. Of the 609 drivers found positive for alcohol, 9.5% (5.5% (NL)–10.9% (IT)) had a BAC between 0.1 g/L and 0.5 g/L and 65.7% (58.2% (NL)–76.5% (FI)) had a BAC ≥ 1.3 g/L (Figure 1). The median alcohol concentration was 1.6 g/L. No significant differences in alcohol concentrations were found between the countries.

In Belgium, Denmark, Italy, and the Netherlands, significantly more male drivers tested positive for alcohol compared to female drivers ($p < .05$). In all six countries, alcohol-positives peaked in drivers younger than 35 years, with significant differences between the age groups in DK, IT and NL ($p < .05$).

Illicit drugs

The prevalence of amphetamines ranged between 0.1 (IT) and 4.2% (DK) (Table 3). Even after correction for age and gender, Italian drivers tested significantly less positive for amphetamine compared to the other five countries ($p < .05$). Roughly more male than female drivers tested positive for amphetamines, but this was significant only in Denmark ($p < .05$). Amphetamines were mostly observed in combination with benzodiazepines and alcohol.

The highest prevalence of cocaine was recorded in Italy (2.7%, CI: 1.7–4.2), which was significantly more than in Lithuania and Denmark ($p < .05$). A higher prevalence, yet not significant, of cocaine was found in male drivers, except for the Netherlands

Table 2. Description of the injured driver sample in six European countries

Countries	BE % (N)	DK % (N)	FI % (N)	IT % (N)	LT % (N)	NL % (N)	Total
Total N (%)	14.0 (348)	33.7 (840)	2.2 (54)	27.1 (676)	15.5 (387)	7.5 (187)	2492
Week and time of the day (%, N between brackets)*							
N	339	822	54	638	361	187	
Weekday[a]	43.1 (146)	61.2 (503)	44.4 (24)	41.4 (264)	66.8 (241)	48.1 (90)	52.8 (1268)
Weekend day[b]	28.3 (96)	25.8 (212)	35.2 (19)	33.5 (214)	23.5 (85)	12.3 (23)	27.0 (649)
Week night[c]	13.3 (45)	4.7 (39)	9.3 (5)	11.1 (71)	3.0 (11)	24.6 (46)	9.0 (217)
Weekend night[d]	15.3 (52)	8.3 (68)	11.1 (6)	13.9 (89)	6.6 (24)	15.0 (28)	11.1 (267)
Gender (%)*							
N	347	840	54	676	374	187	2478
Male	70.0 (243)	65.1 (547)	79.6 (43)	76.9 (520)	63.9 (239)	80.2 (150)	70.3 (1742)
Female	30.0 (104)	34.9 (293)	20.4 (11)	23.1 (156)	36.1 (135)	19.8 (37)	29.7 (736)
Age groups (%)*							
N	335	834	54	676	363	187	2449
18–24y	21.2 (71)	32.3 (269)	31.5 (17)	18.6 (126)	28.9 (105)	29.4 (55)	26.3 (643)
25–34y	31.6 (106)	24.5 (204)	20.4 (11)	30.8 (208)	26.4 (96)	27.2 (51)	27.6 (676)
35–49y	26.3 (88)	25.8 (215)	18.5 (10)	30.2 (204)	28.9 (104)	24.5 (46)	27.2 (667)
50+	21.0 (70)	17.5 (146)	29.6 (16)	20.4 (138)	16.0 (58)	18.7 (35)	18.9 (463)
Safety belt use (%)							
N	301	N.A.	N.A.	N.A.	N.A.	143	444
Yes	71.4 (215)					74.1 (106)	72.3 (321)
No	28.6 (86)					25.9 (37)	27.7 (123)
Vehicle type (%)							
N	348	831	54	615	373	187	2408
Personal car	93.1 (324)	94.9 (789)	94.4 (51)	93.8 (577)	92.8 (346)	94.1 (176)	94.0 (2263)
Van	6.9 (24)	5.1 (42)	5.6 (3)	6.2 (38)	7.2 (27)	5.9 (11)	6.0 (145)
Crash type (%)*							
N	323	826	51	na	373	161	1734
Single vehicle	48.9 (158)	49.8 (411)	49.0 (25)		29.5 (110)	62.7 (101)	46.4 (805)
Multi vehicles	51.1 (165)	50.2 (415)	51.0 (26)		70.5 (263)	32.1 (60)	53.6 (929)
Injury severity (%)*							
N	337	840	53	676	154	186	2246
2	61.7 (208)	0	56.6 (30)	0	88.3 (136)	48.9 (91)	20.7 (465)
3	28.8 (97)	0	39.6 (21)	0	7.8 (12)	35.5 (66)	8.7 (196)
4	5.9 (20)	0	3.8 (2)	0	2.6 (4)	8.6 (16)	1.9 (42)
5	3.6 (12)	0	0	0	0.6 (1)	7.0 (13)	1.2 (26)
6	0	0	0	0	0.6 (1)	0	0.04 (1)
Equivalent**	0	100	0	100	0	0	67.5
Non response rate (%)	5.4	Unknown***	8.5	0	0	Unknown***	

N = Number of drivers for which the information was recorded.
* Significant difference.
** A different scoring system was used in Denmark and Italy.
*** No registration of or information on the patients that refused is available.
N.A. = not applicable (not recorded).
[a]Monday–Thursday 4.00–22.00.
[b]Friday–Sunday 4.00–22.00.
[c]Monday–Thursday 22.00–4.00.
[d]Friday–Sunday 22.00–4.00.

were we did find a significant difference ($p < .05$). Cocaine was more often found combined than alone.

Belgium and Finland had a significantly higher prevalence of cannabis than the other four countries ($p < .05$) (Table 3). This significance disappears for Finland when correcting for age and gender. In all countries, male drivers tested more frequently positive for THC than female drivers (only significant in Belgium, $p < .05$). No female drivers tested positive for THC in Finland, Lithuania, and the Netherlands. In general, THC was more prevalent among drivers younger than 35 years. THC was often found combined with other substances, mostly alcohol.

Italian drivers (2.1%, CI: 1.6–3.5) tested significantly more frequently positive for illicit opiates than Danish, Lithuanian, and Dutch drivers ($p < .05$). Apart from one case in Italy, all

Table 3. Prevalence in percentage (N between brackets) of alcohol and drugs in seriously injured drivers in 6 European countries

	BELGIUM	DENMARK	FINLAND	ITALY	LITHUANIA	THE NETHERLANDS
	% (N)	% (N)	%(N)	% (N)	% (N)	% (N)
Positive drivers[a]	**52.6 (171)**	**30.3 (252)**	**44.7 (21)**	**32.0 (216)**	**27.8 (107)**	**33.9 (63)**
CI	*47.3–57.8*	*27.3–33.5*	*32.2–57.9*	*28.6–35.6*	*23.6–32.5*	*27.5–40.9*
Female	37.2 (35)	15.8 (46)	20.0 (2)	23.7 (37)	20.9 (28)	13.5 (5)
Male	59.1 (136)	38.1 (206)	51.4 (19)	34.4 (179)	32.4 (77)	38.9 (58)
<35y	55.4 (92)	31.6 (148)	53.8 (14)	38.0 (127)	28.1 (56)	39.6 (42)
≥35y	47.9 (70)[g]	28.3(101)[d]	28.3 (7)	26.0 (89)	27.8 (45)[f]	26.3 (21)
Alcohol						
≥0.1 g/L	42.5 (148)	19.7 (165)	32.1 (17)	23.1 (156)	17.7 (68)	29.6 (55)
CI	*37.4–47.8*	*17.2–22.5*	*21.2–45.4*	*20.0–26.4*	*14.2–21.8*	*23.5–36.5*
Alone	29.9 (98)	14.4 (117)	22.6 (12)	18.5 (125)	15.2 (59)	25.3 (47)
Male	50.6(123)*	27.3 (149)*	35.7 (15)	25.0 (130)*	19.3 (46)	34.2 (51)*
Female	24.0 (25)	5.5 (16)	18.2 (2)	16.7 (26)	16.4 (22)	10.8 (4)
<35y	45.8 (81)	22.5 (106)*	42.9 (12)	26.3 (88)*	19.6 (39)	35.8 (38)*
≥35y	38.0 (60)	16.1 (58)	20.0 (5)	19.9 (68)	16.0 (26)[e]	21.3 (17)
0.1 g/L ≤ alcohol ≤ 0.5 g/L *CI*	4.3 (15) *2.6–7.0*	1.9 (16) *1.2–3.1*	1.9 (1) *0.3–9.8*	2.5 (17) *1.6–4.0*	1.6 (6) *0.7–3.4*	1.6 (3) *0.5–4.6*
≥0.5 g/L *CI*	38.2 (133) *33.3–43.4*	17.8 (149) *15.3–20.5*	30.2 (16) *19.6–43.4*	20.6 (139) *17.7–23.8*	16.1 (62) *12.7–20.1*	28.0 (52) *22.1–34.8*
Amphetamines	**2.6 (9)**	**4.2 (35)**	**3.7 (2)**	**0.1 (1)**	**0.6 (2)**	**2.2 (4)**
CI	*1.4–4.9*	*3.0–5.8*	*1.0–12.5*	*0.0–0.8*	*0.2–2.0*	*0.9–5.5*
Alone	0.9	1.0	0.0	0.0	0.3	1.1
Male	3.3 (8)	5.3 (29)*	4.7 (2)	0.1 (1)	0.8 (2)	2.0 (3)
Female	1.0 (1)	2.0 (6)	0.0 (0)	0.0 (0)	0.0 (0)	2.7 (1)
<35y	3.4 (6)	6.3 (30)*	3.6 (1)	0.0 (0)	0.0 (0)	3.8 (4)
≥35y	1.9 (3)	1.4 (5)	3.8 (1)	0.3 (1)	1.2 (2)	0.0 (0)
Cocaine	**2.3 (8)**	**0.6 (5)**	**0.0**	**2.7 (18)**	**0.3 (1)**	**2.1 (4)**
CI	*1.2–4.5*	*0.3–1.4*	*0.0–6.6*	*1.7–4.2*	*0.1–1.5*	*0.8–5.3*
Alone	0.0	0.0		0.6	0.3	0.0
Male	3.3 (8)	0.9 (5)		3.3 (17)	0.4 (1)	2.0 (3)
Female	0.0 (0)	0.0 (0)		0.6 (1)	0.0 (0)	2.7 (1)
<35y	3.4 (6)	1.1 (5)*		2.4 (8)	0.0 (0)	3.8 (4)
≥35y	0.6 (1)[b]	0.0 (0)		2.9 (10)	0.6 (1)	0.0 (0)
THC	**7.6 (26)**	**1.3 (11)**	**5.7 (3)**	**3.7 (25)**	**0.5 (2)**	**0.5 (1)**
CI	*5.3–10.9*	*0.7–2.3*	*2.0–15.3*	*2.5–5.4*	*0.1–1.8*	*0.1–2.9*
Alone	1.5	0.6	1.9	1.6	0.3	0.5
Male	10.0 (24)*	1.8 (10)	7.1 (3)	4.4 (23)	0.8 (2)	0.7 (1)
Female	2.0 (2)	0.3 (1)	0.0 (0)	1.3 (2)	0.0 (0)	0.0 (0)
<35y	13.6 (24)*	1.3 (6)	10.7 (3)	6.0 (20)*	0.5 (1)	0.9 (1)
≥35y	0.6 (1)[b]	1.4 (5)	0.0 (0)	1.5 (5)	0.6 (1)	0.0 (0)
Illicit opiates	**0.6 (2)**	**0.5 (4)**	**0.0**	**2.1 (14)**	**0.3 (1)**	**0.0**
CI	*0.2–2.1*	*0.2–1.3*	*0.0–6.6*	*1.6–3.5*	*0.1–1.5*	*0.0–2.0*
Alone	0.0	0.0		0.7	0.0	
Male	0.8 (2)	0.7 (4)		2.5 (13)	0.4 (1)	
Female	0.0 (0)	0.0 (0)		0.6 (1)	0.0 (0)	
<35y	0.6 (1)	0.0 (0)		2.7 (9)	0.5 (1)	
≥35y	0.6 (1)	1.1 (4)*		1.5 (5)	0.0 (0)	
Benzodiazepines	**7.3 (25)**	**6.7 (56)**	**10.2 (5)**	**0.7 (5)**	**3.6 (14)**	**0.0**
CI	*5.0–10.5*	*5.2–8.6*	*4.6–21.1*	*0.3–1.7*	*2.1–6.0*	*0.0–2.0*
Alone	1.5	1.2	0.0	0.4	2.3	
Male	6.7 (16)	7.6 (41)	12.8(5)	0.2 (1)	4.2 (10)	
Female	8.9 (9)	5.1 (15)	0.0 (0)	2.6 (4)*	3.0 (4)	
<35y	1.7 (3)	6.8 (32)	11.1 (3)	0.3 (1)	3.0 (6)	
≥35y	11.5 (18)*[c]	6.4 (23)	9.1 (2)	1.2 (4)	4.3 (7)[b]	
Z–drugs	**1.8 (6)**	**1.2 (10)**	**3.8 (2)**	**0.0**	**0.0**	**0.5 (1)**
CI	*0.8–3.8*	*0.7–2.2*	*1.2–12.7*	*0.0–0.6*	*0.0–1.0*	*0.1–2.9*
Alone	0.9	0.5	1.9			0.5
Male	0.4 (1)	1.1 (6)	4.8 (2)			0.7 (1)

Table 3. *(Continued)*

	BELGIUM	DENMARK	FINLAND	ITALY	LITHUANIA	THE NETHERLANDS
	% (N)	% (N)	%(N)	% (N)	% (N)	% (N)
Female	4.9 (5)*	1.4 (4)	0.0 (0)			0.0 (0)
<35y	0.0 (0)	0.4 (2)	3.6 (1)			0.0 (0)
≥35y	2.6 (4)*[d]	2.2 (8)*	4.0 (1)			1.2 (1)
Medicinal opioids	**3.3 (11)**	**4.2 (35)**	**4.0 (2)**	**3.7 (25)**	**7.8 (30)**	**0.5 (1)**
CI	*1.8–5.7*	*3.0–5.8*	*1.2–13.0*	*2.5–5.4*	*5.5–10.9*	*0.1–2.9*
Alone	1.8	2.5	2.0	1.8	5.7	0.5
Male	3.4 (8)	3.5 (19)	2.6 (1)	3.5 (18)	10.1 (24)	0.7 (1)
Female	3.1 (3)	5.5 (16)	9.1 (1)	4.5 (7)	3.7 (5)**	0.0 (0)
<35y	4.0 (7)	1.9 (9)	0.0 (0)	4.2 (14)	6.5 (13)[e]	0.0 (0)
≥35y	1.9(3)[b]	6.9 (25)[b]	8.0 (2)	3.2 (11)	8.6 (14)	1.2 (1)
Alcohol–Drug combination	**13.2 (43)**	**5.4 (45)**	**10.6 (5)**	**4.6 (31)**	**2.3 (9)**	**4.3 (8)**
CI	*10.0–17.2*	*4.1–7.1*	*4.9–21.6*	*3.3–6.5*	*1.2–4.3*	*2.2–8.2*
Male	16.1 (37)	7.6 (41)*	13.5 (5)	5.2 (27)	2.5 (6)	4.7 (7)
Female	6.4 (6)	1.4 (4)	0.0 (0)	2.6 (4)	2.2 (3)	2.7 (1)
<35y	14.5 (24)	6.6 (31)	15.4 (4)	5.4 (18)	1.5 (3)	7.5 (8)*
≥35y	9.6 (14)[h]	3.9 (14)	4.8 (1)	3.8 (13)	3.1 (5)[b]	0.0 (0)
Drug–Drug combination	**2.5 (8)**	**3.5 (29)**	**4.3 (2)**	**2.5 (17)**	**0.8 (3)**	**0.5 (1)**
CI	*1.3–4.7*	*2.5–5.0*	*1.3–13.4*	*1.6–4.0*	*0.3–2.3*	*0.1–2.9*
Male	3.0 (7)	3.7 (20)	5.4 (2)	3.3 (17)*	1.3 (3)	0.7 (1)
Female	1.1 (1)	3.1 (9)	0.0 (0)	0.0 (0)	0.0 (0)	0.0
<35y	3.6 (6)	3.4 (16)	3.8 (1)	3.6 (12)	0.5 (1)	0.9 (1)
≥35y	1.4 (2)	3.6 (13)	4.8 (1)	1.5 (5)	0.6 (1)[b]	0.0

[a]For the calculation of the prevalence of positive drivers substance groups were mutually exclusive. A subject could only be part of one group only, independently of the number of substances taken, either the driver tested positive or not.

* Significant difference in distribution of positive drivers by age or gender ($p < .05$) within a country.

** For one driver positive for medicinal opioids gender was unknown.

CI = confidence interval.

[b]For 1 positive driver age was unknown.

[c]For 4 positive drivers age was unknown.

[d]For 2 positive drivers age was unknown.

[e]For 3 positive drivers age was unknown.

[f]For 6 positive drivers age was unknown.

[g]For 9 positive drivers age was unknown.

[h]For 5 positive drivers age was unknown.

drivers positive for illicit opiates were male. Out of 21 cases from all countries, 16 were in combination with other drugs. The most common combinations were with cocaine and THC.

Medicinal drugs

Finnish drivers tested significantly more frequently positive for benzodiazepines than Italian, Lithuanian, and Dutch drivers ($p < .05$) (Table 3). However, after correction for age and gender, the significance disappeared. The highest prevalence in male drivers was found in Finland (12.8%), and in female drivers in Belgium (8.9%). In Italy, significantly more female drivers tested positive for benzodiazepines than male drivers. In three out of five countries where benzodiazepines were found, a higher prevalence was recorded among drivers older than 35 years. The vast majority of the benzodiazepine-positive drivers tested also positive for another psychoactive substance.

As for the benzodiazepines, Finnish drivers tested significantly more positive for Z-drugs than Italian, Lithuanian, and Dutch drivers ($p < .05$). However, the significance disappeared after correction for age and gender. Only one positive driver was recorded in the Netherlands and none in Italy and Lithuania. Z-drugs were significantly more common among drivers older than 35 years in BE and DK ($p < .05$). Approximately half of the positive drivers were also positive for another substance.

The highest prevalence of medicinal opioids was recorded in Lithuania (Table 3) ($p < .05$). This was almost double compared to the other countries. This difference remained significant, even after correction for age and gender. Medicinal opioids were observed in both genders and in all age groups. Approximately half the cases were found in combination with other substances, mostly alcohol.

Combinations

The highest prevalence of alcohol-drug combinations was found in Belgium (13.2%). Belgium also had the highest prevalence of male (16.1%) and female drivers (6.4%) testing positive for an

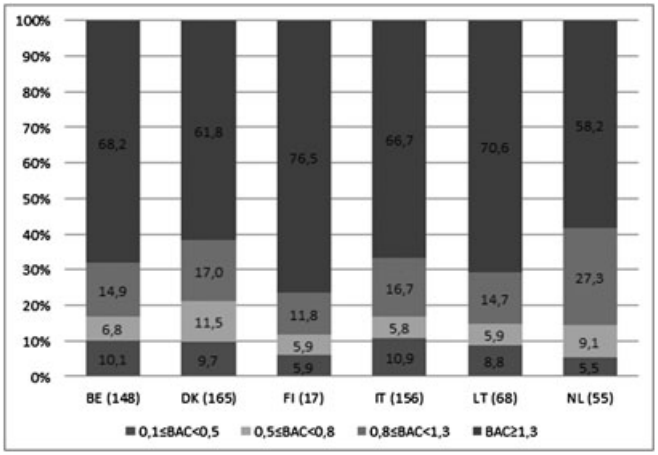

Figure 1. Distribution of positive alcohol findings by BAC-group (in g/L) and by country.

alcohol-drug combination. In the majority of the countries, this combination was more prevailing among drivers younger than 35 years. Drug combinations were mostly observed among male drivers. Female drivers positive for a drug combination were only observed in Belgium (1.1%) and Denmark (3.1%). Prevailing alcohol-drug combinations were alcohol and benzodiazepines (1.1%) and alcohol and cannabis (0.8%). The most common drug-drug combinations were cannabis and cocaine (0.2%) and cannabis and medicinal opioids (0.2%).

Discussion

Summary of the results

This study confirms that psychoactive substances are frequently detected in blood of seriously injured drivers.[9,15,17,27,33] Belgium and Finland had the highest prevalence of alcohol and drugs (roughly 40% of positive drivers in Finland and 50% in Belgium) compared to about 30% in the other countries. For Finland this can be explained by the fact that psychoactive substances are more frequently used by the general population than in other European countries (e.g. Denmark, the Netherlands, and Germany).[34] The sample size in Finland was low, with large error margins. The prevalence found in Belgium was similar to previous studies.[23,35]

Alcohol

Alcohol (BAC ≥ 0.1 g/L) was the most common finding, with few (approximately 10%) BACs <.05 g/L. Other studies found similar results.[16,27] Among the alcohol-positive drivers, 66% had a BAC ≥ 1.3 g/L. In a recent report, the estimated prevalence of alcohol (BAC ≥ 1.3 g/L) among the general driving population in Europe, was 0.39%.[36] This result was based on the outcome of 13 roadside surveys in different European countries. If one could keep this small group of drivers with very high BAC-levels (≥1.3 g/L) off the roads, the number of (alcohol-positive) crashes would significantly drop.

A much higher prevalence of alcohol was found among Belgian drivers (BAC > 0.1 g/L: 42.5%; BAC > 0.5 g/L: 38.2%) compared to the other five countries. This percentage was also higher than in the two previous studies conducted in Belgium (BAC > 0.5 g/L: 35.5%[23] and 34%,[35,37] respectively.[23,35] Belgium also had one of the highest alcohol prevalence in the recent DRUID roadside survey.[36]

No significant differences in the distribution of alcohol concentrations were found between the countries. This is notable since in the DRUID roadside survey, significant differences in the distribution of alcohol concentrations were recorded.[36] Approximately 60% of the Italian and Lithuanian alcohol-positive injured drivers had a BAC ≥0.5 g/l, while in the other countries this was only 20–40%. The high prevalence of high BACs in injured drivers (about 66% of all drivers had a BAC ≥ 1.3 g/L) suggests a high crash risk when driving with such a high BAC. Recent risk estimation calculations have confirmed that driving with a high BAC (≥1.3 g/L) causes a very high risk of getting injured in a car crash.[38]

Illicit drugs

Cannabis was the most common illicit drug, except in Finland. In Europe, it has been estimated that the prevalence of cannabis among injured drivers varies from 3.3–10.0%.[25] Two reviews of studies from European and non-European countries reported prevalence rates of 5–16.9% among non-fatally injured drivers,[39] and 4–14% among injured or fatally injured drivers.[40] In the present study, the prevalence of cannabis ranged from 0.5 (LT and NL) to 7.6% (BE), which is rather low compared to previous studies. Cannabis prevalence was especially high in Belgium, mainly in young (<35 years) male drivers, which confirms the findings of other studies.[21,41–43] A notable finding is the low prevalence found in the Netherlands where only one injured driver (0.5%) tested positive for cannabis. Roadside surveys performed between January 2007 and July 2009 recorded a prevalence of 1.67% among Dutch drivers compared to 0.35% among Belgian drivers.[36] Based on these figures, a higher prevalence of cannabis was expected among injured drivers the Netherlands.

For other illicit drugs, major differences were found among the countries. Some variations exist between the injured drivers sample of the six countries (e.g. significantly more male drivers in Italy), which could partially explain the variations that exist in the presence of illicit drugs between the countries. Amphetamines were more common in northern Europe, while cocaine was more prevalent in southern Europe. Danish and Swedish studies report similar prevalence data[21,44] for amphetamine. The prevalence of cocaine found in Italy (2.7%) is similar to the one recorded in another Italian study (3%).[45] A recent study performed in Spain found an even higher percentage of cocaine-positive drivers (male drivers = 7.2%; female drivers = 3.8%).[46] In general, the prevalence of cocaine found in our study is much lower than in studies from the United States, Denmark, and France (range between 3.6–18.7%).[3,21,27,43,47,48] Finally, illicit opiates were only found in Belgium, Denmark, Italy, and Lithuania. In the DRUID roadside surveys, the prevalence of illicit opiates among the general driving population was < 0.1% in all countries except Italy (0.3%).[36]

Medicinal drugs

We observed major differences between the countries. Benzodiazepines were the most prevailing medicinal drugs in Belgium, Denmark, and Finland, while medicinal opioids were more prevalent in the other three countries. The highest prevalence of medicinal drugs was found in Finland and Denmark, which corresponds to previous data for the Nordic countries.[17,49] However the confidence intervals in Finland were wide due to the low sample size (benzodiazepines: 4.6–21.1%; Z-drugs: 1.2–12.7%). Belgian

drivers tested rather frequently positive for benzodiazepines and Z-drugs (7.3%). This could be expected since Belgium has still one of the highest benzodiazepine consumptions in Europe.[50–52] Secondly, in the DRUID roadside survey, a higher prevalence of benzodiazepines was observed in the Belgian general driving population (2.02%) compared to other countries (NL:0.44%, DK:0.51%, FIN:1.08%; LT:1.44%; IT:1.72%).[36] Some other studies found a prevalence of benzodiazepines ranging between 1.2–9.6%.[3,8,21,41,42,47,48] Benzodiazepines and Z-drugs were recorded in both genders, and more frequently in the older age groups (>35 years). However, supratherapeutic blood concentrations were recorded in only 30 cases (7.3%). This suggests that medicinal drug use was of a therapeutic nature rather than from abuse. Nevertheless, the fact that medicinal drugs were usually detected at sub-therapeutic or therapeutic levels does not exclude a potential driving impairment caused by these drugs, especially as case–control studies revealed that the use of therapeutic doses of, for example, benzodiazepines elevates the risk of motor vehicle accidents.[38,53–55] One should also note that medicinal drugs were very often found in combination with alcohol or other, mostly illicit, drugs.

Combinations

Most substances were found in combination with alcohol or other drugs, from approximately 50% up to 100% of the positive drivers. The high prevalence of drug combinations among injured drivers confirms that the risk increases exponentially when substances are combined.[1,38,42,53,56,57] In the DRUID roadside survey, the weighted average percentage was only 0.37% and 0.39%, respectively, for combinations with alcohol and other drug classes.[36] The synergistic effect of the combination of alcohol and other drugs, resulting in high risk, makes it especially important to identify this group and to remove it from the road. Moreover, our study provides evidence that focusing only on alcohol in traffic safety initiatives will miss the other drugs that are found in a significant proportion of drivers involved in crashes.

From our data, it is apparent that a large percentage of drivers involved in traffic crashes in Europe have alcohol or drugs in their blood. These findings would further motivate effective preventive actions directed against drink and drug-driving. In several countries (e.g. the Netherlands, France, Sweden, and Finland), drink-drivers can only regain the right to drive by having an alcohol interlock device (alcolock) installed in their car. Studies showed that alcolocks are useful in both commercial and non-commercial contexts and result in a decrease of recidivism.[58,59] With regard to medicinal drugs, putting a (legal) responsibility on both the patients and the physician might be a preventive strategy.[60] Healthcare professionals should be encouraged to inform patients about the potential increase in crash risk when taking certain medicinal drugs such as benzodiazepines. Unfortunately, a recent study showed that patient knowledge regarding driving under the influence of medicines was rather low. The authors concluded that by increasing healthcare-provided awareness about medicines and driving, patient knowledge would also increase.[61]

For all six countries, these data clearly indicate that for the two most common drugs, alcohol and cannabis, young male drivers (under 35 years) are the most at-risk driver group. On the other hand medicinal drugs (benzodiazepines, medicinal opioids and z-drugs) were more frequently observed in female and older drivers (over 35 years).

The high prevalence rates of psychoactive substances among crash-involved drivers might provide a justification for routine testing for the most common impairing substances in the emergency department. Furthermore, identifying the presence of alcohol and/or drugs, which is often associated with cross-tolerance to a number of sedative and analgesic medications, may also assist in pain management.[46,62] Finally, a detection in the emergency department helps to identify problematic users of alcohol and drugs and to refer them to an appropriate treatment at an early stage.[63]

Strengths and limitations of the study

As far as we know, this is the first study on seriously injured drivers performed simultaneously in various countries using a common study design, which allows comparison of results between the countries involved.

There are some limitations, however, with regard to the study design and data collection. The hospitals involved in the present study did not always cover the whole of the participating countries. Therefore, some questions can be raised concerning representativeness. Secondly, when applying all inclusion criteria, the sample size for some countries (e.g. FI and NL) became rather small. It is recommended that in future research drivers with an MAIS 1 injury score are also included. There is no clear evidence that the use of psychoactive substances is related to more severe accidents.[64,65] Furthermore, the inclusion percentage of the six studies is not known. Therefore it is impossible to estimate whether selective inclusion introduced a bias.

Although hospital staff was asked to record any drug administered to the driver before blood sampling, there is a possibility that in some cases this was not done. This may have led to an overestimation of the prevalence of benzodiazepines and medicinal opioids. Finally, the maximum delay between the crash and blood sampling was 3 h. The drug concentrations can decrease between the time of the crash and the blood sampling. Therefore, in most cases the measured concentration was lower than at the time of the crash.

Conclusions

This study confirms the high prevalence of psychoactive substances in seriously injured drivers, but we observed major differences between the studied countries. Alcohol (≥ 0.1 g/L) was the most common finding. Notable are the many drivers having a BAC ≥ 1.3 g/L. Cannabis was the most prevailing illicit drug, with benzodiazepines and medicinal opioids the most common medicinal drugs. Illicit drugs were more prevalent among male drivers younger than 35 years, while medicinal drugs were found more often among female drivers older than 35. The majority of psychoactive substances were found in combination with other ones, mostly alcohol. The high prevalence of high BACs and combinations (compared to the roadside survey) suggest that those drivers are most at risk and that preventive actions should target them preferentially.

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