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Research Paper

A comparison of alcohol and drug use by random motor vehicle drivers in Brazil and Norway

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ABSTRACT

Background: A large proportion of road traffic crashes are related to driving under the influence (DUI) of alcohol or drugs. The aim of this study was to compare the use of alcohol, illegal drugs and psychoactive medicinal drugs among random drivers in Brazil and Norway, two countries with the same legal limit for drunk driving, but with marked differences in legislation history, enforcement and penalties for DUI, and to discuss any differences found.
Methods: Roadside surveys were conducted on Fridays and Saturdays between noon and midnight. Samples of oral fluid were collected for analysis of drugs, whereas alcohol was determined by breath testing or by analysis of oral fluid.
Results: High participation rates of 94–97% were obtained in both countries. The weighted prevalence of driving with alcohol concentrations in breath or oral fluid equivalent to blood alcohol concentrations (BAC) above 0.2 g/L was 2.7% (95% CI 2.2–3.3) in Brazil and 0.2% (95% CI 0.0–0.5) in Norway. Stimulants (amphetamines or cocaine) were found in samples from 1.0% (95% CI 0.7–1.4) of drivers in Brazil and 0.3% (95% CI 0.1–0.7) in Norway. The prevalence of amphetamines was highest among Brazilian truck drivers (3.6%; 95% CI 2.0–6.4). Tetrahydrocannabinol was found in samples from 0.5% (95% CI 0.3–0.8) of drivers in Brazil and 1.0% (95% CI 0.6–1.5) in Norway, whereas benzodiazepines or zopiclone were found in 1.0% (95% CI 0.7–1.4) and 1.7% (95% CI 1.2–2.4) of the samples from Brazil and Norway, respectively.
Conclusions: The difference in the prevalence of alcohol may be related to the fact that Norway has implemented steps to reduce drunk driving since 1936, whereas Brazil has attempted to do the same for only a few years. Differences for drugs may be related to different patterns in the use of stimulants, cannabis and medicines.

Introduction

The number of serious road traffic accidents in low and middle income countries has increased during the last decades. When calculating the sum of years of life lost due to premature mortality and years lived with disability, the so-called disability adjusted life years (DALYs), road traffic accidents was globally ranked as the 10th most important reason for lost years of life or years with disability in 2010 (Murray et al., 2012). The World Health Organization predicts that by 2030 road traffic injuries will rise to become the fifth leading cause of death with 2.4 million fatalities (WHO, 2009).

Ninety-one percent of the world's fatalities on the roads occur in low-income and middle income countries, which have only 48% of the world's registered vehicles (WHO, 2011). The number of fatal traffic crashes has decreased steadily in high income countries for the last decades, but the number is increasing in low and middle income countries (WHO, 2011).

The use of alcohol or drugs (drugs are in this article defined as illicit drugs or psychoactive medicinal drugs) is a contributing factor in a large proportion of traffic accidents. However, only 89 countries, covering 66% of the world's population, have a

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comprehensive driving under the influence (DUI) law with a BAC limit of 0.5 g/L or less (WHO, 2013), which is often regarded as an appropriate limit because the crash risk increases significantly for BACs above this concentration (Voas, Torres, Romano, & Lacey, 2012; Zador, Krawchuk, & Voas, 2000). Some countries have also laws against DUI of illegal and medicinal drugs, either per-se laws, zero tolerance, or impairment laws (OECD, 2010; Vindenes et al., 2012). DUI laws, enforcement and penalties vary between countries and have been implemented at different historical moments. Also, the drivers' knowledge and respect for the DUI laws vary (Antov et al., 2012); therefore the incidence of driving under the influence of alcohol or drugs and the involvement of alcohol and drugs in fatal crashes varies.

In the USA, the proportion of drivers involved in fatal crashes who had blood alcohol concentrations (BACs) above the legal limit of 0.8 g/L declined from 48% in 1982 to 31% in 2010 (NHTSA, 2011). The prevalence of drunk driving has also decreased (Kelley-Baker et al., 2013). It is likely that this positive trend may be related to changes in laws, enforcement, and public knowledge and opinion.

In a study of fatal traffic accident victims in Porto Alegre, Brazil, alcohol was found in blood samples from 32.2% of the accident victims (Stampe et al., 2010). Analysis of other psychoactive substances was performed for about two thirds of the cases, with positive findings in about 11% of the samples. In a similar study in São Paulo, 42.3% of drivers involved in fatal road traffic accidents where blood samples were analysed for alcohol had blood alcohol concentrations (BAC) above 0.6 g/L (Ponce, Munoz, Andreuccetti, de Carvalho, & Leyton, 2011). In a Norwegian study of 196 drivers killed in 2006–8, 25.0% were found to have BAC above the legal limit of 0.2 g/L, 10.2% were found positive for illegal drugs, and 13.8% were positive for psychoactive medicinal drugs (Gjerde, Christophersen, Normann, & Mørland, 2011). In the recent European project "Driving under the Influence of Drugs, Alcohol and Medicines" (DRUID), the prevalence of alcohol and drugs in blood samples from seriously injured drivers in six countries and fatally injured drivers in four countries were studied. Type of crash (single or multiple vehicle accident) was available for five and three countries, respectively. Among injured drivers, 41–68% of drivers involved in single vehicle accidents and 15–35% of those injured in multiple vehicle accidents had used alcohol or drugs, whereas among drivers killed in road accidents in three countries, 47–58% of those killed in single vehicle accidents and 19–32% of those killed in multiple vehicle accidents had alcohol (above 0.1 g/L) or drugs present in their blood (Isalberti et al., 2011) (for cut-off concentrations see Isalberti et al., 2011 or Houwing et al., 2012). Comprehensive reviews of alcohol and drug findings in injured or killed drivers in many countries have been published (Gonzalez-Wilhelm, 2007; Kelly, Darke, & Ross, 2004; Penning, Veldstra, Daamen, Olivier, & Verster, 2010; Walsh, de Gier, Christophersen, & Verstraete, 2004), confirming that large proportions of the drives had used alcohol or drugs.

To reduce the number of alcohol and drug related traffic crashes, it is important to reduce the number of alcohol and drug impaired drivers on the roads. As the first country in the world, Norway introduced legal BAC limit in 1936. At that time the limit was set to 0.5 g/L, and for many decades the sentence for drunk driving was three weeks in prison and withdrawal of the driver's license for more than a year. The legal limit was lowered to 0.2 g/L in 2001 and the sentence for drunk driving was changed, to only a fine and withdrawal of the driver's license for low BACs and unconditional imprisonment for BACs above 1.2 g/L in addition to a fine and withdrawal of the driver's license. From 1981 the police was allowed to do random breath testing without any particular suspicion of drunk driving, and if the driver refused to give a breath test, a blood sample could be taken by force. For driving under the influence of drugs, Norway had an impairment law until 2012; then a per-se law was introduced with legislative limits for 20 illegal and medicinal drugs (un-prescribed use) (Vindenes et al., 2012). The impairment law still applies for other drugs.

Brazil introduced a legal BAC limit of 0.8 g/L in 1989; this was reduced to 0.6 g/L in 1997. In 2008 the "zero" limit was introduced with suspension of driving privileges for a BAC above 0.2 g/L. Drivers can refuse to give a breath of blood sample. This option is fairly commonly chosen because the penalty seems not to be very much deterring. The sentence for driving with BAC above 0.6 g/L is imprisonment, a fine, and withdrawal of the driver's license for one year. For lower BACs the penalty is a smaller fine as well as withdrawal of the license. The incidence of drunk driving is fairly high; almost 35% of the population of major urban centres reported driving after drinking at least three units of alcohol during the previous 12 months (Pechansky et al., 2009). Previous studies at sobriety checkpoints in Brazil found that 22–38% of the motor vehicle drivers at night-time in weekends had been drinking (Campos, Salgado, Rocha, Duailibi, & Laranjeira, 2008; Duailibi, Pinsky, & Laranjeira, 2007). Tougher sanctions were implemented in the country at the end of 2012, where any trace of alcohol found in a blood sample or breath test would allow for legal sanctions. However, for driving under the influence of drugs other than alcohol, Brazil still faces a "grey area", where sanctions are clearly described in the law, but the assessment of drug impairment lacks definitions for its implementation.

Brazil and Norway had the same legal limit for alcohol of 0.2 g/L at the time of this study (2008–2009); however, the enforcement and penalties for DUI have been different, as described above. The aim of this study was to compare the use of alcohol and drugs among drivers in random traffic in Brazil and Norway, to discuss reasons for the differences and possible interventions.

Methods

Drivers were recruited for this study using stratified multi-stage cluster sampling procedures between August 2008 and September 2009 in Brazil and between April 2008 and March 2009 in Norway. In the first stage, geographical districts were chosen. In Brazil, federal highways within 50 km from the geographical center of the 27 state capitals were chosen, whereas in Norway, roads were selected within 200 km from Oslo, the Norwegian capital and the largest city of the country; within 120 km from the cities of Bergen, Trondheim and Tromsø, which are the largest cities in western, middle and northern Norway, and within 120 km from Haugesund, the second largest city in south-western Norway. In Brazil, the sample was stratified by the type of vehicle with random selection in proportion to the fleet size in each state; this was not done in Norway. In the second stage, random road sites and time intervals were selected. Recruitment of drivers (drivers of cars, vans, trucks, buses, motorcycles and mopeds) was performed Friday and Saturday between noon and midnight. The third stage consisted of randomly stopping and interviewing drivers who were older than 18 years of age and consented to participate in the studies. The data collection was carried out in cooperation with the Federal Highway Police in Brazil or the Mobile Police Service in Norway. The police stopped the drivers, and they received oral and written information about the study. They were invited by the police (in Brazil) or project team members (in Norway) to participate in the study. More detailed information about the recruitment and sampling procedures has been published earlier (De Boni et al., 2012; Gjerde et al., 2013; Houwing et al., 2011; Pechansky et al., 2012).

Samples of oral fluid were collected using two different devices: the Quantisal Oral Fluid Collection Device (Immunalysis Corporation, Pomona, CA, USA) was used in Brazil, whereas the Statsure Saliva Sampler (Statsure Diagnostic Systems, Framingham, MA,

Table 1
Cut-off concentrations and crude (unweighted) prevalences of alcohol and drugs.

Substance	Cut-off concentration[a] (ng/mL)	Crude prevalence (%)	
		Brazil (N = 3326)	Norway (N = 2038)
Alcohol (ethanol)	0.2 g/L oral fluid 0.10 mg/L air	3.4	0.2
Amphetamines	–	0.7	0.3
Amphetamine	25	0.5	0.1
Diethylpropion (amfepramone)	25	0.0	NA
Fenproporex	25	0.4	NA
Methamphetamine	25	0.0	0.2
3,4-Methylenedioxy-N-ethylamphetamine (MDEA)	25	0.0	0.0
3,4-Methylenedioxy-N-methylamphetamine (MDMA)	25	0.0	0.0
3,4-methylenedioxyamphetamine (MDA)	25	0.0	0.0
Methylphenidate	25	0.0	NA
Benzodiazepines and z-drugs	–	0.7	1.7
Alprazolam	1.0	0.2	0.0
Bromazepam	1.0	0.1	NA
Clonazepam	0.5	0.2	0.1
Diazepam	1.0	0.3	0.4
Flunitrazepam	0.3	0.0	0.0
Lorazepam	1.6	0.1	0.0
Midazolam	0.5	0.0	NA
Nitrazepam	0.5	0.0	0.0
Nordiazepam	1.0	0.0	0.7
Oxazepam	5.0	NA	0.2
Temazepam	1.0	0.0	NA
Zolpidem	10	NA	0.0
Zopiclone	10	NA	0.7
Cocaine	–	0.7	0.3
Cocaine	10	0.7	0.2
Benzoylecgonine	10	0.0	0.3
Cannabis	–		
Tetrahydrocannabinol	1.0	0.4	1.0
Opioids	–	0.0	0.4
Codeine	20	0.0	0.4
Methadone	20	0.0	0.0
Morphine	10	0.0	0.1
Tramadol	50	0.0	NA
Negative	–	94.4	96.4

[a] In un-diluted (native) oral fluid. NA = not analyzed.

USA) was used in Norway because the study was performed as a part of the European DRUID Project (Houwing et al., 2011) and therefore had to comply with the study protocol. Those two devices have identical sampling pads and plastic tubes; thus, there were no differences in the collection of oral fluid. The Quantisal device contained 3 mL buffer whereas the Statsure device contained 1 mL. Both buffers contained phosphate, sodium chloride and antimicrobial agents, and the Statsure buffer also detergents and metal chelators. The difference in sample dilution was accounted for when calculating the alcohol and drug concentrations in native (un-diluted) oral fluid.

Breath alcohol was analysed in Brazil by using breathalysers (Alco-Sensor IV, Intoximeters Inc., St. Louis, MO, USA); a blood to breath ratio of 2000 was used to estimate the BAC. In Norway, alcohol was analysed in sampled oral fluid by using an enzymatic method (Kristoffersen & Smith-Kielland, 2005). The alcohol concentration in native oral fluid was calculated by multiplying the concentration found in the oral fluid-buffer mixture with the actual dilution factor for each single sample (calculated as volume of the oral fluid-buffer mixture divided by the volume of the collected native oral fluid sample; the volume of the native oral fluid sample was determined by weighing the sample) and a blood to oral fluid ratio of 1.22 (Verstraete et al., unpublished observations) was used to calculate the BAC. Cut-off concentrations for alcohol in oral fluid and breath are presented in Table 1.

Drug concentrations in oral fluid-buffer mixtures were analysed using liquid chromatography–tandem mass spectrometry (Øiestad, Johansen, & Christophersen, 2007; Zancanaro et al., 2012). Drug concentrations in native oral fluid were calculated by multiplying the concentrations in the oral fluid-buffer mixtures with the dilution factors. Cut-off concentrations for native oral fluid are presented in Table 1.

Drivers were included in 27 Brazilian states and in five Norwegian regions. The distribution of included drivers between states or regions did not accurately match the distribution of vehicles. Therefore, weighting factors were calculated by dividing the real probability of each vehicle in the state or region by the probability of each vehicle in our sample from each country. Thus, the distribution of included vehicles in the weighted sample matched the actual distribution of vehicles between regions in each country. Individual weights were calculated for each vehicle type for the Brazilian sample and for the total number of vehicles for the Norwegian sample.

The sampling was divided into four time periods: 1: Friday 12:00–17:59; 2: Friday 18:00–24:00; 3: Saturday 12:00–17:59; and 4: Saturday 18:00–24:00. The distribution of drivers over time periods was different for the Brazilian and Norwegian samples of drivers. The prevalence of alcohol or drugs may also be different in those time periods; therefore, each participant in the Brazilian and Norwegian samples were multiplied with a weighting factor so that the weighted distribution for both countries matched a common time period distribution. As distribution we chose the distribution of Norwegian motor vehicles over the four time periods in 2008, which was obtained from the Norwegian Roads

Table 2
Characteristics of included drivers (%).

Characteristics	Brazil ($N = 3326$)	Norway ($N = 2038$)
Gender		
Male*	94.5	72.5
Female*	5.5	27.5
Age groups		
<25*	12.5	10.4
25–34*	33.4	18.5
35–44	27.5	25.7
45–54*	18.7	21.2
55–64*	6.6	16.0
>64*	1.3	8.1
Day and time		
Friday 12:00–17:59*	25.4	39.1
Friday 18:00–24:00*	24.4	18.7
Saturday 12:00–17:59*	24.6	28.6
Saturday 18:00–24:00*	25.6	13.5
Vehicle type		
Car/van*	50.9	99.2
Truck*	10.0	0.4
Bus*	10.1	0.0
Motorcycle or moped*	29.0	0.4

* $p < 0.05$.

Administration (Oslo, Norway); the distribution is presented in a footnote in Table 3.

Possible differences in the distribution of gender, age groups, time intervals and vehicle types were investigated using Pearson's chi-square test for categorical data.

Possible differences in substance use between the two countries were investigated with binomial logistic regression. Type of country was used as a covariate (with two categories: 0 = Brazil, 1 = Norway), and each substance or substance group was included as a dependent variable (also with two categories: 0 = negative, 1 = positive). In all statistical tests, the conventional critical 5% level was used to assess whether the obtained odds ratio (OR) significantly deviated from 1.

For the prevalence of alcohol or drugs, Wilson binomial 95% confidence intervals (95% CI) were calculated incorporating continuity correction (Blyth & Still, 1983; Newcombe, 1998; Wilson, 1927) using the weighted prevalence and actual numbers of included drivers.

Calculation of weighted prevalence of alcohol or drugs and logistic regression analysis were performed using SPSS 20 statistical software (IBM Corporation, Armonk, NY).

The Brazilian study was approved by the Institutional review board of Hospital de Clínicas of Porto Alegre and the Norwegian study by the Regional Committee for Medical and Health Research Ethics.

Results

The refusal rates among those who were asked to participate in the study were 3% in Brazil and 6% in Norway. In total, 3326 drivers were included in Brazil and 2038 drivers in Norway.

The distribution of gender and age among participants in addition to types of vehicles and the distribution of time periods are presented in Table 2. Statistically significant differences between the included drivers in Brazil and Norway ($p < 0.05$) were observed for gender, for five of the age groups, for all time periods and for all vehicle types.

Crude prevalence of alcohol and drugs in samples of oral fluid from drivers in Brazil and Norway are presented in Table 1. Weighted results are presented in Table 3. The prevalence results do not sum up to 100% because samples might be positive for more than one drug.

The most significant difference was observed for alcohol; only 0.2% of Norwegian drivers had BACs above 0.2 g/L, whereas 2.7% of Brazilian drivers had BACs above this limit. The median BAC was 0.41 g/L for Norwegian drivers and 0.42 g/L for Brazil drivers with BAC ≥0.2 g/L. Logistic regression analysis found significant differences between the two countries (OR = 0.09, 95% CI 0.03–0.27) when including gender, age group and time period as covariates in the statistical analysis.

Tetrahydrocannabinol (THC) was more frequently found in samples from Norwegian than Brazilian drivers (0.8% versus 0.5%); this difference was statistically significant (OR = 3.30, 95% CI 1.63–6.70).

A difference was also observed for total use of any stimulant drug (1.1% in samples from Brazilian and 0.3% from Norwegian drivers), although statistically significant only when not including gender as covariate (OR = 0.40, 95% CI 0.17–0.94).

There was no significant difference for other drugs or drug groups.

If studying only male drivers, the prevalence of alcohol and illicit drugs were slightly higher in both countries; for alcohol 2.9% (95% CI 2.4–3.6) and 0.3% (95% CI 0.1–0.7) for Brazilian and Norwegian drivers, respectively, for stimulants 1.1% (95% CI 0.8–1.6) and 0.5% (95% CI 0.2–1.0), and for THC 0.5% (95% CI 0.3–0.9) and 1.3% (95% CI 0.8–2.1) for Brazilian and Norwegian drivers, respectively. For benzodiazepines/zopiclone the prevalence was 0.9% (95% CI 0.6–1.3) and 1.3% (95% CI 0.8–2.1), respectively.

If excluding truck drivers, there were no significant changes except for amphetamines; the prevalence was 0.2% and 0.1% for Brazilian and Norwegian drivers, respectively. This reduction also affected the prevalence of stimulants in total, which was 0.8% and 0.3%. The prevalence of amphetamines in samples from truck drivers in the Brazilian sample was 3.6% (95% CI 2.0–6.4).

Table 3 also shows that the prevalence of alcohol among Brazilian drivers was significantly higher on Saturdays than Fridays, higher prevalence after 18:00 than before. The prevalence of stimulants and THC seemed also to be higher on Saturdays than on Fridays, but the difference was not statistically significant.

Discussion

The main finding of this study was that drunk driving was found to be more common in Brazil than in Norway. The use of stimulants was more common among Brazilian drivers, primarily due to the use of amphetamines by truck drivers, whereas the use of cannabis was more common among Norwegian drivers.

Methods

The recruitment procedures in Brazil and Norway were able to recruit random drivers from roads with medium to high traffic density close to and in major cities during the study periods. The participation rates were good, better than those obtained in most other studies. The participation rates in similar studies in the USA were 79–86% for breath alcohol testing and 67–71% for providing an oral fluid sample (Lacey, Kelley-Baker, Furr-Holden, Brainard, & Moore, 2007; Lacey et al., 2009a, 2009b). The participation rate in the DRUID project varied between countries and ranged from 48% to 77% in Belgium, Finland, Sweden, Lithuania, and the Czech Republic to 90–99% in Hungary, Norway, the Netherlands, Denmark, Portugal, Spain and Poland; whereas in Italy the participation was compulsory and a participation rate of 100% was obtained (Houwing et al., 2011).

Significant differences were observed regarding types of vehicle, primarily reflecting differences among drivers in Brazil and Norway. However, in the Norwegian study, large motor vehicles were under-represented due to lack of parking space on most

Table 3
Weighted prevalence (%)[a] of alcohol and drugs in samples of oral fluid for the four time periods studied. The total prevalence is presented for each single substance or substance group, i.e. alone or in combination with other substances.

Substance(s)	1: Friday12:00–17:59	2: Friday18:00–24:00	3: Saturday12:00–17:59	4: Saturday18:00–24:00	Total[a]
Brazil (no. of drivers)	845	811	818	852	3326
Alcohol	1.1 (0.5–2.1)	1.7 (1.0–3.0)	3.7 (2.5–5.3)	5.8 (4.3–7.6)	2.7 (2.2–3.3)
Stimulants	0.6 (0.2–1.5)	0.7 (0.3–1.7)	1.6 (0.9–2.8)	1.6 (0.9–2.8)	1.0 (0.7–1.4)
Amphetamines	0.3 (0.1–1.1)	0.4 (0.1–1.2)	0.8 (0.4–1.8)	0.7 (0.3–1.6)	0.5 (0.3–0.8)
Cocaine or benzoylecgonine	0.2 (0.0–1.0)	0.4 (0.1–1.2)	0.8 (0.4–1.8)	0.9 (0.4–1.9)	0.5 (0.3–0.8)
THC	0.3 (0.1–1.1)	0.3 (0.0–1.0)	0.6 (0.2–1.5)	0.9 (0.4–1.9)	0.5 (0.3–0.8)
Benzodiazepines or zopiclone	1.0 (0.4–1.9)	0.8 (0.3–1.7)	1.4 (0.7–2.5)	0.4 (0.1–1.1)	1.0 (0.7–1.4)
Opioids	0.0 (0.0–0.6)	0.0 (0.0–0.6)	0.0 (0.0–0.6)	0.0 (0.0–0.6)	0.0 (0.0–0.1)
One or more drugs	1.9 (1.1–3.1)	1.3 (0.7–2.5)	3.7 (2.5–5.3)	2.9 (1.9–4.4)	2.4 (1.9–3.0)
Multiple drugs	0.0 (0.0–0.6)	0.4 (0.1–1.2)	0.5 (0.2–1.3)	0.3 (0.1–1.1)	0.2 (0.1–0.5)
Alcohol and drug(s)	0.0 (0.0–0.6)	0.0 (0.0–0.6)	0.1 (0.1–1.4)	0.4 (0.1–1.1)	0.1 (0.0–0.3)
All negative	96.9 (95.5–97.9)	96.9 (95.6–98.1)	92.8 (90.7–94.4)	91.7 (89.6–93.4)	95.0 (94.2–95.7)
Norway (no. of drivers)	797	382	583	276	2038
Alcohol	0.1 (0.0–0.8)	0.0 (0.0–1.2)	0.4 (0.1–1.4)	0.0 (0.0–1.7)	0.2 (0.0–0.5)
Stimulants	0.2 (0.0–1.0)	0.2 (0.0–1.7)	0.4 (0.1–1.4)	0.6 (0.1–2.9)	0.3 (0.1–0.7)
Amphetamines	0.0 (0.0–0.6)	0.2 (0.0–1.7)	0.2 (0.0–1.1)	0.6 (0.1–2.9)	0.1 (0.0–0.5)
Cocaine or benzoylecgonine	0.2 (0.0–1.0)	0.0 (0.0–1.2)	0.2 (0.0–1.1)	0.6 (0.1–2.9)	0.2 (0.1–0.5)
THC	0.5 (0.2–1.4)	0.8 (0.2–2.5)	1.3 (0.6–2.8)	2.3 (0.9–4.9)	1.0 (0.6–1.5)
Benzodiazepines or zopiclone	2.4 (1.5–3.8)	1.5 (0.6–3.6)	0.7 (0.2–1.9)	1.8 (0.7–4.4)	1.7 (1.2–2.4)
Opioids	0.5 (0.2–1.4)	0.8 (0.2–2.5)	0.2 (0.0–1.1)	0.0 (0.0–1.7)	0.4 (0.2–0.8)
One or more drugs	3.3 (2.2–4.8)	3.2 (1.7–5.6)	2.2 (1.2–3.9)	4.7 (2.6–8.1)	3.2 (2.5–4.1)
Multiple drugs	0.3 (0.0–1.0)	0.2 (0.0–1.7)	0.4 (0.1–1.4)	0.6 (0.1–2.9)	0.3 (0.1–0.7)
Alcohol and drug(s)	0.0 (0.0–0.6)	0.0 (0.0–1.2)	0.0 (0.0–0.8)	0.0 (0.0–1.7)	0.0 (0.0–0.2)
All negative	96.6 (95.0–97.7)	96.8 (94.4–98.3)	97.3 (95.5–98.4)	95.3 (91.9–97.4)	96.6 (95.7–97.3)

[a] Weighted for number of vehicles in each state or region so that the distribution of the weighted sample matched the actual distribution. Weighted for time periods so that the weighted samples matched the following distribution: 34.9%, 23.1%, 25.3%, and 17.4% for time periods 1–4.

roadside survey sites. Trucks represented 4.2% of the total vehicle-kilometres driven in Norway in 2008 (Vågane, 2012) but only 0.4% of included drivers. The prevalence of alcohol or drugs in samples of oral fluid among truck drivers in Norway has previously been found to be lower than among car and van drivers (Gjerde et al., 2012), so the under-representation of truck drivers in the Norwegian sample is expected to have little effect on the total findings.

The number of motorcycle riders was also under-represented in the Norwegian sample; the number of kilometres driven by motorcycles corresponds to 2.8% of the total vehicle-kilometres driven (Vågane, 2012) but only 0.4% of the included drivers. Some reasons for this under-representation might have been that drivers below 18 years of age, who mostly were driving mopeds, were excluded from the study, that the police might have prioritized controlling cars and vans and that few control sites where located on roads where motorcycles and mopeds were most commonly used. In Brazil, motorcycle riders represented 29% of the drivers.

Two different collection devices for oral fluid were used; however, sampling was equal and recoveries of drugs were similar (Langel et al., 2008; Moore et al., 2006; Quintela, Crouch, & Andrenyak, 2006). Therefore, we expect the analytical findings in oral fluid collected with those two devices to be similar.

Findings

There were marked differences in the prevalence of alcohol, but also differences regarding the prevalence of stimulants and THC. The differences are partly related to differences in gender distribution. The proportion of female drivers was very low in Brazil, constituting only 5.5% of the participants, whereas among Norwegian drivers, 27.7% were female. It has previously been found that the use of illicit drugs was more common among male than female drivers in Norway and other European countries (Gjerde et al., 2013; Houwing et al., 2011), therefore differences in the gender distribution has affected the total findings. In this study, the total differences in the prevalence of THC in samples from Brazilian and Norwegian drivers was not statistically significant, as the 95% CI were overlapping. However, when only studying male drivers, the difference was significant. Logistic regression analysis, which included gender and other factors as covariates, also found significant differences in THC findings.

The prevalence of stimulants was lower in samples from Norwegian drivers than in samples from Brazilian drivers, although the differences for the individual compound groups amphetamines and cocaine/benzoylecgonine were not statistically significant. Of the amphetamines, only amphetamine and methamphetamine were found in the Norwegian samples. In Brazil, the most frequently used amphetamine drug was fenproporex, which is an appetite suppressant but also used as a stimulant drug, and which is metabolized to amphetamine after intake (Comiran et al., 2012). The majority of the amphetamine findings in Brazilian samples were therefore due to intake of fenproporex. This drug has not been available in Norway. In Brazil, amphetamines were most commonly found in samples from truck drivers, which confirms the finding of high prevalence of amphetamines in urine samples from Brazilian truck drivers in a previous study (Leyton et al., 2012; Silva, Greve, Yonamine, & Leyton, 2003).

There were large differences regarding the prevalence of drunk driving. The result for Norway was equal to the previously published prevalence of 0.2–0.3% (Gjerde et al., 2008, 2013), in spite of the fact that drivers were included only Fridays and Saturdays between noon and midnight in this study, whereas weighted averages for the whole week was reported previously. The proportion of Brazilian drivers with BAC above 0.2 g/L was lower than estimated in a study in inner-city São Paulo performed during Friday and Saturday nights using passive breath sensors. In that study, 27% of drivers in 2007 and 11% of drivers in 2009 were positive for alcohol (Campos et al., 2013). This high prevalence was probably related to the fact that the study was performed only in the city and not on federal highways and that it was performed between 11 pm and 3 am only.

The low prevalence of drunk driving in Norway is probably related to the fact that Norway has had a strict DUI law since 1936 with strong enforcement and hard sentences for a long time period. Random breath testing (RBT) was introduced in Norway in 1981; drivers can be stopped and asked to provide a breath sample

anywhere without any suspicion of DUI. Random breath testing is used by 74% of the world's countries to help enforce drink–driving laws, but this figure varies with country income status, with 88% of high-income, 77% of middle-income, and 45% of low-income countries adopting this practice (WHO, 2013). In 2008, more than 0.3 million roadside breath alcohol tests per million inhabitants were performed by the police in Norway (Jost, Popolizio, Allsop, & Eksler, 2010). If a driver refuses to give a breath sample a blood sample may be taken by force. After more than 70 years of strong enforcement of the DUI law combined with severe penalties and many information campaigns, it is now socially unacceptable to drive with BAC above the legal limit in Norway (Assum, 2010).

During the time of the study in Brazil and until very recently, suspected drunk drivers might refuse to provide breath or blood samples and sanctions and penalties would be low at that point. Brazil still struggles to reverse the scenario towards a more positively enforced approach and a socially undesirable combination of drinking and driving, as is shown in Norway. There are different reasons for that – ranging from the recent changes in the law – which still has not caught up as a cultural aspect of daily driving – to enforcement issues. It is still culturally accepted to drink and drive at almost any occasion in Brazil, and only recently the combination of preventive campaigns and repeated roadside blocks have started to promote change. Although penalties have grown tougher in the last years, enforcement and quick, effective sanctions or imprisonment are still scare – yielding a sense of impunity that is still part of the driving culture in the country (Pechansky & Chandran, 2012).

There are different reasons to consider when trying to understand the differences in the prevalence of drunk driving found between Norway and Brazil. Norway has implemented a sequential set of steps regarding drunk driving since 1936, whereas Brazil has only seriously attempted to modify this relationship in the last five years. All things considered, it may take a generation or more for these changes and implementations to be expressed in a substantial reduction of figures in countries such as Brazil and other low and middle income countries, which face the same reality. According to theories of social deterrence derived from the social sciences, the "rational choice" of a protective behaviour – such as wearing seatbelts, reducing speed and avoiding drunk or drugged driving – is in the end the outcome of a decision balance tilted towards societal gains versus individual benefits (Grasmick & Bursik, 1990; Watling, Palk, Freeman, & Davey, 2010). This only happens in a milieu where the individual feels that his deviant behaviour comes at a very high price. Therefore, the high incidence of drunk driving in Brazil when compared to Norway may in the end be a reflection of a combination of factors, such as: a very recent implementation of a strict "dry law"; a culture of permissiveness or low enforcement with regard to enforcement and sanctioning, and ultimately lack of structure to adequately measure enforcement and direct social policies accordingly. This is a reality of many developing countries such as Brazil, where law implementation and strict enforcement are not the rule. Effective approaches such as systematic data collection and rigorous exchange of information with transit authorities and policymakers may eventually reduce this gap in the future.

It is also important to note that alcohol policies in general are more permissive in Brazil than in Norway. This lack of regulation is probably related to the findings reported by Health Metrics and Evaluation, where alcohol use was found to be the third risk factor for disease burden in Brazil (IHME, 2010a) whereas in Norway it ranks eight (IHME, 2010b). In Norway, the alcohol related burden was primarily associated with mental health; whereas in Brazil, it was mainly related to violence and traffic accidents, reflecting an alcohol market that is young and poorly regulated. However, these conclusions are based on limited data on the exposure of alcohol and drugs and the outcome of diseases and injuries.

The risk for involvement in road traffic accidents has in general been found to be higher among drivers under the influence of alcohol than among drivers under the influence of cannabis, cocaine or a medicinal drug (Bernhoft, Hels, Lyckegaard, Houwing, & Verstraete, 2012); however, the risk is of course also related to the dose taken. The use of a psychoactive medicinal drug in prescribed doses giving a concentration in blood corresponding to low and medium therapeutic levels is expected to give only a slight increase in crash risk. However, recreational use of psychoactive medicines to get "high" and combination of two or more psychoactive medicines, illicit drugs or alcohol may cause highly increased crash risk.

The incidence of drunk driving was found to be fairly high in Brazil, higher than in Norway and many European countries (Houwing et al., 2011). To reduce the number of traffic accidents related to use of alcohol or drugs, it is therefore most important to reduce the number of drunk drivers. In countries where the incidence of drunk driving is low and driving under the influence of drugs is more frequent, such as Norway, actions against drugged driving may also be important. This may also be the case for subgroups of drivers who are commonly using drugs and are often involved in crashes, such as truck drivers in some countries (Drummer et al., 2004; Oliveira, Yonamine, Andreuccetti, Ponce, & Leyton, 2012).

There are different actions and interventions that can be used to prevent DUI and DUI-related crashes causing material damage, injuries and fatalities; however, laws, resources and funding may be a limiting factor in many countries.

Firstly, it is important that the appropriate laws are in place and that they make it difficult or unattractive to try to escape from prosecution if apprehended by the police for DUI.

Secondly, the enforcement should be comprehensive and visible so that drivers perceive the risk for being arrested as significant if driving under the influence of alcohol or drugs. The uses of RBT and sobriety checkpoints or roadblocks are effective in this respect (Cobiac, Vos, Doran, & Wallace, 2009; Elder, Shults, & Sleet, 2002; Ferguson, 2012; Peek-Asa, 1999; Solomon, Chamberlain, Abdoullaeva, & Tinholt, 2011). Cost-benefit analyses have shown that increased RBT will even be cost-effective in Norway (Elvik et al., 2012), which already has a large number of RBT campaigns performed each year. The inability to effectively detect and prosecute impaired drivers reduces the perceived risk of apprehension and, in turn, the deterrent effect of the law.

Thirdly, education and information campaigns to teach drivers about the risks posed by driving under the influence of alcohol or drugs and consequences regarding punishment for DUI are important. Information should also be given on possible reductions in the quality of life for drivers, third parties and their families if the driver or another road user is seriously injured or killed in a crash. Studies have shown that carefully planned mass media campaigns that are well executed and implemented in conjunction with other on-going preventive activities, such as high visibility enforcement, were effective in reducing DUI (Elder et al., 2004).

Fourthly, introducing alcohol interlocks in cars of drivers convicted for drunk driving and treatment or rehabilitation programs for drivers with alcohol abuse problems may reduce DUI recidivism (Elder et al., 2011; Willis, Lybrand, & Bellamy, 2004).

And finally, the possibility of easily getting alternative transportation, such as taxis and buses, may reduce the incidence of drunk or drugged driving.

Conclusion

Driving with BAC above the legal limit of 0.2 g/L was found to be more common in Brazil than in Norway. The use of stimulants (amphetamines or cocaine) was more common among the Brazilian drivers, primarily due to high prevalence of amphetamines in

samples from truck drivers, whereas the use of cannabis was more common among Norwegian drivers. It is most important to reduce the incidence of drunk driving, because alcohol is commonly used and because alcohol impairment poses a larger risk to road safety than impairment after using a medicinal or illegal drug. In countries and in subgroups of drivers where the prevalence of drunk driving is low and driving under the influence of drugs is more frequent, actions against drugged driving may also be important.

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Conflict of interest

All authors declare that they have no conflicts of interest.

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