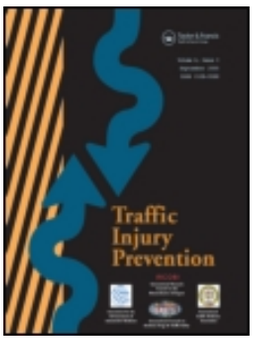

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Norwegian Roadside Survey of Alcohol and Drug Use by Drivers (2008–2009)

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Objective: To examine alcohol and drug use among random drivers in different regions of Norway by analyzing oral fluid, compare drivers in urban and rural areas, compare with results from the roadside survey in southeastern Norway in 2005–2006, and roughly estimate the prevalence of driving with blood drug concentrations above the new Norwegian legislative limits among random drivers. This roadside survey was part of the European DRUID (Driving Under the Influence of Drugs, Alcohol and Medicines) Project.

Methods: Drivers were selected for a voluntary and anonymous study using a stratified multistage cluster sampling procedure in collaboration with the Mobile Police Service. Samples of oral fluid were taken using the Statsure Saliva Sample (Statsure Diagnostic Systems, Framingham, MA), and the drivers' gender, age, and nationality were recorded. Samples of oral fluid were analyzed for alcohol or drugs, for a total 28 psychoactive substances.

Results: One hundred eighty-four roadside survey sessions were conducted and 10,004 drivers were asked to participate. The refusal rate was 5.8 percent. Psychoactive substances were found in 4.8 percent of the 9410 oral fluid samples analyzed. Alcohol was detected in 0.3 percent, medicinal drugs in 3.2 percent, and illegal drugs in 1.5 percent of the samples. Illegal drugs were significantly more frequently detected in samples from southeastern Norway including the capital Oslo, whereas medicinal drugs were more frequently detected in samples from southeastern Norway excluding Oslo. Illegal drugs were significantly more frequently detected in samples from drivers in urban areas than in rural areas, though there were no significant differences for alcohol and medicinal drugs. Medicinal drugs were most commonly found in samples collected during the daytime on weekdays (3.8%), and illegal drugs were most commonly found in samples collected during late night on weekdays or weekends (2.8%–3.2%). The most commonly found substances were the sleeping agent zopiclone (1.4%), the main active substance in cannabis tetrahydrocannabinol (1.1%), and the sedative drug diazepam (0.7%). The prevalence of driving with drug concentrations above the Norwegian legislative limits for blood was estimated to be about 0.2 percent for alcohol, 0.6 percent for illegal drugs, and about 1.3 percent for medicinal drugs.

Conclusions: The incidence of drink driving was very low, though driving after using psychoactive illegal or medicinal drugs was more frequent.

Supplemental materials are available for this article. Go to the publisher's online edition of *Traffic Injury Prevention* to view the supplemental file.

Keywords: alcohol, drugs, impairment, epidemiology

Introduction

It is well known that a large number of road traffic crashes are related to the use of psychoactive substances, particularly alcohol. Therefore, most countries have introduced legal limits for alcohol, and some countries have zero tolerance laws or impairment laws regarding driving under the influence of psychoactive medicinal and illegal drugs.

A legal blood alcohol concentration (BAC) limit of 0.5 g/kg blood (about 0.05 g/dL) was introduced in Norway in 1936, and the enforcement of the law has historically been strong compared to many other countries; in 2008 more than 0.3 million roadside breath alcohol tests per million inhabitants were performed by the police in Norway (Jost et al. 2010). The punishment for drunk driving was for many decades unconditional imprisonment for at least 3 weeks and suspended driver's license for 2 years when driving with a BAC above the legal limit. The legal limit was reduced to 0.2 g/kg blood (about 0.02 g/dL) in 2001, and the punishment was also moderated. In February 2012, legislative limits were also introduced for 20 other psychoactive substances (Vindenes et al. 2012). The combination of low legal limits, strong enforcement, severe punishment, and information campaigns has made drunk driving socially unacceptable by the vast majority of the population (Assum 2010).

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The incidence of drunk driving in Norway has decreased during the last decades. In the 1980s, 0.3 percent of the motor vehicle drivers had BACs above 0.05 g/dL (Glad 1985), whereas in 2005–2006, about 0.1 percent of the drivers had alcohol concentrations in oral fluid above 0.05 g/dL and 0.3 percent above 0.02 g/dL (Gjerde et al. 2008); the alcohol concentration in oral fluid has been shown to correspond closely to the BAC (Jones 1979). A study organized by the European Traffic Police Network (TISPOL) found that only 0.2 percent of 32,000 Norwegian drivers had breath alcohol concentrations above the legal limit (TISPOL 2009). On the other hand, the number of blood samples from suspected drugged drivers submitted for drug analysis by the police increased from about 2076 in 1989 to 4525 in 2008 (Edland-Gryt 2009), which is a high number for a country with such a small population. The high number is probably related to strong enforcement of driving under the influence laws.

A study of psychoactive substances in blood samples from fatally injured car and van drivers in Norway in 2006–2008 found that 37.8 percent of the drivers had used alcohol or drugs prior to the crash; alcohol concentrations above 0.02 g/dL were found in 25.0 percent of the samples, illicit drugs in 10.2 percent, and psychoactive medicinal drugs in 13.8 percent of the samples. The prevalence of psychoactive drugs in samples from drivers killed in single-vehicle accidents was 64.3 percent, whereas the prevalence in samples form drivers killed in multiple-vehicle crashes was 17.9 percent (Gjerde, Christophersen et al. 2011).

We have previously studied the use of alcohol and drugs by random drivers in southeastern Norway, excluding the capital Oslo, during 2005–2006 (Gjerde et al. 2008). Alcohol or drugs were found in 4.5 percent of the samples. Illegal drugs were most frequently found among young male drivers, and medicinal drugs were most prevalent among elderly female drivers.

The new roadside survey of 2008–2009 was performed as a part of the European DRUID project (DRUID Project) to study the use of alcohol and drugs by drivers in 13 European countries. The study was designed to compare the situation in different countries and to calculate odds ratios for involvement in traffic crashes after using alcohol and different drug classes (Hels et al. 2011). The same analytical cutoff concentrations (alcohol or drug concentrations above which a sample is regarded as positive) were used by all participating countries. In order to enable a comparison of the drug prevalence in blood samples with the prevalence in oral fluid samples, drug cutoff concentrations were chosen so that the prevalence of positive drug findings would be equal in samples of blood and oral fluid from the studied population (also called *equivalent cutoffs*; Gjerde and Verstraete 2011;Verstraete et al. 2011). For some drugs, the cutoff concentration in oral fluid had to be higher than in blood and for other drugs, lower. The analytical cutoffs were different from those used in previous studies because of the requirement for equivalent cutoffs in oral fluid and blood.

The aim of this report is to give an overview of the results from the Norwegian roadside survey of 2008–2009 to supplement the results that already have been published in the DRUID roadside survey reports (Bernhoft et al. 2012; Houwing et al. 2011a, 2011b) and give a more in-depth analysis. The cutoffs used in this report are equal to those used in the study we performed in 2005–2006 (Gjerde et al. 2008), which was performed only in southeastern Norway, excluding the capital Oslo, and are for most substances lower than those used in the DRUID roadside survey reports. The study described in this article was performed in southeastern, southwestern, middle, and northern Norway, and drivers in Oslo were also included.

Methods

Study Design

Geographical Area

For practical and economical reasons, we could not perform roadside sampling completely by random in such a sparsely populated country as Norway, which has only 13 inhabitants per square kilometer (34 per square mile). Therefore, 6 representative regions were selected: 2 regions in southeastern Norway (Hedmark and Romerike and Buskerud and Asker-Bærum), 2 regions in southwestern Norway (Hordaland and Haugaland), and 2 regions in middle and northern Norway (Trøndelag and Troms); see Figure 1. The selected regions were located in 5 of Norway's 10 Mobile Police Service districts. Oslo police gave the Mobile Police Service of surrounding districts permission to stop drivers within Oslo.

Drivers were selected from April 2008 to March 2009 using a stratified multistage cluster sampling procedure. In the first stage, representative police districts were selected. In the

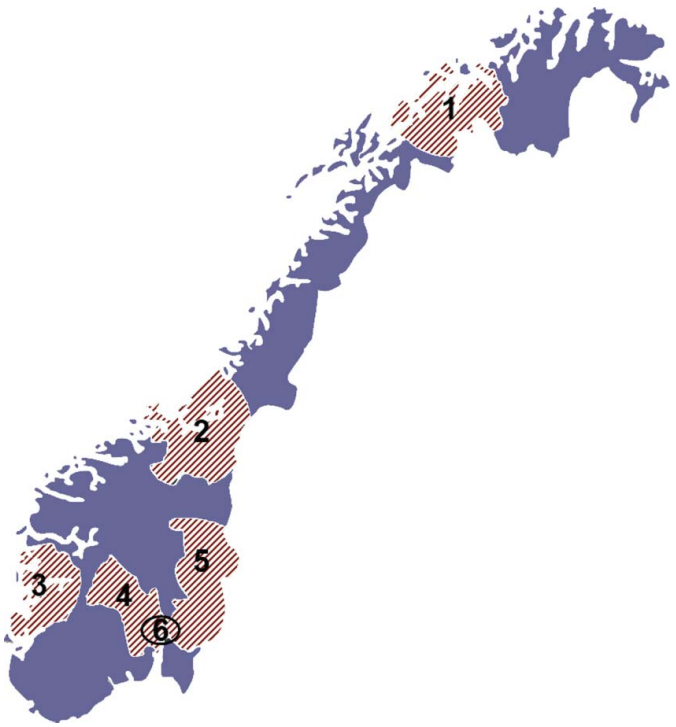

Fig. 1. Map showing the study regions: 1, Troms; 2, Trøndelag; 3, Hordaland and Haugaland; 4, Buskerud and Asker-Bærum; 5, Hedmark and Romerike; 6, Greater Oslo area (color figure available online).

second stage, random road sites and time intervals were selected according to a table of random sampling numbers (Lindley and Miller 1966). The third stage consisted of randomly stopping drivers. The data collection was carried out in cooperation with the National Mobile Police Service of Norway, which has the right to stop vehicles at random along highways without any particular suspicion.

Roads were chosen by first randomly selecting map coordinates within the study regions, weighted according to the population in the area, and then choosing the roads closest to the selected map coordinates. Road sites included both urban and rural roads but only within about 120 km from the Mobile Police Service headquarters in Haugesund, Bergen, Trondheim, and Tromsø and in southeastern Norway within about 200 km of Oslo.

Time intervals were chosen by first randomly selecting a period of 3 to 5 consecutive days for each police district for each season of the year. For each day, the starting time for roadside sampling was randomly selected. However, a few of the selected time periods had to be changed to comply with working time regulations for police officers. The time intervals covered 7 days per week and 21 h per day (excluding the time period from 3 a.m. to 6 a.m. due to working time regulations).

For each day, the police chose 2 road sites that were suitable as checkpoints located within a 30- to 45-min drive from each other. After stopping drivers at random for 2 h at the first site, the personnel had a 1-h break during which they moved to the second sampling site and continued sampling for 2 h. If more cars passed the site than the police or the research team could handle, the police were instructed to stop cars at random, rather than stopping old cars, young drivers, or other possible suspects of drugged driving.

Oral and written information about the project was given to each driver; leaflets were available in 12 languages. After an informed consent was obtained, a sample of oral fluid was taken and a questionnaire was filled in. Participating drivers did not receive any reward for taking part in the survey. The study was approved by the Regional Committee for Medical and Health Research Ethics.

Biological Samples

Samples of oral fluid were collected using Statsure Saliva Sampler (Statsure Diagnostic Systems, Framingham, MA). The oral fluid sampling kits were inspected visually, and kits that did not contain any buffer or contained a too small volume of buffer as observed visually were discarded (about 5%). When sampling oral fluid, the collection pad was placed under the tongue until the indicator turned blue or until 5 min had passed. The vial was then capped and labeled with a bar code label identical to the bar code of the questionnaire. The sample was kept in a bag at a temperature of approximately 5°C for a maximum of about 6 h. Samples from southeastern Norway were transported by car to the laboratory in Oslo and then frozen at about −20°C. Samples from other parts of Norway were frozen locally at about −20°C after each day of sample collection. Frozen samples were transported to Oslo by airplane in well-insulated containers to prevent the frozen samples from thawing during transport, and samples were kept frozen at the laboratory until analysis.

Analysis of Oral Fluid

One day before the analysis of oral fluid started, samples were thawed and weighed to determine the total amount of oral fluid collected, and aliquots were pipetted into separate tubes for analysis of alcohol and drugs. The concentrations of alcohol and drugs in undiluted oral fluid were calculated based on the weight of oral fluid collected, assuming that 1.0 mL buffer was present in the collection device. Analytical results are expressed in nanograms per milliliter of undiluted (native) oral fluid for drugs and in grams per deciliter for alcohol.

Alcohol was analyzed by an automated enzymatic method using alcohol dehydrogenase (Kristoffersen and Smith-Kielland 2005). Alcohol concentrations in oral fluid were multiplied by 1.22 to obtain the corresponding concentration in blood (A. Verstraete et al., unpublished observations, November 2009). Drug concentrations in oral fluid–buffer mixtures were determined by liquid chromatography–tandem mass spectrometry (Øiestad et al. 2007) using 3-point calibration. Analytical cutoff concentrations are presented in Table A1 (see online Appendix) and are equal to those used in our study performed in 2005–2006 (Gjerde et al. 2008). Samples with drug concentrations above the linearity limits for the analytical methods were diluted and reanalyzed.

Statistical Testing

Weighted prevalences of alcohol or drugs in samples of oral fluid were calculated using PASW 17 statistical software (IBM Corporation, Armonk, NY).

The participants were disaggregated into geographical strata from 4 regions: (1) middle and northern Norway, (2) southwest, (3) southeast except greater Oslo, and (4) the greater Oslo area. The weighted prevalence was calculated by first calculating the weight for the number of included drivers in relation to the population as follows: let p_a be the reported population in regions a, $a = 1, \ldots, 4$. The 4 p_as add to 1. Furthermore, let n be the total number of drivers and n_a be the number of included drivers in region a. Preliminary weights w_a were calculated such that the distribution of included drivers between regions in the weighted sample matched the proportion of the population; that is, $w_a \cdot n_a/n = p_a$, giving $w_a = p_a \cdot n / n_a$. Similarly, preliminary weights v_b, $b = 1, \ldots, 8$ for time periods of the week were calculated for each of the 4 regions; the 8 time periods were as follows: (1) Monday to Friday 04:00 a.m. to 9:59 a.m.; (2) Monday to Friday 10:00 a.m. to 3:59 p.m.; (3) Monday to Thursday 4:00 p.m. to 9:59 p.m.; (4) Monday to Thursday 10:00 p.m. to 11:59 p.m. and Tuesday to Friday 12:00 a.m. to 3:59 a.m.; (5) Saturday to Sunday 4:00 a.m. to 9:59 a.m.; (6) Saturday to Sunday 10:00 a.m. to 3:59 p.m.; (7) Friday to Sunday 4:00 p.m. to 9:59 p.m.; (8) Friday to Sunday 10:00 p.m. to 11:59 p.m. and Saturday to Monday 12:00 a.m. to 3:59 a.m. Time periods 5 to 8 were defined as weekend. The final weights for all drivers sampled in region a and time period b were given by $w_a \cdot v_b$.

Finally, let y_{abc} indicate the result of a drug test on the cth sampled driver in region a and time period b, where $y_{abc} = 1$ if the test is positive and 0 if it is negative. The prevalence of the drug was then estimated by $\sum_{\text{abcd}}(w_a \cdot v_b \cdot y_{abc}) / \sum_{\text{abcd}}(w_a \cdot v_b)$.

Pearson's 2-sided chi-square test for categorical data was used and Wilson binomial confidence intervals (Wilson 1927) were calculated incorporating continuity correction (Blyth and Still 1983; Newcombe 1998) using weighted prevalences and actual numbers of included drivers.

Estimation of cutoff concentrations in oral fluid corresponding to those used for blood was performed as described previously (Verstraete et al. 2011) using either mean or median oral fluid–to-blood ratios or prevalence regression (Gjerde and Verstraete 2011). Approximate 95 percent confidence intervals (CIs) for mean oral fluid–to-blood ratios were calculated as follows: $x' \pm 1.96 \cdot s/n^{\frac{1}{2}}$, where x' is the sample mean, s is the sample standard deviation, and n is the number of observations. Approximate 95 percent CIs for median oral fluid–to-blood ratios were estimated by first calculating the confidence interval quantiles p using the Wald method (Simonoff 2003): $p = p' \pm 1.96 \cdot [p'(1-p')/n]^{\frac{1}{2}}$, where p' for the median is 0.5 and n is the number of observations. Approximate CIs for prevalence regression curves were calculated by regression analysis using Microsoft Excel.

Results

Overview of Included Drivers

Altogether 184 roadside survey sessions were conducted, and 10,004 drivers were asked to provide a voluntary and anonymous sample of oral fluid. A total of 5.8 percent (583 drivers) refused to provide a sample of oral fluid. The refusal rate varied between different regions; in the southeast including Oslo, 6.2 percent; in the southwest, 6.7 percent; and in the middle/north, 3.9 percent. The refusal rate was highest between 6 a.m. and 10 a.m. (8.4% on weekdays and 9.4% on weekends) and lowest on weekends between 10 a.m. and 4 p.m. (3.6%). We were not allowed to collect any data on those who refused to participate in the study.

Eleven samples contained less than 0.1 mL of oral fluid and therefore could not be analyzed; those drivers were excluded. In addition, 28 samples contained sufficient volume for one method only (either alcohol or drugs); the analytical results for those are included. Thus, data from a total of 9410 drivers are included in this article, including 7992 car drivers, 1269 van drivers, 80 truck drivers, and 69 motorcycle or moped drivers.

About 23 percent of the drivers were included in middle or northern Norway, 20 percent from the southwest, 33 percent from the southeast except Oslo, and 25 percent from greater Oslo. As a comparison, in January 2001 about 24 percent of the population lived in middle or northern Norway, 24 percent in the southwest, 33 percent in the southeast, and 19 percent in greater Oslo (Statistics Norway).

Twenty-nine percent of the drivers were female, which roughly corresponds to the gender distribution of drivers in general road traffic (Vågane 2005). Seven percent were of foreign nationality. The age distribution was as follows: younger than 25, 10.6 percent; 25 to 34, 17.9 percent; 35 to 44, 24.0 percent; 45 to 54, 21.3 percent; 55 to 64, 17.0 percent; and older than 64, 9.2 percent. Age was not recorded for 0.1 percent of the drivers. However, we also observed that the distributions of age and gender among foreign drivers were different from those for Norwegians. Among Norwegian and foreign drivers, 51.3 and 68.0 percent were younger than 45 years of age, respectively, and 29.3 and 18.5 percent were female.

Alcohol and Drug Findings

Analytical results above the analytical cutoff limits are presented in Table A1 (see online Appendix) and show that the total prevalence of drivers who had recently used alcohol or drugs was 4.8 percent. The prevalence of alcohol above the cutoff of 0.01 g/dL was 0.3 percent, and the prevalence of alcohol above the legal limit of 0.02 g/dL was 0.2 percent.

It is likely that the prevalence of alcohol and drugs among drivers who refused to participate in this study was higher than among the participants. The police detected 6 drunk drivers who refused to provide oral fluid sample, which was detected by the routine breath alcohol testing performed by the police before referring the drivers to the study team. Those drivers are not included in our material but correspond to 0.06 percent more positive alcohol findings than reported in this article.

The use of defined cutoff concentrations is a systematic way of reporting analytical results regardless of the capability of the analytical methods (as long as the methods' limits of quantitation are lower than the cutoff concentrations) and enables a comparison of findings with other studies. The cutoff concentrations used in this study were equal to those used in our roadside survey performed in 2005–2006 and are listed in Table A1 (see online Appendix). Only results above the cutoff are included in the data presented. The cutoffs for most substances were lower than those used by the DRUID project in the calculation of odds ratios for accident involvement and for comparing drivers from different countries (Bernhoft et al. 2012; Hels et al. 2011; Houwing et al. 2011a, 2011b). The weighting of results was also different from that used in the DRUID project; in this article, weighting according to time periods was performed for each geographical stratum separately and, finally, weighting according to the populations in geographical regions was performed.

The results presented in Tables 1–3 and Tables A2–A3 (see online Appendix) represent findings of active drugs plus their active or inactive metabolites, thus reflecting a somewhat wider time range than the active drug only.

Analytical results for drivers in urban and rural areas are presented in Table 1 and show significantly higher prevalence of the major illegal drugs in samples from urban areas than rural areas ($P = .003$).

There were significant regional differences regarding use of illegal and medicinal drugs (Table 2). The prevalence of medicinal drugs was highest in samples from southeastern Norway excluding Oslo, and the prevalence of illegal drugs was highest in samples from southeastern Norway including Oslo.

Table 1. Weighted prevalence (and 95% CI) of alcohol and drugs in samples from drivers on urban and rural roads

Substance findings	Urban	Rural	Total	*P*
Total alcohol or drugs	5.2 (4.6–5.8)	4.5 (3.9–5.2)	4.8 (4.4–5.3)	.100
Alcohol	0.4 (0.3–0.6)	0.3 (0.2–0.5)	0.3 (0.2–0.5)	.394
Psychoactive medicinal drugs	3.3 (2.8–3.8)	3.1 (2.6–3.7)	3.2 (2.9–3.6)	.623
Zopiclone	1.5 (1.2–1.9)	1.3 (1.0–1.7)	1.4 (1.2–1.7)	.604
Benzodiazepines	1.8 (1.5–2.2)	1.4 (1.0–1.8)	1.6 (1.4–1.9)	.168
Diazepam/nordiazepam	1.1 (0.8–1.4)	0.8 (0.6–1.1)	1.0 (0.8–1.2)	.111
Codeine	0.3 (0.2–0.5)	0.6 (0.4–0.9)	0.4 (0.3–0.6)	.056
Illegal drugs	1.9 (1.6–2.3)	1.1 (0.8–1.5)	1.5 (1.3–1.8)	.003
Tetrahydrocannabinol	1.5 (1.2–1.9)	0.8 (0.6–1.1)	1.1 (0.9–1.4)	.002
Amphetamines	0.4 (0.3–0.6)	0.2 (0.1–0.4)	0.3 (0.2–0.4)	.209
Cocaine/benzoylecgonine	0.5 (0.3–0.7)	0.2 (0.1–0.4)	0.4 (0.3–0.6)	.027
Total no. of samples analyzed	5163	4247	9410	—

The prevalence of medicinal drugs was higher in samples collected between 6 a.m. and 4 p.m. during weekdays than on weekends or at night (Table 3). Zopiclone was the most frequently detected medicinal drug. It was most prevalent in samples collected during weekday mornings, and the prevalence declined through the day. Alcohol and illegal drugs were most prevalent in samples collected at night and early weekend mornings. In samples collected between Friday 10 p.m. and Saturday 4 a.m. and Saturday 10 p.m. to Sunday 4 a.m. ($n = 335$), the prevalence of alcohol was 0.9 percent and the prevalence of illegal drugs was 3.6 percent.

Significant differences were found between Norwegian and foreign drivers (Table A2, see online Appendix). The prevalence of alcohol and illegal drugs was significantly lower among Norwegian drivers, and the prevalence of medicinal drugs was somewhat higher, although not statistically significant.

Analytical results in relation to gender and age are presented in Figure 2 and show that illegal drugs were most often found in samples from young men, whereas medicinal drugs were most often found in samples from elderly women.

Analytical results for drivers in southeastern Norway from the studies in 2005–2006 and 2008–2009 are presented in (Table A3, see online Appendix). The same cutoff concentrations were used, and only drivers from the same police districts were included. There were some differences, particularly higher prevalence of benzodiazepines, tetrahydrocannabinol (THC), and cocaine in the 2008–2009 study.

Estimation of Driving with Drug Concentrations Above the New Legislative Limits

Drug concentrations in oral fluid cannot be used to accurately estimate drug concentrations in blood for an individual; however, there is a positive correlation between drug concentrations in oral fluid and blood (Gjerde et al. 2010; Verstraete et al. 2011; Wille et al. 2009), which makes it possible to estimate drug use in a cohort; for example, the prevalence of drug concentrations in blood above a given cutoff (Gjerde and Verstraete 2010, 2011; Verstraete et al. 2011).

Norway implemented legislative limits for a number of drugs in 2012. To estimate the prevalence of blood drug concentrations above the legislative limits among the included drivers, equivalent cutoff concentrations in oral fluid were used. The use of equivalent cutoff concentrations in oral fluid and blood will give the same prevalence of positive samples if analyzing oral fluid or blood in a large cohort of drug users. Paired samples of oral fluid and blood were used to determine equivalent cutoffs; see Verstraete et al. (2011). The equivalent cutoff concentrations in oral fluid and blood are presented in Table 4 together with prevalence data. In addition, mathematical simulations were used to estimate the blood drug concentration distribution matching the obtained drug concentrations in oral fluid using a previously published procedure (Gjerde and Verstraete 2010). This procedure cannot be used for small cohorts; therefore, we performed this procedure only for diazepam, zopiclone, and THC.

Table 2. Weighted prevalence (and 95% CI) of alcohol and drugs in samples from drivers in different regions

Substance findings	Greater Oslo	Southeast except Oslo	Southwest	Middle/north	*P*
Total alcohol or drugs	5.3 (4.4–6.3)	6.3 (5.5–7.2)	3.9 (3.1–4.9)	3.3 (2.6–4.1)	.000
Alcohol	0.5 (0.3–0.9)	0.4 (0.2–0.7)	0.1 (0.0–0.4)	0.2 (0.1–0.5)	.090
Psychoactive medicinal drugs	2.9 (2.3–3.7)	4.2 (3.5–5.0)	3.0 (2.3–3.9)	2.3 (1.7–3.1)	.002
Zopiclone	1.5 (1.1–2.1)	1.8 (1.4–2.4)	1.5 (1.0–2.2)	0.6 (0.3–1.1)	.004
Benzodiazepines	1.4 (1.0–2.0)	2.0 (1.5–2.6)	1.3 (0.9–1.9)	1.5 (1.0–2.1)	.194
Diazepam/nordiazepam	0.9 (0.6–1.4)	1.2 (0.9–1.7)	0.7 (0.4–1.2)	1.0 (0.7–1.6)	.378
Codeine	0.5 (0.3–0.9)	0.5 (0.3–0.8)	0.5 (0.2–1.0)	0.3 (0.1–0.6)	.649
Illegal drugs	2.1 (1.6–2.8)	1.9 (1.5–2.5)	1.0 (0.6–1.6)	1.0 (0.7–1.6)	.002
Tetrahydrocannabinol	1.5 (1.1–2.1)	1.3 (1.0–1.8)	0.7 (0.4–1.2)	0.9 (0.6–1.4)	.047
Amphetamines	0.4 (0.2–0.8)	0.5 (0.3–0.8)	0.1 (0.0–0.4)	0.2 (0.1–0.5)	.058
Cocaine/benzoylecgonine	0.7 (0.4–1.1)	0.6 (0.4–1.0)	0.1 (0.0–0.4)	0.0 (0.0–0.2)	.000
Total no. of samples analyzed	2345	3061	1839	2165	—

Table 3. Weighted prevalence (and 95% CI) of alcohol and drugs in samples from drivers at different times of the week

Substance findings	Weekday 6:00 a.m.–9:59 a.m.	Weekday 10:00 a.m.–3:59 p.m.	Weekday 4:00 p.m.–9:59 p.m.	Weekday 10:00 p.m.–2:59 a.m.	Weekend[a] 6:00 a.m.–9:59 a.m.	Weekend[a] 10:00 a.m.–3:59 p.m.	Weekend[a] 4:00 p.m.–9:59 p.m.	Weekend[a] 10:00 p.m.–2:59 a.m.	*P*
Total alcohol or drugs	5.8 (4.4–7.5)	5.9 (5.0–6.9)	4.2 (3.2–5.4)	4.1 (2.8–5.8)	4.3 (2.7–7.1)	4.1 (3.2–5.2)	3.2 (2.4–4.3)	6.0 (4.2–8.5)	.003
Alcohol	0.6 (0.3–1.4)	0.3 (0.1–0.6)	0.2 (0.1–0.7)	0.2 (0.0–1.1)	0.0 (0.0–1.2)	0.8 (0.5–1.4)	0.0 (0.0–0.3)	0.9 (0.4–2.3)	.004
Psychoactive medicinal drugs	3.6 (2.6–5.0)	4.8 (4.0–5.8)	2.7 (1.9–3.8)	1.8 (1.1–3.2)	2.9 (1.5–5.2)	2.5 (1.8–3.4)	1.9 (1.3–2.8)	2.8 (1.6–4.7)	.000
Zopiclone	1.8 (1.1–2.9)	2.4 (1.8–3.1)	1.0 (0.6–1.8)	0.7 (0.2–1.6)	0.7 (0.0–2.5)	1.1 (0.7–1.8)	0.7 (0.4–1.4)	0.5 (0.1–1.8)	.000
Benzodiazepines	1.2 (0.6–2.1)	2.0 (1.5–2.7)	1.7 (1.1–2.6)	1.4 (0.8–2.7)	2.2 (1.0–4.2)	1.2 (0.8–1.9)	1.0 (0.6–1.7)	2.3 (1.2–4.0)	.216
Diazepam/nordiazepam	0.6 (0.3–1.4)	1.3 (0.9–1.9)	1.0 (0.6–1.8)	0.7 (0.2–1.6)	1.4 (0.5–3.2)	0.8 (0.5–1.4)	0.8 (0.4–1.4)	1.6 (0.7–3.1)	.336
Codeine	0.7 (0.3–1.6)	0.6 (0.3–1.0)	0.2 (0.1–0.7)	0.2 (0.1–1.1)	0.0 (0.0–1.2)	0.3 (0.1–0.8)	0.4 (0.2–1.0)	0.5 (0.1–1.8)	.373
Illegal drugs	1.6 (0.9–2.7)	1.0 (0.7–1.5)	1.5 (0.9–2.3)	3.2 (2.1–4.7)	2.9 (1.5–5.2)	1.1 (0.7–1.8)	1.5 (1.0–2.3)	2.8 (1.6–4.7)	.002
Tetrahydrocannabinol	1.1 (0.5–2.0)	0.8 (0.5–1.3)	0.9 (0.5–1.6)	2.3 (1.4–3.6)	1.4 (0.5–3.2)	1.1 (0.7–1.8)	1.3 (0.8–2.0)	1.6 (0.7–3.1)	.097
Amphetamines	0.1 (0.0–0.7)	0.3 (0.1–0.6)	0.2 (0.1–0.7)	0.9 (0.4–2.0)	1.4 (0.5–3.2)	0.3 (0.1–0.8)	0.2 (0.1–0.7)	0.9 (0.4–2.3)	.005
Cocaine/benzoylecgonine	0.1 (0.0–0.7)	0.2 (0.1–0.5)	0.6 (0.3–1.2)	0.9 (0.4–2.0)	0.0 (0.0–1.2)	0.0 (0.0–0.3)	0.4 (0.2–1.0)	0.7 (0.2–2.1)	.006
Total no. of samples analyzed	949	2381	1363	760	385	1628	1413	531	—

[a]Weekend was defined as Friday 4 p.m. until Monday 4 a.m.

Discussion

The key findings in this study were that psychoactive substances were found in 4.8 percent of oral fluid samples from random drivers. Alcohol was detected in a relatively small proportion of the samples (0.3%) compared to medicinal drugs (3.2%) and illegal drugs (1.5%). Illegal drugs were significantly more frequently detected in samples from drivers in urban areas than rural areas and in samples collected during late night on weekdays or weekends.

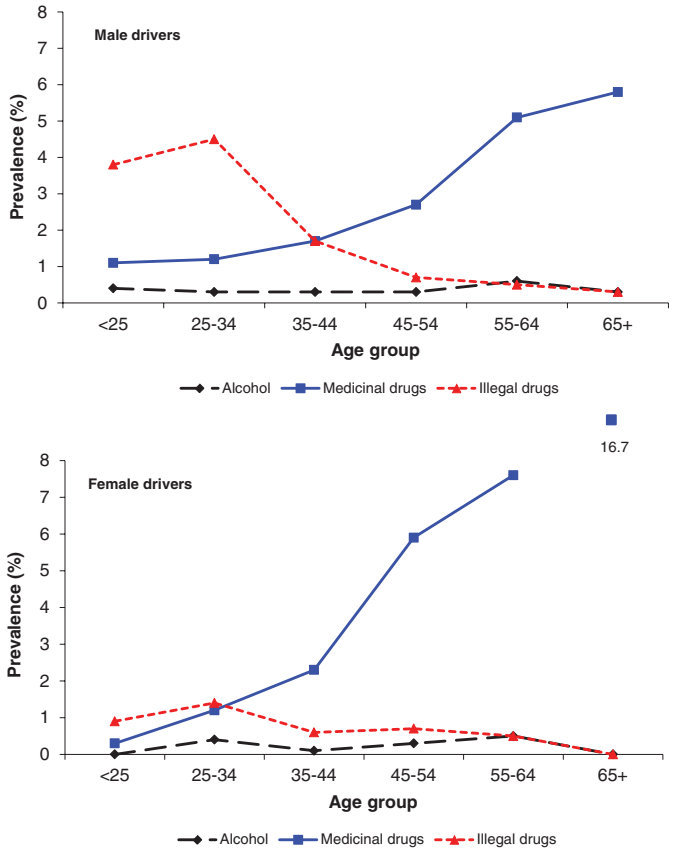

Fig. 2. Prevalence of alcohol, medicinal drugs, and illegal drugs in samples from male and female drivers in relation to age (color figure available online).

The DRUID roadside survey was primarily designed for use in a case-control study to estimate odds ratios for the involvement in road traffic crashes associated with the use of different psychoactive substances. A second aim was to compare the use of alcohol and drugs in different countries in Europe. The cutoff concentrations used made it possible to combine results from blood and oral fluid samples. Another difference from most previous studies was that mutually exclusive substance groups were reported, not total findings for each substance (e.g., a sample being positive for THC and diazepam would not be counted as positive for those substances but only for multiple drugs).

The aim of this article was to present a more in-depth analysis of the data on alcohol and drugs among random drivers in Norway using the same cutoff concentrations that were used in our first large roadside survey performed in 2005–2006 (Gjerde et al. 2008). In that study, only drivers from southeastern Norway excluding Oslo were included, and information about road type (urban or rural) was not recorded. Therefore, our new study provided important additional information compared to the first one. The study design was also improved to reduce the refusal rate, which was 12.0 percent in the study in 2005–2006 and 5.8 percent in the new study, thus providing somewhat more reliable prevalence data. In the 2005–2006 study, the police informed the drivers about the study and to ask them whether they would participate or not. If they were willing to participate, the study team gave more detailed information. The improvement was simply that the police information step was omitted and the study team asked the drivers for participation, thus shortening the time required for each participating driver to about 5 min.

In this study we also counted the number of drivers who provided a positive breath alcohol test to the police but refused to participate in our study. We also included motorcycle and truck drivers, not just car and van drivers, as in the DRUID project reports.

Geographical Differences

The results showed significant differences between urban roads and rural roads and between regions of the country. Samples from drivers in the most densely populated region

Table 4. Estimated prevalence of alcohol and drug concentrations above the legislative limits in blood based on prevalence in oral fluid samples including 95 percent CIs

Substance	Legislative limit in whole blood (ng/mL)	Using equivalent cutoffs for blood and oral fluid			Mathematical simulation Prevalence (%) (95% CI[b])
		Formulae[a] (95% CI for the slope)	Equivalent cutoff in oral fluid (ng/mL) (95% CI)	Prevalence (%) (95% CI)	
Alcohol	0.02 g/dL	—	0.02 g/dL (—)	0.2 (0.1–0.3)	—
Medicinal drugs	—	—	—	1.3 (1.0–2.0)	—
Alprazolam	3	$y = 0.350x$ (0.301–0.399)	1.1 (1.0–1.3)	0.04 (0.01–0.11)	—
Clonazepam	1.3	$y = 0.174x$ (0.159–0.190)	0.23 (0.21–0.25)	0.11 (0.06–0.22)	—
Diazepam	57	$y = 0.0392x^c$ (0.0381–0.0403)	2.2 (2.2–2.3)	0.35 (0.24–0.50)	0.41 (0.21–0.61)
Flunitrazepam	1.6	$y = 0.145x^d$ (0.072–0.218)	0.23 (0.17–0.29)	0.04 (0.01–0.10)	—
Methadone	25	$y = 2.16x$ (1.48–2.85)	54 (37–71)	0.03 (0.01–0.10)	—
Morphine	9	$y = 9.50x$ (6.36–12.64)	86 (59–110)	0.02 (0.00–0.10)	—
Nitrazepam	17	$y = 0.0899x$ (0.036–0.143)	1.5 (1.1–2.0)	0.07 (0.02–0.19)	—
Oxazepam	172	$y = 0.264x$ (0.223–0.306)	45 (38–53)	0.06 (0.02–0.14)	—
Zolpidem	31	$y = 0.273x$ (0.251–0.319)	8.5 (7.8–9.9)	0.00 (0.00–0.05)	—
Zopiclone	12	$y = 2.52x$ (1.26–3.78)	30 (19–41)	0.63 (0.37–1.26)	0.64 (0.33–0.95)
Illegal drugs	—	—	—	0.6 (0.4–0.8)	—
Amphetamine	41	$y = 18.0x$ (16.8–20.8)	740 (690–850)	0.07 (0.02–0.14)	—
Cocaine	24	$y = 20.5x$ (13.3–27.7)	490 (330–650)	0.03 (0.01–0.10)	—
MDMA[e]	48	$y = 13.6x$ (0–29)	650 (190–1100)	0.00 (0.00–0.05)	—
Methamphetamine	45	$y = 20.7x$ (15.5–23.2)	930 (700–1040)	0.11 (0.06–0.23)	—
THC	1.3	$y = 27.2x^{1.39}$ (21.2–34.9; 1.20–1.57)	39 (29–53)	0.49 (0.35–0.67)	0.79 (0.40–1.18)

[a]Formulae determined by the DRUID project (Verstraete et al. 2011); x = concentration in blood, y = concentration in oral fluid.
[b]A standard deviation of 25 percent was used for calculation of 95 percent CIs (Gjerde and Verstraete 2010).
[c]Recalculated formula using previous data generated by the DRUID project (Verstraete et al. 2011).
[d]Based on average oral fluid to blood concentration ratios from previously published data (Gjerde et al. 2010; Verstraete et al. 2011).
[e]Methylenedioxymethamphetamine; ecstacy.

(southeastern Norway including Oslo) were found to have a higher prevalence of illegal drugs than samples obtained in other regions of the country. The same tendency was found when comparing samples from drivers stopped in urban versus rural areas. We previously assumed that the use of illegal drugs was more common in large cities, especially Oslo, than in rural areas; our results confirmed this assumption. The incidence of drink driving was very low in all of the studied regions of the country and confirmed the finding in the roadside survey of 2005–2006 and the results from the TISPOL study of alcohol use among random drivers (TISPOL 2009).

Age and Gender

The large differences between age groups and genders (Figure 2) confirmed previous findings from Norway (Gjerde et al. 2008), and the trends were similar to results from other countries participating in the DRUID project (Houwing et al. 2011a).

Time of the Week

The prevalence of illegal drugs was higher among samples collected at night than among those collected during the day, but there was no marked difference between weekday and weekend nights. Similar results were found for most other countries participating in the DRUID project (Houwing et al. 2011a). The prevalence of alcohol seemed to be somewhat higher on weekend nights (0.9%). Other countries have observed more significant differences in the incidence of drunk driving on weekend nights compared to other periods of the week (Houwing et al. 2011a).

Medicinal drugs were more commonly found in samples from drivers stopped during the daytime on weekdays than in other time periods, similar to the results for other countries (Houwing et al. 2011a). In Norway, this seemed mainly to be due to high prevalence of the sleeping agent zopiclone at daytime. This was not unexpected because 6.4 percent of the population had one or more prescriptions of zopiclone dispensed from a pharmacy in 2008 (Rønning et al. 2009). Caille et al. (1984) found a mean concentration in oral fluid of about 2 ng/mL 24 h after administration of a therapeutic dose of 7.5 mg of zopiclone. As an average, we would expect to find zopiclone concentrations above the cutoff concentration of 10 ng/mL for about 12 h after taking the tablet (Caille et al. 1984). As expected, we found that the prevalence of zopiclone decreased through the day due to metabolism and elimination. Despite the high prevalence of zopiclone, the odds ratio for involvement in fatal accident associated with zopiclone use was found to be low in a previous study (Gjerde, Normann, Christophersen, Samuelsen, and Mørland 2011).

Norwegian Versus Foreign Drivers

When comparing Norwegian and foreign drivers, significant differences were initially observed regarding the use of alcohol and illegal drugs (Table A2). For this comparison we also weighted for age distribution and gender because a larger proportion of foreign drivers were young and a larger proportion were men. The differences between Norwegian and foreign drivers were not unexpected; the European DRUID roadside results showed that the prevalence of alcohol and illegal drugs in samples from Norwegian drivers was significantly lower

than in many other European countries (Bernhoft et al. 2012; Houwing et al. 2011a).

Comparison with the 2005–2006 Study

The results from this study were compared with the former study performed in 2005–2006 (Gjerde et al. 2008). There was a significant increase in the prevalence of illegal drugs and benzodiazepines and a possible decrease in the prevalence of alcohol above 0.01 g/dL. Different geographical areas were included in those 2 studies. However, significant differences were also observed when comparing results from the same geographical regions. One important difference between the studies was the use of different oral fluid sampling devices. In the first study, the Intercept sampling device was used. This device stimulates the production of oral fluid and also changes the pH locally in the mouth. This may affect the equilibrium between drug concentration in oral fluid and blood, causing the concentration either to increase or decrease. This is particularly important for basic compounds like amphetamines, opiates, and cocaine and probably of less importance for neutral compounds like benzodiazepines. The stimulation of oral fluid production may also cause a dilution of the drug concentration, thereby lowering the prevalence of drug concentrations above cutoff. This effect is particularly important for THC, because the detected THC in oral fluid is mainly caused by residual THC from the oral cavity after smoking cannabis; THC is distributed to a small extent from blood to oral fluid (Niedbala et al. 2001). Therefore, the same type of sampling device should be used when investigating changes in drug use over time. However, the DRUID project team decided that Statsure Saliva Sampler should be used by all participating countries based on a drug recovery study (Langel et al. 2008).

Statistically significant differences were observed between the studies in 2005–2006 and 2008–2009 regarding THC, cocaine, and benzodiazepines when comparing drivers in the same geographical area. The difference for THC was probably mainly due to dilution of oral fluid combined with poor recovery of THC from the Intercept device, which was used in the 2005–2006 study. Studies have found a recovery of 38 percent (Kauert et al. 2006; Øiestad et al. 2007) for the Intercept device, whereas for the Statsure device the recovery was found to be 85 percent (Langel et al. 2008).

For cocaine, alprazolam, and diazepam, no significant differences in recovery were observed (Langel et al. 2008). The use of cocaine has been increasing in Norway in recent years; 3.5 and 4.3 percent of the drivers arrested for driving under influence of drugs were positive for benzoylecgonine (a metabolite of cocaine) in 2005 and 2008, respectively (Edland-Gryt 2009). Some increase in cocaine findings among random drivers was therefore expected; however, a 7-fold increase is unlikely to reflect the actual situation. The use of a sampling device that stimulated salivation in the 2005–2006 study may also have provided an incorrect low prevalence due to sample dilution. For benzodiazepines there has also been an increase in findings among arrested drivers drug between 2005 and 2008: about 23 percent for diazepam and 26 percent for clonazepam (Edland-Gryt 2009). Thus, the increased prevalence of benzodiazepines in samples from our latest study compared to the previous one may at least partly be due to increased use among drivers.

The prevalence of alcohol above 0.01 g/dL was 0.5 percent in the first study and 0.2 percent in the second one ($P = .053$, a difference that is on the border of statistical significance). This might be due to an actual reduction in the incidence of driving after drinking alcohol, but it may also be due to random variation or other reasons.

Comparison with Other Countries

Roadside surveys of alcohol or drug use among drivers have also been performed in the United States (Lacey et al. 2009a, 2009b), Canada (Beirness and Beasley 2010), Australia (Davey and Freeman 2009; Drummer et al. 2007), and Brazil (Pechansky et al. 2010), in addition to those discussed in our previous paper (Gjerde et al. 2008). A study was also performed in Thailand using urine samples (Ingsathit et al. 2009), but it is difficult to compare drug findings in urine with oral fluid because drugs and their metabolites can be detected in urine for a much longer time than in oral fluid after a single intake (Verstraete 2004).

Studies at sobriety checkpoints in Brazil found that 22 to 38 percent of motor vehicle drivers at night on weekends had been drinking, and about 20 percent had alcohol levels above the legal limit corresponding to 0.06 g/dL in blood (Campos et al. 2008; Duailibi et al. 2007). In a recent study covering 26 Brazilian state capitals and the Federal District, breath testing of random drivers was performed between noon and midnight on Fridays and Saturdays. In total, 4.8 percent had detectable alcohol on the breath, as did 7.3 percent of those driving after 8 p.m. (Pechansky et al. 2010).

In the United States, breath alcohol was detected in 12 percent of drivers at night on weekends, 4.5 percent with findings corresponding to BACs above 0.05 g/dL (Lacey et al. 2009a). In our study, 0.9 percent of the drivers at night on weekends had BACs above 0.02 g/dL. In the European DRUID project, alcohol findings varied between countries. The weighted prevalence of alcohol concentrations above 0.01 g/dL (total findings including combinations with drugs) were about 9.6 percent in Italy, 6.7 percent in Belgium and Portugal, 5.1 percent in Spain, 3.9 percent in Lithuania, and lower in the remaining participating countries. On weekend nights, the prevalence of alcohol concentrations above 0.05 g/dL were 8.2 percent in Italy, 6.3 percent in Belgium, 2.5 percent in Spain, and 2.0 percent in Lithuania (Houwing et al. 2011a).

The incidence of drunk driving seems to be similar in Norway, Sweden, and Finland (Bernhoft et al. 2012; TISPOL 2009). The DRUID study also found a low incidence of drunk driving in Hungary, but this was not confirmed by TISPOL data (TISPOL 2009).

As far as drugs are concerned, it is difficult to compare different studies mainly because different cutoffs were used, except for the DRUID project, where results using the same cutoff concentrations for all 13 participating countries have been published. In those study reports, the total prevalence for each drug was not reported, only mutually exclusive substance

groups (Bernhoft et al. 2012; Houwing et al. 2011a, 2011b). For some drugs, very high cutoffs were used—for example, 360 ng/mL for amphetamine, which is 18 times higher than the recommended cutoff for drug driving studies (Walsh et al. 2008) and 14 times higher than the cutoff use in this article. This cutoff is, in our opinion, too high to study the prevalence of amphetamine use among drivers, but it can be used in studies where results for blood and oral fluid are combined.

Driving with Drug Concentrations Above the New Legislative Limit

An estimation of the proportion of random drivers who had blood drug concentrations above the new legal limits was made using oral fluid. Therefore, the estimates must not be regarded as accurate. We also present approximate 95 percent CIs for the estimations. The mathematical simulation method could be used only for the most prevalent drugs because about 100 positive samples are needed to obtain acceptable accuracy of the simulation. The estimations for diazepam, zopiclone, and THC obtained when using mathematical simulation were similar to those obtained when equivalent cutoffs were used.

The legal limits for drugs were set to correspond to one fifth of the observed concentration in whole blood after taking a typical recreational and inebriating dose of the drug (Vindenes et al. 2012). Therefore, the data presented in Table 4 reflect which drugs most frequently cause impaired driving among drivers in normal traffic. Our estimations showed that zopiclone, THC, and diazepam (in that order) were the 3 most common drugs present in concentrations above the legal limits among random drivers.

We found that driving with a BAC above 0.02 g/dL was less prevalent (0.2%) than driving with blood drug concentrations above the legal limits for zopiclone, THC, and diazepam. In total, our findings suggest that about 1.3 and 0.6 percent of the drivers had concentrations of medicinal drugs and illegal drugs above the legal limits, respectively. These findings are similar to our previous estimation based on a roadside survey performed in southeastern Norway in 2005–2006 (Gjerde et al. 2008), where we estimated that 1.1 and 0.4 percent of the drivers had blood concentrations above the new legal limits for medicinal and illegal drugs, respectively (Gjerde, Normann, Christophersen, and Mørland 2011).

According to the revised Norwegian driving under the influence law, a driver with a concentration of a medicinal drug in blood exceeding the legal limit is not necessarily convicted if the driver obtained the drug through a prescription and the concentration was within the therapeutic range and the driver did not show any indication of impairment. Therefore, a large proportion, probably the vast majority, of those with concentrations of medicinal drugs above the legislative limits would not be convicted of drug driving.

Conclusion

Illegal drugs were more frequently found in samples of oral fluid obtained from car and van drivers in urban areas than in rural areas and more frequently found in samples from drivers in southeastern Norway including the capital Oslo than in other parts of the country. There was an increase in use of cocaine and benzodiazepines among drivers compared to the results of the roadside survey of 2005–2006. Driving with alcohol concentrations above the legal limit was less frequent than driving with concentrations of illegal drugs above the new legal limits, and driving with medicinal drugs above the legal limits was even more frequent. In total, the incidence of driving under the influence of alcohol or drugs in Norway was less frequent than in many other countries.

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