Can the use of psychoactive drugs in the general adult population be estimated based on data from a roadside survey of drugs and driving?

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ABSTRACT

A roadside survey of drugs and driving was performed in south-eastern Norway in 2005-6. Samples of saliva from a total of 10,503 drivers above 20 years of age were analysed, and the results were weighted for under- and over-sampling compared to the population distribution in the study area. Weighted results were compared with data on dispensed prescriptions of zopiclone, codeine and diazepam at Norwegian pharmacies in the same area and with self-reported use of cannabis. When using roadside data to estimate drug use, the use of medicinal drugs was under-estimated by 17-59% compared to amounts dispensed. One of the main reasons for the under-estimation may be that a large proportion of the users of psychoactive medicinal drugs are not frequent drivers. For cannabis, self-reported data corresponded approximately to the estimated prevalence range. The results indicate that roadside surveys cannot be used for accurate estimations of drug use in the population, but may provide minimum figures.

INTRODUCTION

Obtaining accurate data on the use of psychoactive drugs in the population is difficult. Interviews or questionnaires are most often used to collect data on drug use, but these techniques are known to under-estimate the actual consumption (1-4).

Norway has a nationwide prescription registry. Therefore, dispensing of psychoactive medicinal drugs from pharmacies can be studied accurately. The registry contains information on all dispensed prescriptions to individual patients outside institutions. The national identification number of the patient in addition to information on the physician prescribing the drug is recorded for all dispensed prescriptions. We can therefore obtain good statistics on the dispensing of prescription drugs from pharmacies in relation to age, gender, region, and more. In addition to legal sales of psychoactive medicinal drugs, there is also some illegal import of benzodiazepines and opioids, which is not recorded (5).

For illegal drugs, questionnaires and interviews are commonly used to collect consumption data in different populations and sub-populations. In Norway, national surveys on alcohol and drug use are organised by Statistics Norway regularly, and the results are used for a number of purposes (6). Due to a low participation rate and the fact that many individuals are unwilling to report the use of illegal drugs, the reliability of the reported alcohol and drug use may be questioned.

The aim of this study was to use the results from a roadside survey of drugs and driving using oral fluid (saliva) testing to estimate the use of selected psychoactive medicinal drugs and cannabis in the general adult population, and compare the results with sales data for medicinal drugs and self-reported use of cannabis.

MATERIALS AND METHODS

Roadside survey

The data collection was carried out in cooperation with five National Mobile Police Service (MPS) districts in south-eastern Norway from April 2005 to April 2006 (7). Drivers of motor vehicles were selected using a stratified two-stage cluster sampling procedure. In the first stage, random road sites and time intervals were selected according to a table of random sampling numbers (8). Sampling periods of three days were selected for each police district for each month during one year (although this was done in such a way that two or more districts never collected data on the same dates and that working hour regulations were not violated). For each day, two consecutive 4 h periods were randomly selected for sample collection at two different road sites. The police then chose the exact time and place allowing for practical considerations. The second stage consisted of randomly stopping drivers. A target number of drivers was determined for each specific site and time period before the sampling started. This number was based on official statistics of traffic volume and ranged from 15 to 60 drivers. During the sampling period, the MPS stopped the first approaching car or motorcycle when the data collection personnel were ready for a new driver. The MPS first carried out their own routine controls (e.g., breath alcohol testing or driver's licence control). Afterwards the drivers were asked to proceed to the study team, who requested voluntary and anonymous participation in the project. Oral and written information about the project was given to each driver. If informed consent was given, a sample of oral fluid was taken and data on gender, age, date, time and geographical site were recorded. In general, the sampling procedure was designed in a way

that should ensure that the drivers rendering samples should give a representative picture of the total driver population.

Samples of oral fluid were collected using the Intercept® Oral Specimen Collection Device from Orasure Technologies, Inc. (Bethlehem PA, USA). The sample was kept in a bag at a temperature of approximately 5°C for a maximum of 6 h, and then frozen at about -20°C. Drug concentrations in oral fluid-buffer mixtures were determined by liquid chromatography – tandem mass spectrometry (9) and concentrations in un-diluted oral fluid were calculated.

The prevalence of drugs was estimated by a weighted average for four 6 h periods of the day, using weights adjusted for under- or over-sampling of the data compared to overall population statistics regarding age, gender, day of the week, and time of the day, weighting to equal distribution during the day and from day to day. Drivers below 20 years of age were not included in the current study.

Suitable cutoff concentrations to estimate drug use during defined time intervals

Zopiclone

In a study of zopiclone, the mean concentration in oral fluid 24 h after oral administration of 7.5 mg was 2 ng/ml (10). Therefore, the prevalence of use of 7.5 mg during the last 24 h can be estimated by using a cutoff of 2 ng/ml.

Codeine

A mean codeine concentration of 7 ng/ml has been found in oral fluid 12 h after oral administration of 30 mg codeine phosphate (11). When using 7 ng/ml as cutoff, the prevalences of use of 30 mg during the last 12 h can be estimated. No data on mean concentrations after 24 h have been found.

Diazepam

A mean diazepam concentration of 1.5 ng/ml was observed in oral fluid 24 h after administration of 0.143 mg/kg, corresponding to 10 mg for a 70-kg person (12). Thus, when using this concentration as cutoff, the prevalence of diazepam use of 10 mg single dose during the last 24 h can be estimated.

Cannabis

After smoking 20-25 mg THC and collecting oral fluid with the Intecept device, a mean THC concentration of 0.4 ng/ml was found in oral fluid-buffer mixture 24 h after smoking (13), corresponding to 1.2 ng/ml in undiluted oral fluid.

National survey using postal questionnaires

A national survey "Level of living" is carried out by Statistics Norway on a annual basis (6). The survey is performed by sending a postal questionnaire to a nationally representative subsample of 10,000 persons. The data were collected using a stratified selection by municipality of residence. Questions on selected health-related topics are included every third year. The survey "Level of living 2005" (6) included a number of questions on alcohol and drug use. Individual survey data were obtained from Norwegian Social Science Data Services (http://nsddata.nsd.uib.no).

The participants were asked about the frequency of cannabis use and had the following answer options: "Never"; "Once per month or more seldom"; "2-3 times per month"; "Once per week"; "2-3 times per week"; and "4-7 times per week".

The average number of cannabis smokers per day was estimated using the following procedure. For those answering "once per month or more seldom" we suggest that about once per 90 days would be close to the average. Thus, if 90 persons chose this answer option, the average would be that one person smoked cannabis per day. Similarly, for those answering "2-3 times per month" we suggest that the average would be 2.5 times per month, or one person smoked cannabis every 12 days, as average. If 12 persons answer this option, the average would be that one of those persons smoked per day. In the same way, all replies were transformed to number of persons smoking cannabis per day, and then the sum of all answers was calculated, representing the total average number of persons smoking cannabis per day. The average number of cannabis smokers was thus calculated as follows: ([number who smoked cannabis once per month or more seldom]/90) +([number who smoked cannabis 2-3 times per month]/12) + ([number who smoked cannabis 2-3 times per week]/2.8) +([number who smoked cannabis once per week]/7) +([number who smoked cannabis 2-3 times per week]/2.8)+ ([number who smoked cannabis 4-7 times per week]/1.3).

Data from the Norwegian Prescription Database

From 2004 all pharmacies in Norway have to submit data to the Norwegian Prescription Database (NorPD) on all prescription drugs dispensed to individual patients outside institutions. Each record contains a unique person-identifier, thus age and gender for the patient is known. Quantities are measured as Defined Daily Doses (DDDs) as determined by the WHO collaborating centre for drug statistics (http://www.whocc.no). One DDD for zopiclone is 7.5 mg, codeine 100 mg and diazepam 10 mg. Data for the studied area in 2005 were obtained from NorPD (http://www.norpd.no).

Distributions of age and gender

The age and gender distributions of the general population in the studied area in 2005 were obtained from Statistics Norway (http://www.ssb.no). The population data in each police district was obtained from the Ministry of Justice and Police (14). The data were from 2000, but no significant relative changes between districts were expected for 2005.

Weighting

For the roadside survey data, the weighted prevalence was calculated to match the distribution of the general

Table 1. Weights for under- and over-sampling of drivers ≥ 20 years.

		Distribution of drivers for each time period of the day (%)				Weights for each time period of the day			
Characteristics	Distribution (%)	00.00-05.59	06.00-11.59	12.00-17.59	18.00-23.59	00.00-05.59	06.00-11.59	12.00-17.59	18.00-23.59
Age / gender	Of population								
20-29 /males	7.3	15.6	7.4	8.2	12.8	0.47	0.99	0.89	0.57
30-39 /males	9.6	24.5	13.9	13.9	15.3	0.39	0.69	0.69	0.63
40-49 /males	9.9	18.6	17.6	15.7	16.4	0.53	0.56	0.63	0.61
50-59 /males	9.2	19.0	13.8	16.8	15.3	0.49	0.67	0.55	0.60
60+ /males	12.6	5.9	17.2	15.4	10.2	2.12	0.73	0.82	1.24
20-29 / females	7.1	4.8	4.7	4.4	5.8	1.47	1.51	1.60	1.23
30-39 / females	9.7	3.7	7.8	7.8	7.2	2.60	1.24	1.24	1.35
40-49 / females	9.8	4.1	7.2	7.3	8.0	2.39	1.36	1.33	1.22
50-59 / females	9.1	3.0	6.6	6.3	6.2	3.06	1.38	1.44	1.47
60+ / females	15.7	0.7	3.8	4.1	2.9	21.11	4.14	3.78	5.39
Police district	Of population								
Østfold & Follo	21.1	21.6	12.4	21.6	26.4	0.98	1.71	0.98	0.80
Romerike & Hedmark	23.1	12.3	28.9	17.2	14.1	1.88	0.80	1.35	1.64
Gudbrandsdal & V-Oppland	10.4	19.3	18.3	25.4	16.6	0.54	0.57	0.41	0.63
Buskerud & Asker/Bærum	24.0	26.0	25.3	18.3	19.2	0.92	0.95	1.31	1.25
Telemark & Vestfold	21.4	20.8	15.1	17.5	23.8	1.03	1.41	1.22	0.90
Day of the week	Of the week								
Mon-Thu	57.1	41.6	62.8	58.3	43.6	1.37	0.91	0.98	1.31
Fri	14.3	7.4	14.2	13.4	22.7	1.92	1.01	1.07	0.63
Sat	14.3	15.6	10.9	14.6	15.1	0.92	1.31	0.98	0.94
Sun	14.3	35.3	12.1	13.7	18.6	0.40	1.18	1.04	0.77

population in the study area as follows: let p_a be the proportion of the general population in police district *a, a* = 1,…, 5. The five p_a's add to 1. Furthermore, let *n* be the total sample size, and n_a the sample size in police district *a*. Preliminary weights w_a were calculated such that the distribution between police districts in the weighted sample matched the distribution of the general population, i.e. $w_a \cdot n_a/n = p_a$, giving $w_a = p_a \cdot n / n_a$. Similarly, preliminary weights v_b, b = 1,…,4 for days in a week (four groups: Mon-Thu, Fri, Sat and Sun) and u_c, c = 1, …,10 for age group and gender (see Table 1) were calculated. The final weights for all drivers sampled in police district *a*, weekday *b* and age/gender *c* were given by $w_a v_b u_c$. Finally, let y_{abcd} indicate the result of a drug test on the *d*'th sampled driver in police district *a* weekday *b* and hour *c*, y_{abcd} being 1 if the test is positive and 0 if it is negative. The prevalence of the drug was then estimated by $\sum_{abcd} (w_a v_b u_c y_{abcd}) / \sum_{abcd} (w_a v_b u_c)$.

For the self-reported data on cannabis use, the weighted prevalence was calculated by weighting for the distribution of age and gender of the general population in the study area.

Confidence intervals

Confidence intervals for binomial proportions were calculated using the Wald method (15). An approximate 95% confidence interval for p is $p' \pm 1.96 (p'(1 - p')/n)^{1/2}$, where p' is the sample proportion of successes and n is the total number of cases.

RESULTS

Weighting factors for roadside survey

Samples from 10,816 drivers were collected. Drivers below 20 years of age (n=309) and drivers for whom gender and age was not recorded (n=4) were deleted from the database in order to enable a simple comparison with drug sales statistics from the Norwegian Prescription Database.

Of the 10,503 included drivers, zopiclone was detected in 231 samples of oral fluid, diazepam in 77, codeine in 104, and tetrahydrocannabinol (THC) in 59 samples.

The distribution of age, gender and days of the week for the included drivers are presented in Table 1 for four 6 h time periods of the day and compared with the distribution for the general population in the study area. Calculated weights for different time periods of the day are also presented in the table.

Results from roadside survey

Drug prevalences were calculated for each time period of 6 h. Crude and weighted prevalences are shown in Table 2.

Zopiclone

The highest weighted prevalence of zopiclone above 2 ng/ml was 3.4% and was observed in the morning (between 06:00 and 11:59 h). The 95% confidence interval (CI) was 2.7–4.1%. This finding reflects the use of zopiclone during the last 24 h.

Table 2. Analytical findings.

Characteristics	Detection window	Crude prevalence for each time period (%) 00.00-05.59	06.00-11.59	12.00-17.59	18.00-23.59	Weighted prevalence for each time period (%) 00.00-05.59	06.00-11.59	12.00-17.59	18.00-23.59
No. of drivers	-	269	2951	4434	2849	–	–	–	–
Zopiclone ≥ 2.0 ng/ml	24 h	0.7	2.2	2.2	1.4	0.4	3.4	2.6	2.6
Codeine ≥ 7 ng/ml	12 h	1.5	1.2	1.0	0.7	1.6	1.4	1.1	0.8
Diazepam ≥ 1.5 ng/ml	24 h	0.0	0.5	0.5	0.3	0.0	0.7	0.5	0.5
THC ≥ 1.2 ng/ml	24 h	1.5	0.3	0.6	0.7	2.7	0.2	0.5	0.5

Codeine

The highest weighted prevalence was 1.6%, observed in the late night (between 00:00 and 05:59 h). This was based on a low number of subjects (see Table 2) giving a very wide 95% CI (0.1–3.1%). The weighted prevalence in the morning was 1.4% (95% CI 1.0–1.8%); this was a more reliable proportion because of a large number of studied subjects. This finding reflects the use of codeine during the last 12 h. If adding this prevalence with the prevalence 12 h later (0.8%, 95% CI 0.5–1.1%), the total prevalence of use was 2.2% (95% CI 1.5–2.9%).

These findings suggest that 2.2% of the drivers had used a dose of 30 mg or more. As one DDD is 100 mg, the results corresponds to an estimated consumption 0.7 DDD per 100 drivers (95% CI 0.5–1.0).

Diazepam

Using a cutoff of 1.5 ng/ml, which corresponds to average concentrations in oral fluid 24 h after intake of one DDD, the highest weighted prevalence was observed in the morning and was 0.7% (95% CI 0.4–1.0).

Cannabis

Using a cutoff of 1.2 ng/ml for THC, which reflects the use of cannabis during the last 24 h, the maximum weighted prevalence was 2.7%, observed during the late night (95% CI 0.8–4.6). Due to a low number of drivers, the prevalence for this period was unreliable. The weighted prevalence in the afternoon (between 12:00 and 17:59 h) was 0.5% (95% CI 0.3–0.7).

Dispensed prescriptions

Overview of dispensed prescriptions for zopiclone, codeine and diazepam in the study area, which comprised 1.3 million inhabitants above 20 years of age, are presented in Table 3.

Weighting factors for self-reported cannabis use

Of the 10,000 individuals selected for the "Level of living"survey, some persons living abroad or in institutions or who had diseased were excluded. In total, 9,187 eligible persons received the questionnaire, and 5,212 responded (56.7%). Individuals with missing gender or age or who did not answer questions on the use of cannabis were removed prior to analysis. The final sample consisted of 1,921 men and 2,219 women; from south-eastern Norway 948 men and 1,102 women. Weights adjusting for distribution of age and gender are presented in Table 4.

Table 3. Dispensed prescriptions for adults aged 20 years or more in the studied area.

Dispensed prescriptions in 2005	Zopiclone	Codeine	Diazepam
Total million DDD	19.3	8.2	7.1
Million DDD per day	0.053	0.022	0.019
No. of DDD per 100 persons per day	4.1	1.7	1.5

Table 4. Weights for under- and over-sampling of questionnaire respondents.

Characteristics	Distribution in the general population ≥ 20 years (%)	Distribution of respondents in "Level of living 2005" (%)	Weights
Males aged			
20-29	7.31	6.39	1.14
30-39	9.63	8.93	1.08
40-49	9.91	9.07	1.09
50-59	9.21	10.20	0.90
60+	12.60	11.66	1.08
Females aged			
20-29	7.09	7.37	0.96
30-39	9.68	12.05	0.80
40-49	9.75	11.71	0.83
50-59	9.11	10.29	0.89
60+	15.70	12.34	1.27

Results for self-reported cannabis use

Crude and adjusted results are presented in Table 5. The sum of self-reported cannabis use was that 0.5% smoked cannabis per day (95% CI 0.2–0.8%).

Comparison between estimates based on the roadside survey and sales data or self-reported cannabis use

The estimates based on data from the roadside survey are compared with data on dispensed medicinal drugs from pharmacies in the study area and self-reported use of cannabis in Table 6.

DISCUSSION

In this report we have interpreted each finding of a medicinal drug as if the user has taken one singe defined daily dose (DDD) for diazepam or zopiclone and 0.3 DDD for codeine. The analytical cutoff concentrations have been set to detect the use of one DDD (or 0.3

Table 5. Self-reported use of cannabis last 12 months, and estimated use per 24 h. Results are weighted for age and gender distribution.

Frequency	Crude proportion (%)	Weighted proportion (%)	Divide by	Per 24 h (%)
Once per month or more seldom	1.85	1.92	90	0.02
2-3 times per month	0.34	0.38	12	0.03
Once per week	0.29	0.32	7	0.05
2-3 times per week	0.24	0.24	2.8	0.08
4-7 times per week	0.44	0.46	1.3	0.36
Total	3.2	3.3	–	0.5

Table 6. Comparison between estimates based on the roadside survey and amount of dispensed medicinal drugs from Norwegian pharmacies or self-report on cannabis use.

	No. of DDD per 100 persons (95% confidence interval)	
Substance	Based on roadside survey	Based on dispensed drugs or self-reported use
Zopiclone	3.4 (2.7–4.1)	4.1
Codeine	0.7 (0.5–1.0)	1.7
Diazepam	0.7 (0.4–1.0)	1.5
Tetrahydrocannabinol	0.5 (0.3–0.7)	0.5 (0.2–0.8)*

*Estimated self-reported incidence of use (%) per 24 h

DDD for codeine) for an average of either 12 or 24 h.Few studies have been performed to determine drug concentrations in oral fluid 12 or 24 h after a single intake of a defined dose. Therefore, the cutoff concentrations we have used may not accurately reflect the mean concentrations for larger populations 12 or 24 h after single intake.

The adjusted prevalence of zopiclone among drivers after weighting was 17% lower than the number of DDD dispensed from pharmacies per 100 persons, albeit not significantly lower. For codeine the adjusted prevalence among drivers was 59% lower, and for diazepam 53% lower. Both these results were significant (see Table 6).

There may be several reasons for these differences. It can be expected that the use of those drugs may be higher in the non-driving and infrequent driving populations, as the use of those drugs is more common among older persons, especially women (7), and many of those do not drive at all or drive infrequently. Other reasons might be that some patients do not use the prescribed medicinal drug or use it infrequently, and some patients are using higher doses than one DDD per day and are still classified by analytical testing as if one DDD had been taken (or 0.3 DDD for codeine).

On the other hand, taking less than the prescribed dose may give a positive drug finding if the sample is collected shortly after the drug was taken. These cases would also, based on the analytical testing, be incorrectly classified as having taken one DDD (or 0.3 DDD for codeine). In addition, the prescription registry does not reflect the total amounts of drugs dispensed because data on drugs given in hospitals or other institutions are not included, and some drivers may have purchased psychoactive medicinal drugs on the illegal market (5). The two latter facts are expected to be of have minor effects on the accuracy.

The detection of THC in oral fluid after smoking cannabis is a result of contamination of the oral cavity, and does not directly reflect the concentration in blood (13). Eating and drinking could cause oral fluid to be positive for THC for a shorter time than 24 h after smoking one single dose, while smoking cannabis several times during a day may have caused the oral fluid to be positive for a longer time than 24 hours.

We have previously found that the use of cannabis was under-reported in a study of employees (4); only two out of seven persons who had used cannabis during the last 48 h admitted to this when using a questionnaire. Studies in the USA have also found underestimation of cannabis use, but to a lesser extent than cocaine and heroin (1, 3). Therefore, we were surprised to see that the estimated prevalence of cannabis used based on data from the roadside survey produced similar figures.

The vast majority of Norwegian drivers avoid driving after having consumed alcohol. We have found that about 20% of the working population reported having consumed alcohol during the last 24 h in a workplace study (4); on the other hand, only about 0.3% of random drivers were found to have blood alcohol concentrations above 0.2 g/l, which is the legal limit in Norway (7). It is also expected that many drug users refrain from driving for some hours after drug intake, especially if they believe that their ability to drive safely has been impaired. Therefore, our findings among drivers must be regarded as minimum figures of the prevalence of drug use in the Norwegian population.

CONCLUSION

The estimated use of codeine and diazepam was lower than data from the prescription registry indicated. The estimated use for zopiclone was also lower, but not significantly. For cannabis, the estimated use was similar to self-reported data. Roadside surveys cannot be used for accurate estimations of drug use in the population, but may provide minimum figures.

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