Project No. TREN-05-FP6TR-S07.61320-518404-DRUID

**DRUID**
Driving under the Influence of Drugs, Alcohol and Medicines

Integrated Project
1.6. Sustainable Development, Global Change and Ecosystem
1.6.2: Sustainable Surface Transport

**6th Framework Programme**
Deliverable 2.3.4

# Responsibility study: Psychoactive substances among killed drivers in Germany, Lithuania, Hungary and Slovakia

Due date of deliverable: 14.02.2011
Actual submission date: 24.02.2011

Start date of project: 15.10.2006
Duration: 60 months
Organisation name of lead contractor for this deliverable: LMU
Revision 1.0

| Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006) | | |
|---|---|---|
| **Dissemination Level** | | |
| PU | Public | X |
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**DRUID Deliverable 2.3.4**

# Responsibility study: Psychoactive substances among killed drivers in Germany, Lithuania, Hungary and Slovakia.

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# EXECUTIVE SUMMARY

**Introduction:**
Within the framework of the DRUID-project WP2 was concerned with the collection of epidemiological data to substance use in the driving population. As a part of WP2 the present study which was conducted in Germany, Lithuania, Hungary and Slovakia was to contribute to knowledge on substance use among killed drivers and estimate relative risks among fatally injured drivers responsible for a fatal traffic accident when driving under the influence of alcohol and/or other psychoactive substances. In addition in-depth analysis of accidents of killed drivers tested positive for psychoactive substances was carried out with the purpose of analyzing the contribution of human failure patterns under influence to accident causation.
**Material & Method:**
Data of killed drivers was sampled prospectively by means of a database established within the DRUID-framework in the years 2008 and 2009 and increased by retrospective data. The analysis included 483 subjects, 18 years and older, killed within 10 hours after being involved in a traffic accident. Responsibility analysis was conducted with the method proposed by Robertson and Drummer (1994) which allocated the 483 subjects in 419 cases and 64 controls. Subsequently a toxicological analysis was carried out where the 23 DRUIID-core substances as well as several other additional substances were screened for. An in–depth analysis of 20 killed drivers was carried out by means of a systematic accident causation catalogue.
**Results:**
43% of the killed drivers were tested positive for psychoactive substances at the time of the accident (alcohol ≥ 0.1 g/L and/or detection of licit/illicit drugs in blood sample). 85% of positively tested subjects were under the influence of alcohol. The majority of subjects who consumed alcohol were severely intoxicated (blood concentrations ≥ 1.2 g/L), a condition more frequently found in East-European samples. Licit and illicit drugs were detected in 13% and 10% of positive subjects, respectively, whereas the most frequently found licit/illicit drugs were benzodiazepines and cannabis (3.7% and 2.5% of whole sample). Due to in particular a low number of controls the results of odds ratio (OR) calculations were in most cases not significantly different from one and therefore the corresponding analysis did not show an effect of the respective substance on the risk of being responsible for a fatal accident. However, there were three exceptions. In the Slovakian subsample adjusted (age, gender) OR for subjects with blood concentrations of alcohol ≥ 1.2 g/L were 8.16 (95% CI 1.15 – 58.11). For the whole sample effects remained significant for subjects with alcohol ≥ 0.1 g (OR=4.57, 95% CI 2.02 – 10.38) as well as dose-dependent for alcohol ≥ 1.2 g/L (OR=20.84, 95% CI 3.10 – 140.16). The corresponding confidence intervals are wide and therefore the precision of estimate is poor.
**Discussion:**
Alcohol was by far the most widely used substance among the killed drivers who in the majority of cases were severely intoxicated. Licit and illicit drugs were involved in less than 15% of subjects with a positive toxicological analysis, however, restricting the sample to killed drivers possibly yields lower figures than found when analyzing all drivers. In terms of preventive measures and legislative consideration alcohol should be emphasized as a key substance which presents a permanent threat to road safety in Europe. In order to establish a solid database on the use of psychoactive substances among drivers with a sufficient number of subjects for epidemiological analysis continuation of the prospective sampling of fatally injured drivers is on all accounts desirable. Future improvements of the database should involve inclusion of injured/non-injured drivers and an extended list of screened substances. In this way continuous data to the use of psychoactive substance among the driving population could be provided, presenting a useful tool to monitor the use of psychoactive substances in traffic and support legislative and preventive measures.

# I RESPONSIBILITY STUDY

## INTRODUCTION

In 2005 over 41.000 people lost their lives in traffic accidents in the EU and approximately 1.7 million people were injured with a minimum of 150.000 of survivors suffering from permanent disability [1, 2]. Involvement in a road accident remains one of the three leading causes for deaths and hospital admission for EU citizens; in the group of under 50 year old inhabitants it even holds the leading position [3].

Facing these challenges, in 2001 the EU laid down measures with the overall objective of improving road safety and reduce deaths due to road accidents by half by 2010 [4].

Since an increasing number of road accidents in the EU are accompanied by the use of psychoactive substances (i.e. alcohol, illicit drugs and medicines) certain measures must be taken in order to gain insight and achieve knowledge relating to substance use and traffic participation and its impact on road safety.

Thus, in order to provide scientific support with respect to substance use and traffic participation to the EU transport policy, an integrated European Union (EU) project called "Driving Under the Influence of Drugs, Alcohol and Medicines (DRUID)" of which the present report is a part of, was launched in 2006. DRUID consists of several different work packages which tackle different questions and approaches relative to driving under the influence such as classifications, enforcement, experimental studies, evaluation of strategies concerned with prevention, penalization and rehabilitation as well as epidemiological studies and relative risk estimates which are dealt with in Work Package 2. A substantial part of the work done in WP2 is concerned with collecting data about prevalence and accident risks of different substances in traffic. Through accession of several new member states from Eastern Europe after the enlargement of the EU and the limited knowledge regarding substance use and traffic participants in those countries the data collected in WP2 yields valuable information to the status of substance use in those countries.

**Objective of the present study**

As a part of WP 2, Task 2.3.3 – culpability studies takes on two of the objectives of WP 2:

- Relative risk estimates for traffic accident involvement of drivers under influence of alcohol and other psychoactive substances who have been responsible for a fatal traffic accident (based on accident and in-depth analysis).
- Contribution of results to differences in the patterns of psychoactive substance use among different EU countries (e.g. North-, West-, and East-European countries).

The present study was conducted in four European countries (Germany, Lithuania, Hungary and Slovakia) in order to evaluate and compare the relative risks among fatally injured drivers responsible for a fatal traffic accident when driving under the influence of alcohol and/or other psychoactive substances. In the respective countries this was in many ways a pilot project where data material and blood samples of traffic fatalities were utilized systematically for accident analysis. Originally the analysis of retrospective Swedish data was planned for the study; however, it turned out that the initial inclusion criteria were not suitable for further analysis in the responsibility study. In-depth analysis of accidents of killed drivers with a positive toxicological test in Germany and Lithuania was carried out with the purpose of analyzing the contribution of human failure patterns under influence to accident causation. Furthermore the sampled data was to provide an insight into the proportion of drivers under the influence of psychoactive substances among fatally injured drivers in those four different European countries and the substances used.

## SUBJECTS AND METHODS

**Study population**

The study population was comprised of fatally injured car drivers, 18 years and older, in traffic accidents, who were killed within 10 hours after the accident (i.e. including immediate deaths, death at the scene of the accident and in hospital) within the respective catchment area and the respective time frame of the study. Overall WP2-requirements did not specify time limits regarding time of death. In an effort to be able to reduce the number of missing cases and simultaneously get a representative toxicological profile of the subjects it was decided to set the maximum elapsed time after accident to 10 h.

All cases were subjected to autopsy by a forensic medical expert and blood samples were obtained from each fatality and analyzed with toxicological methods. Accidents which took

place off-road as well as cases which occurred due to suicide or natural causes were excluded. Cases which had incomplete information on confounding variables (age, gender, etc., 7 exclusions), variables concerned with the responsibility analysis (34 exclusions) or incomplete data regarding toxicological analysis (lack of blood samples, 32 exclusions) were excluded. Furthermore 14 cases where no approval could be obtained from the respective public prosecution office were excluded.

**Setting of study**

Germany

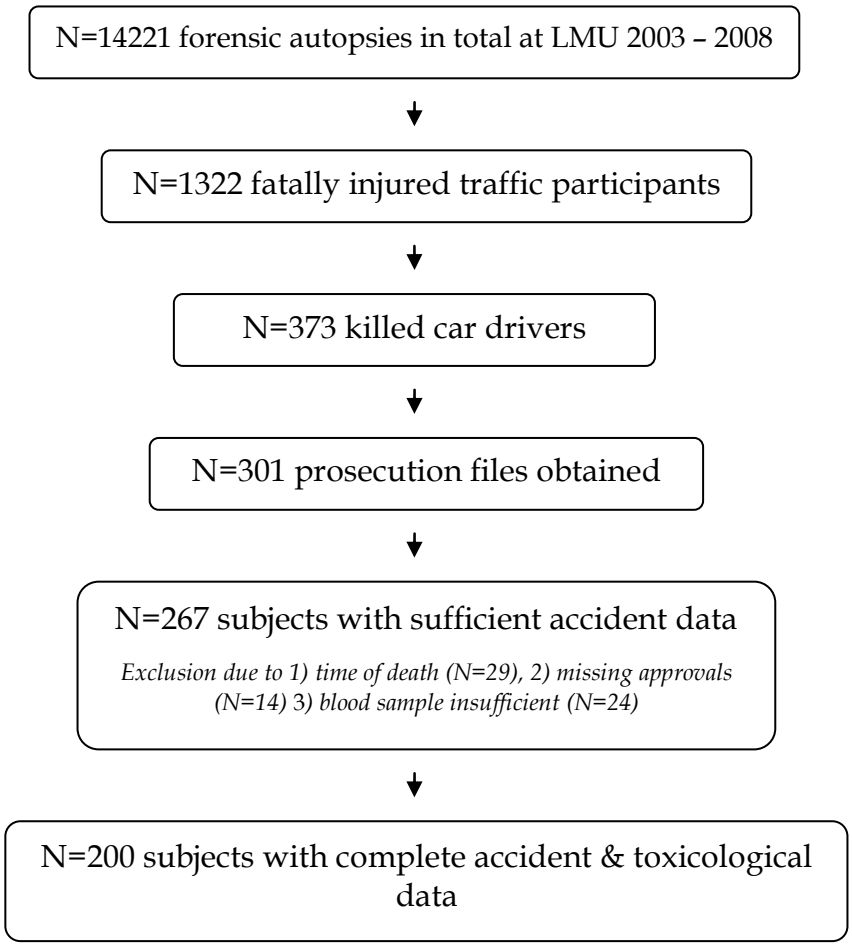
The German data of n = 200 was sampled by the Biomechanics and Accident Analysis Unit at the Institute of Forensic Medicine of the Ludwig-Maximilians-University in Munich. The study was approved by the Ethical Committee of the University of Munich. The cases used for the study were sampled from a database established within the framework of DRUID and comprised data from autopsy protocols, public prosecution records as well as technical reports and police reports. The data was collected prospectively between January 1st 2008 and December 31st 2009 and increased by retrospective data of the years 2003 – 2007. The sampling procedure of the LMU is shown below (Figure 1). The toxicological analyses in blood were performed by the Toxicology department of the Institute of Forensic Medicine, LMU.

The region of study comprised the catchment area of public prosecution offices in southern part of Bavaria which is the largest by area and southernmost federal state of Germany (with the districts Upper and Lower Bavaria and Swabia). The number of inhabitants in the catchment area is approx. 7.32 Million, ca. 58.5% of all inhabitants in the whole of Bavaria (12.5 Million).

The implementation of the study at the LMU was to a high degree dependent on operating principles of the ten public prosecutors responsible for the study's catchment area. The decision whether a traffic fatality undergoes an autopsy and whether a toxicological analysis is performed on the blood sample of a fatally injured traffic participant is made by the respective public prosecutor; however blood alcohol concentrations (BAC) are routinely performed at every autopsy if blood is available. The approvals for the use of public prosecution records and for the use of preserved blood from autopsy for supplementary toxicological analysis had to be obtained for each case separately. This circumstance and the fact that the proportion of autopsy orders vary considerably among public prosecutors affected the corresponding capture rates for the LMU sample. A total of 373 killed car drivers were autopsied per order from public prosecutors at the LMU between 2003 and 2008 (Fig. 1).

These represent 30.6% of all killed car drivers in the catchment area in the study period. In the end 200 subjects could be included with sufficient data and toxicological material. This corresponds to a capture rate of 16.4% for the LMU sample.

**Figure 1:** Sampling procedure at the LMU, Munich, Germany




Lithuania

The Lithuanian data of 41 fatally injured drivers was sampled by associates of the State Forensic Medicine Service in Vilnius (former Institute of Forensic Medicine of Mykolas Romeris University) administered by the Ministry of Justice. The study was approved by the Lithuanian Bioethics Commission. In Lithuania the autopsy and compulsory toxicological analysis of traffic fatalities is imposed by law. The data used in the study was drawn from autopsy protocols, police reports and technical reports. The data sampling took place from April 2008 until October 2009. The catchment area of the Lithuanian study comprised the regions of Vilnius, Kaunas and Klaipeda which inhabit 1.9 Million people, approx. 58.6% of the total population of Lithuania. In the study period 78 autopsies of all kinds of drivers were performed in the respective catchment area. Of those 78 drivers, 50 drivers (48 car drivers and 2

drivers of a PTW) were primarily considered for the present study; however nine car drivers had to be excluded due to lack of data or blood material resulting in an overall capture rate of killed car drivers of 81.3%.

Hungary

The Department of Forensic Medicine at the University of Szeged was concerned with the data sampling of the 93 Hungarian cases. Ethical approval was obtained for the study. In Hungary the autopsy and compulsory toxicological analysis of traffic fatalities is imposed by law. The data material was derived from autopsy protocols, police records and technical expert opinions. The data sampling was carried out between January 1st 2008 and December 31st 2009. Data were sampled from 3 counties of South-Hungarian regions (Bács-Kiskun, Csongrád, Békés) and from Jász-Nagykun-Szolnok county of North-Hungary which together inhabit around 17% of the total Hungarian population (ca. 10 Million). The regions under study are subjected to rather heavy transit traffic; therefore approximately 10% of the cases were fatalities with a foreign citizenship (mainly Romanian). Autopsies of the Hungarian fatalities were performed at the Department of Forensic Medicine in Szeged and at respective Forensic Expert and Research Institutes in Bács Kiskun, Békés, Jász-Nagykun-Szolnok counties. All samples underwent a toxicological analysis at the Department of Forensic Medicine in Szeged. In the study period 102 car drivers died in the catchment area, of those 93 could be considered for the study resulting in a capture rate of 91.2%.

Slovakia

The data material of 149 Slovakian traffic fatalities was collected at the Institute of Forensic Medicine, Faculty of Medicine at the Comenius University in Bratislava. The Institute of Forensic Medicine maintains a database from which the Slovakian cases were drawn. In Slovakia the autopsy and compulsory toxicological analysis of traffic fatalities is imposed by law. Police reports and autopsy protocols were considered for the study. Cases which were included in the Slovakian sample were collected between January 2005 and December 2009. The catchment area included the two westernmost of eight Slovakian districts, Bratislava and Trnava, which together inhabit 1.2 Million people (ca. 22 % of total inhabitants of Slovakia). All killed car drivers in the catchment area and the study period (n=170) were considered for the present study, however 21 subjects had to be excluded due to delayed time of death which resulted in a capture rate of 87.6%.

**Measures and descriptions of variables**

Method used for the assessment of responsibility

As agreed upon among participants of the WP 2 – "Other studies" [Minutes of Meeting in Munich, 23 – 24 March 2009] a certain terminology was defined to describe the studies conducted within WP 2. Culpability studies and responsibility studies have the same aim, namely to compare drivers who are responsible for a traffic accident with drivers who are not responsible of a traffic accident. It was decided to define "culpability" in terms of legal regulations and "responsibility" in terms of accident causation. The present study is a responsibility study.

Responsibility in terms of being responsible for a fatal traffic accident was defined by using the method proposed by Robertson and Drummer [5]. This validated method considers eight different factors pertaining to the setting of the accident and the driver:

Condition of the road;
Condition of the vehicle;
Driving conditions;
Type of crash;
Witnesses' observations;
Road law obedience;
Difficulty of task;
Level of fatigue.

Based on the sum of the scores for each of the eight factors drivers are classified into three categories as responsible, contributory or non-responsible. In order to show a consistent approach with the other responsibility study of WP 2 (DRUID – Deliverable 2.3.2 [6]) we used a validated adapted version of the Robertson and Drummer method. This included merging the contributory subjects with the responsible cases. Furthermore since the responsibility analysis was conducted irrespective of the toxicological analysis which results were undisclosed as the responsibility analysis was carried out, we assessed the factor „Obedience of road law" independent of toxicological status. The factor „Level of fatigue"could not be assessed with the available data and was not included in the analysis. In order to ensure a comparable implementation of the responsibility method among all partners several meetings where held where the corresponding procedures were discussed.

Additional variables

Additionally to the variables required for the responsibility analysis, the following variables were selected for further analysis due to their reported or possible association of being responsible for a fatal traffic accident or driving under the influence of alcohol and/or drugs:

- Gender (male vs. female);
- Age in years;
- Age in years classified in four levels (18 – 24 yrs vs. 25 – 34 yrs vs. 35 – 49 yrs vs. 50+ yrs);
- Type of crash (single-vehicle vs. multi-vehicle crash);
- Light conditions in four categories (day vs. dusk/dawn vs. night w. artific. light vs. night);
- Location of accident (urban vs. rural);
- Type of traffic participation (car drivers vs. drivers of PTW [1]);
- Alcohol: exact value in g/L;
- Alcohol classified in five categories according to concentration in g/L
  (0.0 ≤ only alcohol ≤ 0.09 vs. 0.1 ≤ only alcohol ≤ 0.49 vs. 0.5 ≤ only alcohol ≤ 0.79 vs. 0.8 ≤ only alcohol ≤ 1.19 vs. 1.2 ≤ only alcohol);
- THC exact value in ng/mL;
- THC-COOH exact value in ng/mL;
- Cannabinoids: detected in sample (according to DRUID-cut-offs) yes/no;
- Amphetamines: detected in sample (according to DRUID-cut-offs) yes/no;
- Cocaine: detected in sample (according to DRUID-cut-offs) yes/no;
- Opiates: detected in sample (according to DRUID-cut-offs) yes/no;
- Opioids: detected in sample (according to DRUID-cut-offs) yes/no;
- Benzodiazepines: detected in sample (according to DRUID-cut-offs) yes/no;
- Z-drugs: detected in sample (according to DRUID-cut-offs) yes/no;

The Biomechanics and Accident Analysis Unit at the Institute of Forensic Medicine of the Ludwig-Maximilians-University in Munich prepared the data sheets that were used for data sampling in all participating institutes.

[1] The Lithuanian sample contained two cases with drivers of a PTW. Those two cases were already included in the database prior to a definite decision on the characteristics of the sampled population. All other participants sampled solely car drivers.

**Toxicological analysis**

Cases were excluded if more than 10 hours had elapsed until death. In the majority of cases death occurred immediately after the accident or within the first three hours after accident (94.8% of all subjects). In these cases blood samples used for the toxicological analysis were obtained at the autopsy of the respective subjects which normally took place one or two days after the accident. A few samples were drawn at the scene of the accident (by an emergency physician).

Blood samples of those cases who survived the accident by more than three hours but deceased within 10 hours of the accident were in most instances drawn at the respective autopsy, a few samples were however obtained at scene or in hospital.

Those fatalities that did not die immediately were assessed with regards to relevant toxicological impact at the time point of accident in terms of time period between accident and death, time period between death and blood sampling and possible medication in hospital (which was also detected in blood).

There were 15 German drivers and 10 Slovakian drivers who died later than three but not more than 10 hours after accident (5.2% of whole sample). The toxicological analysis of these cases revealed a typical medication used in the case of an emergency while treating severely injured subjects at scene or in hospital (i.e. analgesics, narcotics, sedatives, hypnotics, anaesthetics, relaxants like Ketamin, Midazolam, Lidocain, Atracurium). These cases were included, however in order to be able to evaluate the toxicological status at the time of the accident we disregarded the medication applied in the situation of vital threat.

In general, whether a subject was impaired due to consumption of psychoactive substances at the time of the accident can not be estimated by the results of the toxicological analysis alone. In fact the corresponding interpretation is dependent on several factors. In the case of licit drugs these comprise duration of drug usage respectively prescriptions as well as dose regime and recent dose increase of the respective subject. Similar questions apply to consumption of illicit drugs, i.e. duration of usage and possible development of tolerance. Unfortunately, in the majority of cases this kind of information was not available so impairment of subject was assumed if blood analysis revealed potentially relevant results.

Regarding the body region from which blood samples were drawn, for almost all cases where blood samples originated from the respective autopsy, blood was taken from a femoral vein, in few cases where this was not possible heart blood was used. Blood samples

drawn at the scene of the accident or in hospital were mainly drawn from a basilic vein (superficial vein of the upper limb).

Details concerning the toxicological analysis of the respective participating institutes are enclosed in Annex I. In the following, as an example of the toxicological analysis procedure, we describe in short the method used at the LMU:

Alcohol:
- blood test in all cases;

Cannabis, amphetamines, opiates, cocaine:
- 1) immunological testing in blood;
  2) analysis in whole blood by means of GC-MS **(**Gas chromatography-mass spectrometry) when the test is positive;

Sedativa and Extra substances:
- additional HPLC-DAD-Screening (High-performance liquid chromatography) in blood in all cases, if enough blood is available.

According to the proposed DRUID cut-off values the following whole blood concentrations of respective substances were considered as positive limits even if the analytical limits of detection and quantification were lower:

Ethanol

Ethanol ≥ 0.1 g/L

Cannabinoids

THC (Δ9-tetrahydrocannabinol) ≥ 1 ng/mL

THC-COOH (11-nor-9-carboxy-Δ9-tetrahydrocannabinol) ≥ 5 ng/mL

Amphetamines

Amphetamine, Methamphetamine, MDMA (3,4-Methylenedioxymethamphetamine)

MDE = MDEA (3,4-Methylenedioxyethylamphetamine), MDA (3,4-Methylenedioxyamphetamine ≥ 20 ng/mL

Cocaines

Cocaine ≥ 10 ng/mL

Benzoylecgonine ≥ 50 ng/mL (a cocaine metabolite)

Opiates

Morphine ≥ 10 ng/mL

Codeine ≥ 10 ng/mL

6-Monoacetylmorphine (6-MAM) ≥ 10 ng/mL

Opioids

Methadone ≥ 10 ng/mL

Benzodiazepines

Diazepam ≥ 20 ng/mL

Oxazepam ≥ 50 ng/mL

Nordiazepam (Nordazepam) ≥ 20 ng/mL

Alprazolam ≥ 10 ng/mL

Clonazepam ≥ 10 ng/mL

Lorazepam ≥ 10 ng/mL

Flunitrazepam[2] ≥ 2 ng/mL

Z-drugs

Zolpidem ≥ 20 ng/mL

Zopiclone ≥ 10 ng/mL

**Statistical analysis**

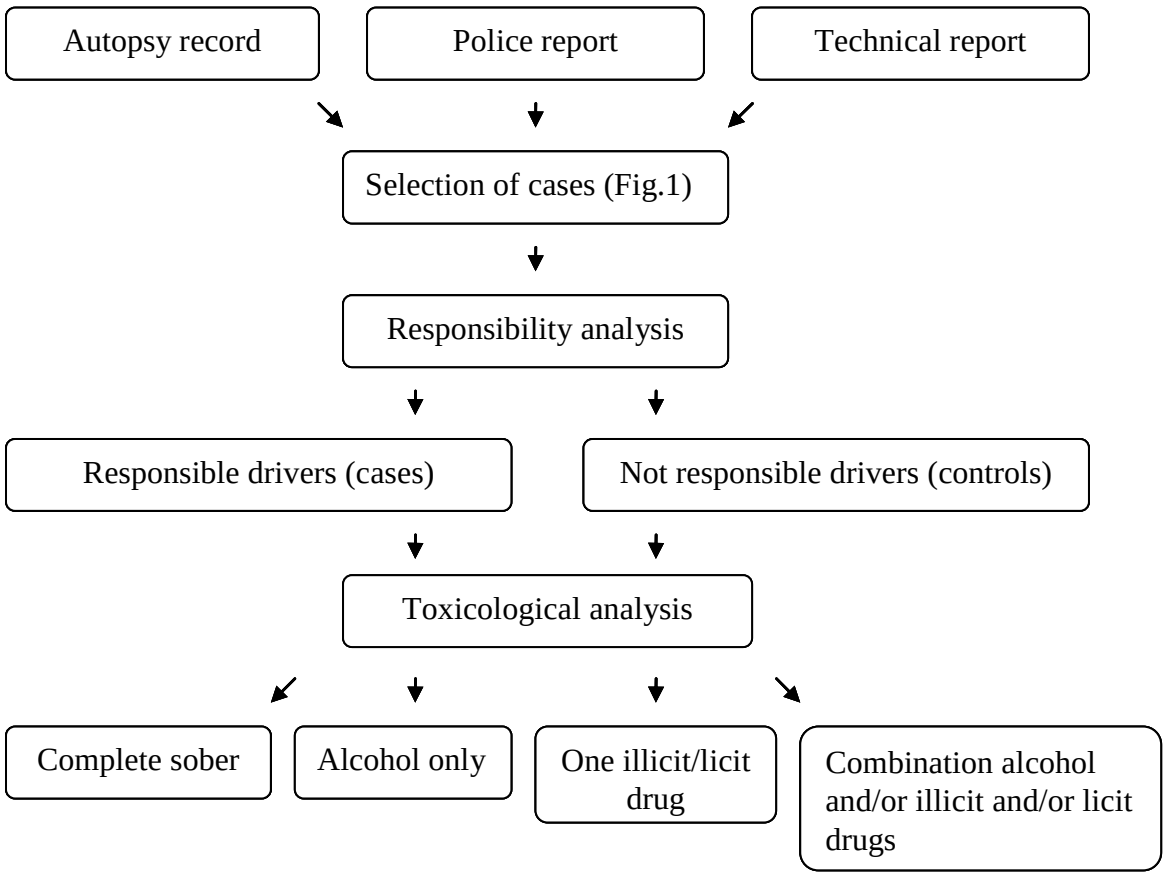
All variables analysed were either both nominal and ordinal or were dichotomized (positive/negative) based on cut-off levels for continuous parameters. Comparisons between the different countries in the accident characteristics were performed by calculating frequency distributions by groups (age-groups, substance groups, accident characteristics etc.) and cross tabulations. Analytical statistics were applied by comparing the severely intoxicated alcohol group to the sample of sober subjects (alcohol < 0.1 g/L) by comparing frequencies of characteristics. Therefore Chi Square tests with significance level of $\alpha = 0.05$ were performed. Crude and adjusted (age, gender) odds ratios (OR) and their respective 95% confidence limits for the risk of being responsible for a fatal accident while under influence of a psychoactive substance were calculated with Mantel-Haenszel Statistics.

All calculations were carried out with the statistical software package SPSS 18.

[2] Additionally 7-aminoflunitrazepam (as main biomarker in post-mortem samples) at LMU and CU as well as Norflunitrazepam and 7-acetamidoflunitrazepam at LMU as a part of the routine screening.

The overall analysis procedure is subsumed in Figure 2.

**Figure 2:** Analysis procedure



## RESULTS

### Description of sample

Germany

The German sample had the highest proportion of killed female drivers (27.0%) of all country samples and highest mean age of all country samples, 45.8 years (range 18 – 88 yrs) (Table 1). This is reflected in the distribution of the German subjects according to age classes with 41.0% being 50 years and older, approximately 22% were between 18 – 24 and 35 – 49 years respectively and 14.5% were between 25 – 34 years. The German sample also had the highest proportion of multi-vehicle accidents as well as accidents in rural setting compared to other samples (71.0% and 91.5%, respectively). Over 60% of the accidents in Germany happened during the day with 27.0% accidents being accidents during night time.

Lithuania

The 41 Lithuanian fatalities were on average 33.2 years old (range 18 – 82 yrs) (Table 1). 37 subjects (90.2%) were males. Over 40 percent of Lithuanian subjects were younger than 25 years, 8 subjects were 25 – 34 years old at time of death, 12 people (29.2%) were 35 – 49 years old and 4 (9.7%) were 50 years old and older. More than half of the accidents in Lithuania were single-vehicle accidents (53.7%), with 18 (43.9%) respectively 19 (46.3%) accidents taking place in the daytime respectively night time. The majority of the Lithuanian sample were accidents in a rural setting (75.6%) and of 41 events, 39 were accidents with cars whereas two fatally injured drivers used a PTW.

Hungary

The Hungarian sample included 93 fatalities with sufficient information available for analysis (Table 1). Of those fatalities 78 (84.0%) were males. The mean age of the Hungarian sample was 41.2 years (range 18 – 81 yrs). This reflects the distribution of the age classes where almost one third of the cases were 50 years and older (32.3%) and only 12.9 % (12 subjects) were younger than 25 years. The age classes 25 – 34 years and 35 – 49 years respectively made up approximately a quarter of the Hungarian cases. All Hungarian fatalities were driving a car with more than half of the accidents being a multi-vehicle event (61.3%) as well as being accidents which took place during the daytime (52.7%). Night-time accidents made up for 35.5% of all accidents. As in the other countries the majority of Hungarian accidents took place in a rural setting (87.1%).

Slovakia

The mean age of the 170 Slovakian fatalities was 39.4 years (range 18 – 82 yrs) (Table 1). A total of 127 of those were males (85.2%). 25 victims (16.8%) were 18 – 24 years at time of death, 46 (30.9%) at the age of 25 – 34, 38 (25.5%) aged 35 – 49 and 40 (26.8%) 50 years or older. The Slovakian sample included 76 (51.0%) single-vehicle accidents and 73 (49.0%) multi-vehicle accidents, with a majority (76.5%) of accidents taking place in a rural setting. Over 60% of the Slovakian events occurred during the day and all accidents were ones with cars.

**Table 1:** Description of sample

| Explanatory variable | Number of subjects (n) [%] | | | | |
|---|---|---|---|---|---|
| | **Germany (n=200)** | **Lithuania (n=41)** | **Hungary (n=93)** | **Slovakia (n=149)** | **Total (n=483)** |
| **Male sex** | 146 [73.0] | 37 [90.2] | 78 [84.0] | 127 [85.2] | **388 [80.3]** |
| **Female sex** | 54 [27.0] | 4 [9.8] | 15 [16.1] | 22 [14.8] | **95 [19.7]** |
| **Mean age in years** | 45.8 | 33.2 | 41.2 | 39.4 | **41.7** |
| **Age classes** | | | | | |
| **18 - 24** | 45 [22.5] | 17 [41.5] | 12 [12.9] | 25 [16.8] | **99 [20.5]** |
| **25 - 34** | 29 [14.5] | 8 [19.5] | 25 [26.9] | 46 [30.9] | **108 [22.4]** |
| **35 - 49** | 44 [22.0] | 12 [29.2] | 26 [28.0] | 38 [25.5] | **120 [24.8]** |
| **50 +** | 82 [41.0] | 4 [9.7] | 30 [32.3] | 40 [26.8] | **156 [32.3]** |
| **Type of crash** | | | | | |
| **Single vehicle** | 58 [29.0] | 22 [53.7] | 36 [38.7] | 76 [51.0] | **192 [39.8]** |
| **Multi vehicle** | 142 [71.0] | 19 [46.3] | 57 [61.3] | 73 [49.0] | **291 [60.2]** |
| **Light conditions:** | | | | | |
| **Day** | 129 [64.5] | 18 [43.9] | 49 [52.7] | 93 [62.4] | **289 [59.8]** |
| **Dusk or dawn** | 12 [6.0] | 3 [7.3] | 6 [6.5] | 0 [0.0] | **21 [4.3]** |
| **Night (artificial light)** | 5 [2.5] | 1 [2.4] | 5 [5.4] | 0 [0.0] | **11 [2.3]** |
| **Night** | 54 [27.0] | 19 [46.3] | 33 [35,5] | 56 [37.6] | **162 [33.5]** |
| **Location:** | | | | | |
| **Urban** | 17 [8.5] | 10 [24.4] | 12 [12.9] | 35 [23.5] | **74 [15.3]** |
| **Rural** | 183 [91.5] | 31 [75.6] | 81 [87.1] | 114 [76.5] | **409 [84.7]** |
| **Vehicle type:** | | | | | |
| **Car** | 200 [100.0] | 39 [95.1] | 93 [100.0] | 149 [100.0] | **481 [99.6]** |
| **Motorcycle** | 0 [0.0] | 2 [4.9] | 0 [0.0] | 0 [0.0] | **2 [0.4]** |

**Results of responsibility analysis**

The responsibility analysis yielded a total of 419 cases (86.7%) and 64 controls (13.2%). The proportion of cases vs. controls differed to a certain degree among the participants. The highest proportion of controls (16%) was in Germany, the lowest proportion of controls was found among the Lithuanian subjects (7.8%). The results of the responsibility analysis are demonstrated together with the results of the toxicological analysis in Table 3 (Annex II).

**Results of toxicological analysis (see also Annex II, Table 2)**

Germany

Of 200 German subjects 68 (34%) had a positive toxicological screening (Annex II, Table 2). 42 of 68 subjects (61.8% of drug positive subjects) tested positive for alcohol only (≥ 0.1 g/L), with more than half of those cases being equal or above 1.2 g/L. Four subjects had blood concentrations of 2.0 g/L and more (18.2% of all subjects ≥ 1.2 g/L).

Only one subject had THC-concentrations above 1 ng/mL whereas two subjects had THC-COOH-concentrations above 5 ng/mL (with or without THC-concentrations below 1 ng/mL). There was one case respectively positive on amphetamines and opiates as well as two cases respectively positive on benzodiazepines and Z-drugs.

Four subjects had consumed alcohol and one illicit/licit drug respectively (alcohol + cannabinoids, amphetamines, benzodiazepines and Z-drugs respectively). One subject had consumed a combination of alcohol, opiates and benzodiazepines whereas one subject was tested positive for benzodiazepines combined with antidepressants.

A screening is routinely done at the LMU for several analytes which was also the case for the subjects included in the present study. This screening for so called "DRUID – Extra substances" was positive for seven subjects (3.5%), two of them in combination with alcohol (Annex II, Table 2).

Lithuania

Of 41 Lithuanian cases 26 subjects (63.4%) tested positive in a toxicological screening (Annex II, Table 2). 25 of those subjects (96.1% of subjects with positive screening results) tested positive for blood alcohol concentrations over 0.1 g/L without further substances. Except for one case all Lithuanian cases where the subject had consumed solely alcohol had blood concentrations of 1.2 g/L or more. Of those 24 subjects 15 (62.5%) had blood concentrations of 2.0 g/L or more. One subject was tested positive on THC and THC-COOH.

Hungary

Of 93 Hungarian fatalities 50 subjects (53.8%) had a positive toxicological screening (Annex II, Table 2). Of those subjects with a positive test 37 had consumed alcohol only resulting in blood concentrations of over 0.1 g/L. Of those 37 alcohol-positive subjects (74.0% of subjects with a positive toxicological screening), 25 had concentrations over 1.2 g/L whereas 14 subjects of those 25 (56%) were severely intoxicated with blood concentrations of 2.0 g/L or more. Three fatalities had consumed alcohol and drugs. The substances detected in combination with alcohol were THC-COOH and two cases showed a combination with benzodiazepines. Nine subjects were positive for only one substance, seven of them for benzodiazepines and two subjects for THC-COOH. One subject was tested positive for a combination of opiates and benzodiazepines.

Slovakia

A total of 62 (41.6%) of the 149 Slovakian subjects had a positive toxicological screening (Annex II, Table 2). 52 fatalities (83.9% of positively tested subjects) were screened positive for alcohol only (concentrations over 0.1 g/L). According to alcohol classes the majority of cases had concentrations which exceeded 1.2 g/L (n = 36). Of those 36 subjects, 17 fatalities (47.2%) had blood concentrations of 2.0 g/L or more. Five subjects tested positive for combinations of alcohol and substances; the substances detected in combination with alcohol were THC, benzodiazepines, cocaine and amphetamines as well as cannabis + amphetamines. Four subjects were positive on solely one substance, THC, amphetamines, opiates and neuroleptics respectively. One subject had consumed a combination of cannabis and amphetamines.

Of a total of 107 subjects at or above 1.2 g/L, 50 subjects (46.7% of subjects ≥ 1.2 g/L) in total had blood concentrations of 2.0 g/L. There were noticeable differences in these cases with regards to regional distribution. While only four German subjects (18.7% of German subjects ≥ 1.2 g/L) had blood concentrations of 2.0 g/L and above this proportion was much higher in the Eastern-European catchment areas being the highest in Lithuania with 62.5% (n=15) followed by Hungary (56%, n=14) and Slovakia (47.2%, n=17).

Whole sample

206 of a total of 483 subjects (42.7%) had a positive toxicological screening for one or more psychoactive substances (Annex II, Table 2). Of those 206 positively tested subjects 160 tested positive for alcohol only (77.7%). Another 16 subjects detected positive with combinations of alcohol and licit (n=7) or illicit drugs (n=7) with two cases being positive on alcohol and licit

as well as illicit drugs which adds the group of drivers with alcohol involvement up to 176 subjects (85.4% of positive subjects). The remaining 30 subjects consisted of 18 subjects with licit drugs (singular or combinations of licit substances) and 12 with illicit drugs (singular or combinations of illicit substances).

Taking a look at the overall involvement of licit and illicit drugs (singular use or in combination with other licit/illicit drugs or alcohol) for licit drug the overall involvement accounted for 27 subjects (13.1% of positively tested subjects / 5.6% of whole sample). The overall involvement of illicit drugs in the study concerned 21 subjects (singular use and combinations with other illicit, licit drugs and alcohol) which corresponded to 10.2% of all drug positive drivers and 4.3% of the whole sample (n = 483).

Considering the whole sample on a descriptive level, taking the responsibility analysis and the toxicological analysis into account, Table 3 (Annex II) reveals the uneven distribution of the presence of psychoactive substances among cases (n = 419) and controls (n = 64). As for alcohol concentrations above 0.1 g/L the sample included 153 cases (36.5% of all cases) vs. 7 controls (10.9% of all controls) which means that the proportion of alcohol-positives is more than three times higher in the group of cases. For the rest of the sample with a positive toxicological screening (n = 46) these effects do not emerge to the same extinct as for alcohol where there were 42 cases (10.0% of all cases) vs. 4 controls (6.3% of all controls).

Regarding the number of subjects per category of psychoactive substance the category which included blood concentrations of alcohol of 1.2 g/L and above played a prominent role (n=107, 66.9% of all alcohol-positive subjects). Therefore it seemed interesting whether the sample characteristics of this group differed to the sample characteristics of drivers with alcohol concentrations below 1.2 g/L. A corresponding analysis yielded the following results: Drivers who had blood concentrations of 1.2 g/L alcohol and above were more frequently males (88.1% vs. 77.0 % of drivers ≤ 1.2 g/L) aged 25 – 34 years (32.1% vs. 19.2%) or 35 – 49 years (34.9% vs. 22.1%) and were more often involved in single-vehicle accidents (67.9% vs. 30.1%) at night (56.9% vs. 27.1%). In contrast drivers aged 50 years and above were considerably underrepresented among subjects with concentrations of 1.2 g/L and above (10.1% vs. 38.9% of drivers ≤ 1.2 g/L). These differences were all statistically significant (p-value < 0.05).

**Results of odds – ratio calculations for subsamples**

In general OR calculations for the respective subsamples were made difficult or impossible due to the uneven distribution of cases vs. controls within the respective categories of psychoactive substances. For instance there were 22, 24 and 25 cases respectively for alcohol concentrations above 1.2 g/L in Germany, Lithuania and Hungary respectively, however no controls for this category. Adjustments were made for gender and age. Due to the low number of subjects and the resulting low statistical power the results of the OR calculations are except for one category (Slovakia, Table 6) not significantly different from the value 1 and therefore except for this one category the analysis does not demonstrate an effect of the analyzed substances on being responsible for a fatal crash. We conducted the OR calculations only on subjects who were completely sober (blood concentrations of alcohol below 0.1 g/L and no other illicit or licit drugs detected) and subjects who had a positive screening for only one substance (alcohol, cannabis, benzodiazepines). This analysis included a total of 440 subjects.

Germany

Due to the low number of cases vs. controls OR calculations were only possible for the two categories displayed in Table 4. Crude and adjusted odds ratios do not show a significant difference from value 1 and therefore a correspondent effect of alcohol on the risk of being responsible for a fatal crash can not be accounted for in this study.

**Table 4:** OR for the German subsample

| **Psychoactive substance** | **Germany (n = 176)** | | | | |
|---|---|---|---|---|---|
| | **Nr. of subjects** | **Crude OR** | **95% CI** | **Adjusted OR (§)** | **95% CI** |
| **0 ≤ Alcohol < 0.1 g/L** | 131 | 1.00 | | | |
| **0.1 ≤ Alcohol < 0.5 g/L** | 15 | (0.99) | 0.26 - 3.77 | (1.05) | 0.26 – 4.25 |
| **0.8 ≤ Alcohol < 1.2 g/L** | 5 | (0.99) | 0.11 - 9.24 | (0.54) | 0.04 – 7.81 |

§ Adjusted for age and gender

Lithuania

Due to the low number of cases vs. controls an OR-calculation with the Lithuanian data was not possible (Annex II, Table 3).

Hungary

Due to the low number of cases vs. controls OR calculations were only possible for the two categories displayed in Table 5. Crude and adjusted odds ratios do not show a significant difference from value 1 and therefore a correspondent effect of alcohol or benzodiazepines on the risk of being responsible for a fatal crash is not demonstrated.

**Table 5:** OR for the Hungarian subsample

| | **Hungary (n = 87)** | | | | |
|---|---|---|---|---|---|
| **Psychoactive substance** | **Nr. of subjects** | **Crude OR** | **95% CI** | **Adjusted OR (§)** | **95% CI** |
| **0 ≤ Alcohol < 0.1 g/L** | 43 | 1.00 | | | |
| **0.1 ≤ Alcohol < 0.5 g/L** | 12 | (0.66) | 0.11 - 3.91 | (0.69) | 0.12 – 3.91 |
| **Benzodiazepines** | 7 | (0.79) | 0.08 - 7.98 | (0.63) | 0.04 – 9.75 |

§ Adjusted for age and gender

Slovakia

Due to the low number of cases vs. controls OR calculations were only possible for the one category displayed in Table 6. For alcohol concentrations of 1.2 g/L and above odds ratios are significantly different from 1, crude odds ratios being 9.78 and adjusted OR being 8.16. However, the corresponding confidence intervals are extremely wide resulting in poor precision estimates.

**Table 6:** OR for the Slovakian subsample

| Psychoactive substance | Slovakia (n = 136) | | | | |
|---|---|---|---|---|---|
| | Nr. of subjects | Crude OR | 95% CI | Adjusted OR (§) | 95% CI |
| **0 ≤ Alcohol < 0.1 g/L** | 87 | 1.00 | | | |
| **1.2 ≤ Alcohol** | 36 | 9.78 | 1.26 - 76.10 | 8.16 | 1.15 - 58.11 |

§ Adjusted for age and gender

**Results of odds – ratio calculations for whole sample (pooled data)**

OR calculations were done for the substance categories where a sufficient number of cases and controls in order to conduct such calculations were available. Of a total of 483 subjects 440 could be considered for the OR – calculations.

Table 7 shows the result of the OR calculations with regards to the risk of being responsible for a fatal traffic accident while under influence of alcohol (yes [blood concentrations ≥ 0.1 g/L] vs. no [blood concentrations < 0.1 g/L and no other substances/medication detected).

**Table 7:** Whole sample – OR of the risk of a killed driver being responsible for a fatal traffic accident while under influence of alcohol (blood concentrations ≥ 0.1 g/L)

| Psychoactive substance | Whole sample (OR) (n = 440) | | | | |
|---|---|---|---|---|---|
| | Nr. of subjects | Crude OR | 95% CI | Adjusted OR (§) | 95% CI |
| **0 ≤ Alcohol < 0.1 g/L** | 276 | 1.00 | | | |
| **0.1 ≤ Alcohol** | 152 | 4.92 | 2.18 - 11.13 | 4.57 | 2.02 – 10.38 |

§ Adjusted for age and gender

Crude and adjusted odds ratios for alcohol consumption (yes/no) are similar and moderately high with OR around 4.5. However, bearing the uneven distribution of subjects over the different alcohol categories (Table 8) with proportionally fewer subjects in the categories of lower consumption and many severely intoxicated subjects in mind, these OR values must

be interpreted with care. In order to have a clearer picture of the OR of the respective alcohol categories we calculated (where possible) the OR for each dosage level. For one category no calculation was possible due to missing controls in this category. For two categories (0.1 ≤ Alcohol < 0.5 g/L and 0.8 ≤ Alcohol < 1.2 g/L) calculations were possible, however the results (OR around 1.5) were not statistically different from value 1 and the analysis does not show an effect of these alcohol concentrations on the risk of being responsible of a fatal crash. In contrast the OR for alcohol concentrations of 1.2 g/L and more are statistically different from 1 and extremely high (adjusted OR around 20), however the confidence intervals are extraordinary wide and therefore the precision of estimate is very poor.

Table 8 also shows the results of OR calculations regarding cannabis (THC ≥ 1 ng/ml) and benzodiazepines. The number of subjects was low for those categories, resulting in a low statistical power which is reflected in the respective OR which are not statistically different from the value 1 and the wide confidence intervals. Therefore the analysis does not show an effect of those substances on the risk of being responsible for a fatal accident.

**Table 8:** Whole sample – OR of the risk of a killed driver being responsible for a fatal traffic accident while under influence of alcohol (five dosage levels)

| **Psychoactive substance** | **Whole sample (OR) (n =440)** | | | | |
|---|---|---|---|---|---|
| | **Nr. of subjects** | **Crude OR** | **95% CI** | **Adjusted OR (§)** | **95% CI** |
| **0 ≤ Alcohol < 0.1 g/L** | 276 | 1.00 | | | |
| **0.1 ≤ Alcohol < 0.5 g/L** | 38 | (1.57) | 0.59 – 4.21 | (1.56) | 0.58 – 4.23 |
| **0.5 ≤ Alcohol < 0.8 g/L** | 0 | * | * | * | * |
| **0.8 ≤ Alcohol < 1.2 g/L** | 7 | (1.43) | 0.17 – 12.01 | (1.18) | 0.14 – 10.20 |
| **1.2 ≤ Alcohol** | 107 | 25.19 | 3.44 – 184.64 | 20.84 | 3.10 - 140.16 |
| **THC ≥ 1 ng/ml** | 3 | (0.48) | 0.04 – 5.34 | (0.26) | 0.01 – 5.31 |
| **Benzodiazepines (y/n)** | 9 | (1.90) | 0.23 – 15.53 | (1.66) | 0.19 – 14.55 |

§ Adjusted for age and gender

* OR-calculations not possible due to low nr. of cases vs. controls

Due to the low number of cases vs. controls calculations for other substances (e.g. cannabis) regarding dose-levels were not possible.

## DISCUSSION

The aim of the responsibility study was to evaluate and compare the relative risks among fatally injured drivers in four different European countries (Germany, Lithuania, Hungary and Slovakia) of being responsible for a fatal traffic accident when driving under the influence of alcohol and/or other psychoactive substances. Furthermore the sampled data was to provide an insight into the proportion of drivers under influence of psychoactive substances among fatally injured drivers in those four different European countries and the substances used.

The results of the study reveal the considerable involvement of psychoactive substances among fatally injured drivers (Annex II, Table 2). More than 40% of all killed drivers had a positive toxicological screening for a psychoactive substance. Among the fatally injured drivers with a positive toxicological screening alcohol is the most widely used substance, being found either as a singular substance or in combinations with illicit/licit drugs in more than 85% of subjects. In this respect other licit or illicit drugs are of secondary importance being involved in 13% and 10% of subjects with a positive toxicological analysis, respectively.

*Alcohol*

The results of our study demonstrate the prominent role that alcohol as a psychoactive substance plays among killed drivers in the respective catchment areas. The majority of drivers driving under the influence of alcohol had blood concentrations over 1.2 g/L with almost half of these drivers at or above 2.0 g/L, hence drivers who consumed alcohol were in general considerably intoxicated and far beyond the tolerance limits of the respective countries[3]. These findings apply in particular to the Eastern-European samples. Comparison of sample characteristics of drivers at or above 1.2 g/L with drivers below 1.2 g/L showed significantly more males, aged 25 – 49 years involved in single-vehicle accidents at night for the group of severely intoxicated drivers. Despite the low statistical power for the calculation of OR, the almost complete lack of controls in the category alcohol > 1.2 g/L could be a hint for the severe impairment of subjects in this group. These findings together with the aforementioned

[3] Germany – administrative offence: 0.00 g/kg [‰] for learner drivers, all drivers between 18-21 years and newly licensed drivers of any age for first two years of licence, 0.5 g/kg [‰] for other drivers. Germany – absolute unfitness to drive: 1.1 g/kg [‰]; Lithuania: 0.02% for drivers in their first two years after gaining a driving license, 0.04% for other drivers; Hungary and Slovakia zero tolerance.

regional differences could possibly contribute to the ongoing discussion concerning legislative thresholds and the focus of preventive measures in future campaigns.

*Illicit drugs*

The overall involvement (singular use and combinations with other illicit/licit drugs or alcohol) of illicit drugs accounted for 10.2% of positively tested drivers and 4.3% of the whole sample. The most frequently found illicit drug was cannabis (n=12, 2.5% of whole sample). Our figures concerning the involvement of illicit drugs in fatal accidents are lower than found in other studies within the DRUID-project [6, 7] and are according to our experience underrepresented. In our opinion this has to do (among other reasons) with restricting the sample to killed drivers. Like stated in the section "Methodological considerations" below, according to literature and the daily experience of forensic toxicologists at LMU dealing with public prosecution matters, presumably an inclusion of surviving drivers would have in this respect yielded different results - probably resulting in a higher proportion of illicit drugs among the overall number of drivers involved in a fatal crash. In other words, the use of illicit drugs among traffic participants has to be monitored closely, in particular in order to detect alterations in consumption behaviour of illicit drugs which more often than other substances tend to be subjected to trends.

On a descriptive level no major differences were detected between the respective subsamples concerning the proportion of illicit drugs. However, concerning the small number of subjects and the descriptive level, a comparison of this kind has to be interpreted with care. Further research with higher case numbers is therefore strongly needed.

*Licit drugs*

The overall involvement of licit drugs (singular use and combinations with other illicit, licit drugs and alcohol) applied to 27 subjects (13.1% of positively tested subjects/5.6% of whole sample). The most frequently found licit drugs were benzodiazepines (n=18, 3.7% of whole sample). Due to routine screening methods at LMU and in Slovakia eight of subjects were tested positive on licit "extra substances" not included in the DRUID core list (Annex II, Table 2). Among substances detected in this step of the analysis were centrally active analgesics and neuroleptics which certainly bear the potential of influencing driving behaviour after consumption. These findings support the inclusion of more psychoactive substances in the list of screened substances in future studies of this kind. Moreover, samples should be

screened for a broad range of relevant substances to avoid false-negative controls of "sober" candidates.

Compared to the other subsamples the Hungarian sample included proportionally many fatalities tested positive for benzodiazepines (seven subjects of a total nr. of nine subjects with benzodiazepines). Whether this finding is a random phenomenon or has to do with the Hungarian drug prescription procedures in general cannot be explained with our current knowledge. Correspondent to illicit drugs, concerning the small number of subjects and the descriptive method, comparative figures of the subsamples have to be interpreted with care.

**Methodological considerations and limitations**

In three countries (Germany, Lithuania, Hungary) subjects were sampled prospectively in the same time period (2008/2009) from a database established within the framework of the DRUID project. German data was additionally increased by retrospective data (2003 – 2007). The Slovakian subjects were sampled from a database already maintained at the University of Bratislava (Sampling period: 2005 - 2009).

In Lithuania, Hungary and Slovakia the autopsy and the compulsory toxicological analysis of traffic fatalities are imposed by law which explains the much higher capture rates of 81 – 91%of all killed drivers in the respective catchment areas compared to Germany where autopsies and toxicological analysis of traffic fatalities are ordered by the respective public prosecutor. The corresponding capture rates for the German sample were 16.4%. Due to the legislation in the participating East-European countries with the compulsory examination of traffic fatalities the corresponding samples are unlikely to be subjected to selection bias whereas the same can not be stated for the German sample. The main reason for the susceptibility of the Bavarian data to selection bias is the dependence of the sampling method on the individual selection criteria of ten different public prosecution offices. Approximately 31% of traffic fatalities are autopsied by prosecutor's order in Bavaria. A part of these fatalities also receive an order for a toxicological analysis. The proportion of autopsy orders varies considerably among the different public prosecution offices (Range: 3 – 100%). The steps of decision-making regarding the selection of subjects for autopsy and toxicological screening are not transparent. Therefore it is uncertain whether drivers are more often or less often subjected to an autopsy order than other traffic participants and the same holds true for the toxicological analysis. A comparison of samples positive for drugs other than alcohol in the regularly ordered cases and the supplementary analysed ones revealed even a slightly

higher percentage of drug-positive results for the supplementary analysis. Only for alcohol, which is easy to detect due to odour of alcohol, the percentage of positive samples in mandated samples is higher.
Due to significant regional differences regarding the proportion of autopsy orders per prosecutor, in this respect a factor contributing to a possible selection bias also has to be assumed. Since the approvals for the use of public prosecution records and for the use of preserved blood from autopsy for supplementary toxicological analysis had to be obtained for each case separately and three of ten public prosecution offices did not grant the request regarding the toxicological analysis of blood samples, this circumstance is an additional factor favouring selection bias in the LMU sample.
Restricting the sample to killed drivers and not for example include surviving drivers (injured and not injured) certainly decreased the number of subjects who were included in the study and consequently the statistical power of the results. However, since toxicological analysis of subjects were a principal component in this study it was desirable to design the study in a manner which reduced bias concerned with collection of blood samples and the subsequent toxicological analysis and hence, increase the comparability of results. However, considering the toxicological profile of injured or non-injured drivers whose blood samples are analyzed at the Dept. of Forensic Toxicology at the LMU in public prosecution procedures, the prevalence of substances is partly higher than in our study, especially THC is, compared to our study, a more frequent finding. It would therefore be a desirable extension of our database to be able to include this population of drivers.

Overall WP2-requirements did not specify time limits regarding time of death. In the present study all subjects who deceased within 10 hours after accident were included. However, it has to be taken into account that some short acting drugs will no longer be detectable or below the DRUID cut offs after a period of up to 10 h between accident and death/blood sampling. In an effort to be able to reduce the number of missing cases and simultaneously get a representative toxicological profile of the subjects the time limit of 10 h was chosen. Since the proportion of cases who deceased between three and ten hours made up around 5% of the whole sample with regard to the results, the effect of the elapsed time between accident and blood sampling on the detection of potentially present is presumably negligible.
The risk of false-negative cases due to already eliminated drugs was diminished by including metabolites in the analysis (e.g. THC-COOH) and by analysis of urine, if available, which expand the time frame of detection respectively.

The responsibility method proposed by Robertson and Drummer was used for the responsibility analysis. Each institute conducted the responsibility analysis separately, however several meetings were held in order to ensure the comparable implementation of the method among the partners. Since there were no major differences regarding the distribution of cases and controls in the four different countries one can assume a similar implication of the method among the four participants of the study. However, given the uneven distribution of cases vs. controls with this method and the subsequent OR calculations which under many circumstances were not possible or did not yield exploitable results due to low statistical power, future analysis of this kind will require a number of subjects which considerably exceed the number of subjects in this study. It is therefore our aim to maintain the established database over several years continuing to collect subjects in the proposed manner. Since the retrospective analysis of blood samples was somewhat inefficient with several German cases excluded due to missing remaining blood samples, future improvements of study design should among other things emphasize prospective sampling.

## CONCLUSION

Regarding the high proportion of killed drivers who at the time of the fatal accident were under influence of alcohol with the majority being severely intoxicated, preventive measures should emphasize alcohol as a key substance which use presents a permanent threat to traffic participants in Europe. Nevertheless around 5% of the analyzed samples were in conjunction with illicit drugs. Here as well efficient countermeasures should be undertaken.

The continuation of the prospective sampling of fatally injured drivers with a focus on their toxicological profile is on all accounts desirable in order to achieve higher case numbers for an improved statistical analysis. We advocate an extension of the database which includes data of surviving drivers (injured and not injured) and in addition a more extensive list of screened substances. In this way continuous data to the use of psychoactive substance among the driving population could be provided, presenting a useful tool to monitor the use of psychoactive substances in traffic and support legislative and preventive measures.

# II IN – DEPTH ANALYSIS

**Synopsis**

**Objective:** The aim of in-depth analysis of accidents of killed drivers with a positive toxicological analysis was to analyze the contribution of human failure patterns under influence of psychoactive substances to accident causation.

**Material & method:** The in-depth analysis was conducted on 20 cases from Germany and Lithuania which were sampled from the database established within the framework of DRUID, Task 2.3.3. The accident data was analyzed according to a systematic accident causation catalogue developed by the Biomechanics and Accident Analysis Unit at the Institute of Forensic Medicine in Munich. The catalogue consists of 17 elements concerned with assessment and in-depth description of traffic accidents which were all evaluated for each case:

Number of parties involved
Accident Type Classification
Time of day and date
Light condition
Vehicle Type
Road classification
Collision type
Driver manoeuvre prior to accident
Driver's task prior to accident
Purpose of trip
Traffic way flow
"Key event failure"
Contributory factors
Belted
Ejected
Age
Gender
Anthropometric data

Additionally to the catalogue the results of toxicological analysis of each case were taken into account. Each case was evaluated by an accident analyst and a forensic toxicologist.

**Results:** In general many of the accidents appear to be of an extremely high severity due to very high velocities as well as relatively slow reaction.
The 20 in-depth cases were distributed over nine substance categories:
- Five subjects with THC (one of those combined THC with alcohol);
- Nine subjects with alcohol only;
- Two subjects who combined substances with alcohol, in the former case with MDMA + MDA and in the latter with opiates and benzodiazepines;
- Four subjects were tested positive for licit drugs only, one subject for antidepressants, benzodiazepines, z-drugs and a combination of benzodiazepines and antidepressants, respectively.

All but one subject with THC were assessed as responsible for the fatal crash which they were involved in.
Considering the substance groups and the respective accidents there was a principle agreement regarding the characteristics of the accidents.
Fatal crashes taking place under the influence of THC were in the majority of cases due to the central depressant effect of THC accidents where distractibility and a prolonged reaction time were causal factors or partly causal for the accident.
Crashes where alcohol was involved were in the most cases accidents where illegal speeding with a consecutive steering mistake played the most prominent role in the respective accident causation. However, there were two cases where the subjects were heavily intoxicated by alcohol and lack of vigilance due to the severe impairment was probably causal for the fatal event.
Lack of vigilance (clouding of consciousness) as well as a prolonged reaction time was on the other hand the most common factor for cases where licit drugs were involved. Z-drugs, benzodiazepines and antidepressants are all central nervous acting drugs with central depressant effects.

**Conclusion:** The in-depth analysis of 20 accidents with drivers under influence of psychoactive substances allowed for a more detailed look at accident causation and human failure patterns than otherwise possible within the framework of the responsibility study. By means of the in-depth analysis with regard to substance groups, certain similarities in the course of events and failures patterns were identified.

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# ANNEX I – TOXICOLOGICAL METHODS

Germany

**Toxicological Analysis Procedure for DRUID core substances at LMU**

Toxicological analysis was performed at the Department of Forensic Toxicology, Institute of Forensic Medicine, LMU.

Blood samples with added sodium fluoride were stored at -20°C until analysis.

All DRUID core substances were included besides a broad range of other psychotropic drugs (HPLC-DAD screening). The Institute took part successfully in DRUID proficiency tests and proficiency tests organized by GTFCh and DGKL in Germany.

**1. Blood Alcohol (Ethanol) determination method**

100 µL of whole blood were spiked with internal standard solution (tert-butyl alcohol) and transferred to a Headspace vial. The vial is closed immediately and measured by HS-GC-FID. A mean value of two replicates was reported.

GC-FID apparatus:

GC HP 5890 Perkin Elmer (Clarus 500) with Headspace Sampler: Turbo

Matrix 110 and column ZB-WAX plus.

**2. Immunological Screening**

CEDIA reagents from Thermo/Fisher Microgenics were used. Whole blood samples were diluted with 0.9% sodium chloride solution, centrifuged and measured by Hitachi 912 (Roche).

The following tests were applied: Cannabinoids, Cocaine-metabolites, Opiates, Amphetamines and Methamphetamines. The DRUID cut-offs for GC-MS/LC-MS were met by the Immunoassay cut-offs of the lab. Positive results were confirmed by means of GC-MS analysis.

**3. GC-MS method for Amphetamines, Opiates and Cocain and Metabolites**

To 1 mL of whole blood internal standard solution (deuterated analogues of all respective core substances) and carbonate buffer (pH 8−9) were added. Solid phase columns (Oasis, Waters) were conditioned with methanol and water. The sample was transferred onto the SPE column. After a washing step with $H_2O$, the column was dried under vacuum for a few minutes. 100 µL Acetone was applied before the analytes were eluted twice with a dichlormethane/isopropanol mixture. The eluate was evaporated to dryness under a nitrogen flow.

First derivatization was performed with PFPA. The samples were measured by GC-MS and subsequently silylated with MSTFA and analyzed by GC-MS for a second time (for benzoylecgonine).

GC-MS apparatus

GC-MS: Agilent 6890 + Agilent MSD 5973

Column: Varian factorFour VF-5 ms capillary column (30 m, 0.25 µm FD, 0.32µm AD) + EZ-guard 5m

EI ionization mode, 70 eV, SIM mode (3 m/z per analyte)

Calibration ranges of core substances, low/high calibration, [µg/L]

Amphetamine, Methamphetamin, MDMA, MDA, MDEA: 7-100/600

Morphine, Codeine: 7-60/300, 6-Acetylmorphine: 1.5-12/60

Cocaine: 1.5-12/60, Benzoylecgonine: 30-500/2500

**4. GC-MS method for Cannabinoids**

After addition of internal standard solution (deuterated analogues of all core substances) and phosphate buffer pH 3.1 mL of whole blood was extracted by a mixture of cyclohexane/ethyl acetate. The upper (organic) phase was evaporated to dryness and the residue was methylated (DMSO/TBAH, methyl iodide, re-extraction with isooctane).

GC-MS apparatus:

GC-MS: Agilent 6890 + Agilent MSD 5973

Column: Varian factorFour VF-5 ms capillary column (30 m, 0.25 µm FD, 0.32µm AD) + EZ-guard 5m

EI ionization mode, 70 eV, SIM mode (3 m/z per analyte)

Calibration ranges of core substances, low/high calibration, [µg/L]

THC: 0.85-6/50, THC-COOH: 5-60/500

**5. HPLC-DAD/FLD method for Benzodiazepines, Z-drugs & Extra Substances**

After addition of internal standard solution and carbonate buffer (pH 9), 1 mL of whole blood was extracted by chlorbutane. The organic phase was evaporated and the remaining residue was reconstituted with a mixture of acetonitrile/$H_2O$. Aliquots were injected into the HPLC-DAD and HPLC-FLD (for analysis of Zopiclone), respectively.

HPLC-DAD/FLD apparatus:

Shimadzu Prominence System

Column: Merck LiChroCART® 250−4 LiChrospher® 60 RP-select B (5 µm)

Mobile Phase: gradient with acetonitrile and phosphate buffer pH 2.37

Calibration ranges of core substances, low/high calibration, [µg/L]

Diazepam, Nordiazepam, Oxazepam: 15-120/1500

Lorazepam: 5-65/400, Alprazolam: 10-30/100, Clonazepam: 5-30/100,

Flunitrazepam: 1-12/35, Zolpidem: 25-400, Zopiclone: 2.5-20/150

Lithuania

**Description of analytical methods**

Sample preparation, analysis device/method (GC-MS, LC-MS etc), internal standard :

- Blood samples were kept in laboratory at -20°C in 6 ml vacutainers with sodium fluoride and potassium oxalate (manufactured by "Vacuette") until analyzed by the toxicological laboratory of The State Forensic Medicine Service in Vilnius;
- The toxicological laboratory takes part in proficiency testing (Round Robin Test; Arvecon GmbH).

**1. Ethanol**

IS: 0.1 % 1-propanol

Chromatographic conditions:

Chromatographic system: Perkin Elmer Clarus 500 TurboMatrix110

Column 1: Elite BAC1 (PE: 0.18 x 10 x 1.0)

Column 1: Elite BAC2 (PE: 0.18 x 10 x 0.63)

Carrier gas: Helium

Temperature: 35°C

Injection: 2 µL

The mean value of four repeat determinations is reported.

**2. Amphetamines**

LLE

1ml whole blood + 1ml H2O + 50µl IS + 200µl 8N NaOH + 5ml 1-chlorobutane. Vortex 1 min.

Organic layer + 1ml 0,2N H2SO4. Vortex 2 min.

Aqueous layer + 100µl 8N NaOH + 1,2ml 1-chlorbutane. Vortex 2 min. Organic layer +100µl tartaric acid in ethylacetate. Evaporate at 40°C, N2 Equipment: Caliper Turbo Vap LV

**Derivatisation**

+ 50µl ethylacetate + 50µg HFBA. 20min. at 70°C. Equipment: Pierce Reacti-Therm III +100µl tartaric acid in ethylacetateat. Evaporate at 40°C, N2 Equipment: Caliper Turbo Vap LV, Reconstitution: 50µl ethylacetate.

**IS** (all : Cerilliant, 1mg/ml, 1000 ng/ml)

Amphetamine-D5

Metamphetamine-D5

MDA-D5

MDMA-D5

MDEA-D5

**Chromatographic conditions:**

Chromatographic system: Agilent technologies 7890A

Column: DB-5ms ( Agilent technologies, ID -0,25 mm, length – 30 m, 5% Phenyl Arylene polymer, non-polar)

Carrier gas: Helium

Temperature gradient: 100°C(1,0)→20°C/min→200°C→30°C/min→300°C(7)

Injection: 2µl

**Mass Spec conditions:**

MS system: Agilent technologies 5975C inert XL MSD with Triple Axis Detector; EI 70 V

| **Compound** | **Rt** | **TIon (m/z)** | **QIon (m/z)** |
|---|---|---|---|
| Amphetamine-D5 (IS) | 5.11 | 244 | 123 |
| Amphetamine | 5.13 | 240 | 91; 118 |
| Methamphetamine-D5(IS) | 6.03 | 258 | 213 |
| Methamphetamine | 6.06 | 254 | 118; 210 |
| MDA-D5(IS) | 7.67 | 167 | 268 |
| MDA | 7.69 | 162 | 240; 375 |
| MDMA-D5(IS) | 8.25 | 258 | 213 |
| MDMA | 8.27 | 254 | 162; 210 |
| MDEA-D5(IS) | 8.43 | 273 | 408 |
| MDEA | 8.45 | 268 | 240; 403 |

**3. Cocaine and Opiates**

**SPE**

Columns: mixed mode, Grace 3 ml/200mg Drug-Clean, Alltech Associates

**Sample:**

1 ml whole blood + 4 ml H2O + 50 µl IS

+ 2 ml phosphate buffer pH-6,2 (K2HPO4 x 3H2O)

| | |
|---|---|
| **Column conditioning** | 3 ml Methanol<br>3 ml H2O<br>1 ml phosphate buffer pH-6,2 |
| **Washing:** | 2 ml H2O<br>2 ml 0,1 N HCl<br>3 ml Methanol |
| **Elution:** | 1 x 3 ml $CH_2Cl_2$/IPA/$NH_4OH$<br>(78:20:2)<br><br>40 ml 2-propanol + 4 ml $NH_4OH$.<br>Mix + 156 ml dichlormethane |

Evaporate at 40°C, $N_2$ Equipment: Pierce Reacti-Therm III

**Derivatisation**

+ 50 µl Ethylacetate + 40 µl BSTFA. 20min. at 100°C. Equipment: Pierce Reacti-Therm III

**IS:**

| | | |
|---|---|---|
| ME-D3 | Cerilliant, 0,1mg/ml | 1000 ng/ml |
| Cocaine-D3 | Cerilliant, 1mg/ml | 1000 ng/ml |
| BE-D | Cerilliant, 1mg/ml | 10 000 ng/ml |
| Codeine-D3 | Cerilliant, 1mg/ml | 2000 ng/ml |
| Morphine-D3 | Cerilliant, 1mg/ml | 2000 ng/ml |
| 6MAM-D3 | Cerilliant, 1mg/ml | 2000 ng/ml |

**Chromatographic conditions:**

Chromatographic system: Agilent technologies 7890A

Column: DB-5ms ( Agilent technologies, ID -0,25 mm, length – 30 m, 5% Phenyl Arylene polymer, non-polar)

Carrier gas: Helium

Temperature gradient (opiates): 150C (3,0) → 10C/min. → 280C (0,0) → 40C/min. → 300C (8,0)

Temperature gradient (cocaine): 80C (4,0) → 40C/min. → 240C (6,0) → 30C/min. → 290C (0,0)

Injection: 2µl

**Mass Spec conditions:**

MS system: Agilent technologies 5975C inert XL MSD with Triple Axis Detector; EI 70 V

| **Compound** | **Rt** | **TIon (m/z)** | **QIon (m/z)** |
|---|---|---|---|
| ME-D3(IS) | 6,98 | 85 | 185; 274 |
| ME | 6,99 | 82 | 182; 271 |
| Cocaine-D3(IS) | 8,87 | 185 | 201; 306 |
| Cocaine | 8,88 | 182 | 198; 303 |
| BE-D3(IS) | 9,07 | 243 | 364 |
| BE | 9,08 | 240 | 256; 361 |
| Codeine-D3(IS) | 15,09 | 374 | 346 |
| Diphenhydramine | 9,62 | 58 | 152; 165 |
| Tramadol | 10,52 | 58 | 245; 335 |
| Methadone | 12,37 | 72 | 165; 178 |
| Codeine | 15,12 | 371 | 234; 343 |
| Morphine-D3(IS) | 15,47 | 432 | 417 |
| Morphine | 15,49 | 429 | 401; 414 |
| 6-MAM-D3(IS) | 16,02 | 402 | 343 |
| 6-MAM | 16,04 | 399 | 287; 340 |
| Zolpidem | 17,9 | 235 | 219; 307 |
| Buprenorphine | 23,44 | 450 | 482 |

**4. Cannabinoids**

**SPE**

Columns: non-polar, Chromabond C8 1 ml/100 mg, Macherey-Nagel Gmbh & Co.

**Sample:**

1 ml whole blood + 1 ml IS + 2 ml H2O

**Column conditioning** 2x1ml Methanol
2x1ml $H_2O$

**Washing:** 1ml H2O

1ml 0,25M acetic acid
1ml H2O

**Elution:** 2x1ml Acetone

Evaporate at 40°C, $N_2$ Equipment: Caliper Turbo Vap LV

**Derivatisation**

+ 150 µl DMSO/TBAH (1ml: 980 µl DMSO/ 20 µl TBAH)

+ 50 µl Jodmethane, 25-30 min room temperature

+ 350 µl 0,1 M HCl + 1 ml Isooctane

Organic layer evaporate at 40°C, N2 Equipment: Caliper Turbo Vap LV

Reconstitute in 40 µl Ethylacetate

**IS:**

| | | |
|---|---|---|
| THC-D3 | Cerilliant, 0,1mg/ml | 30 ng/ml |
| THC-OH-D3 | Cerilliant, 0,1mg/ml | 20 ng/ml |
| THC-COOH-D3 | Cerilliant, 0,1mg/ml | 30 ng/ml |

**Chromatographic conditions:**

Chromatographic system: Agilent technologies 7890A

Column: DB-5ms ( Agilent technologies, ID -0,25 mm, length – 30 m, 5% Phenyl Arylene polymer, non-polar)

Carrier gas: Helium

Temperature gradient: 150C (0,0) → 25C/min. → 280C (9,8)

Injection: 2µl

**Mass Spec conditions:**

MS system: Agilent technologies 5975C inert XL MSD with Triple Axis Detector; EI 70 V

| **Compound** | **Rt** | **TIon (m/z)** | **QIon (m/z)** |
|---|---|---|---|
| THC-D3(IS) | 6,03 | 316 | 248; 331 |
| THC | 6,04 | 328 | 245; 285 |
| THC-OH-D3(IS) | 6,69 | 316 | 260; 361 |
| THC-OH | 6,7 | 313 | 257; 358 |
| THC-COOH-D3(IS) | 7,35 | 316 | 360; 375 |
| THC-COOH | 7,36 | 313 | 357; 372 |

**5. Benzodiazepines**

**LLE**

200µl whole blood + 100µl K2HPO4 (PBS pH-9,2) + 300µl organic mix from (n-Butylacetate and IS Flurazepam 200 ng/ml),

Vortex 1 min.

**Derivatisation**

50µl Upper organic layer transfer to chromatography vials + 10µl (MTBSTFA)Vortex 0,1 min., 20min. at 90°C. Equipment: Pierce Reacti-Therm III

**IS:**

Flurazepam Lipomed 200 ng/ml

**Chromatographic conditions:**

GC/NICI-MS system, Agilent 5975C inert XL el/cl MSD GC System

Column: Agilent 123-5731 DB-5HT, max. 400 °C, 30 m, 0,320 mm, 0,1 µm particle size.

Carrier gas: Helium

Chemical ionization gas – methan (purity 5,5)

Temperature gradient: 180C (0) → 50°C/min. → 325°C → (2,0) Run Time- 4,9 min

Injection: 2µl

**Mass Spec conditions:**

| **Compound** | **RI** (min) | **TIon (m/z)** | **QIon (m/z)** |
|---|---|---|---|
| Flurazepam (IS) | 2,57 | 387 | 389 |
| Diazepam | 2,05 | 284 | 286 |
| Flunitrazepam | 2,32 | 313 | 314 |
| Oxazepam | 2,49 | 268 | 270 |
| Lorazepam | 2,70 | 302 | 304 |
| Alprazolam | 2,84 | 308 | 310 |
| Zopiclone | 3,03 | 143 | 246 |
| Nordazepam | 2,11 | 234 | 384 |
| 7-amino-clonazepam | 2,62 | 249 | 363 |
| Clonazepam | 2,73 | 429 | 431 |

Hungary

Blood samples were taken into Vacutainer tubes containing Na-citrate during autopsy from the femoral vein, and stored at 4 °C until analysis (within 1-2 weeks). Toxicological analysis was performed at the Department of Forensic Medicine, University of Szeged, Hungary.

*Sample processing*

**1. Amphetamines (AMF, MA, MDA, MDMA, MDEA)**

To 200 µl blood sample, 50 µl bicarbonate buffer, 10 µl ISTD solution, and 0.5 ml extraction-derivatization reagent were added during mixing by Vortex. Mixing was continued for an additional 15 seconds and the samples were centrifuged (3000 rpm, 5 minutes). 50 µl from the upper phase was transferred into 32 x 11,6 mm GC vial with 200 µl insert (VWR Int., Germany ), capped, and measured by GC-MS in EI mode.

*Bicarbonate buffer: 8.5 ml cc $NaHCO_3$ solution + 1.5 ml 10 M KOH (dailyprepared); ISTD: mixture of D-5 analogs of AMF, MA, MDMA, and MDEA in a 5 µg/ml concentration each in methanol; Extraction-derivatization reagent: 485 µl toluene + 15 µl HFBA (daily prepared)*

**2. Other DRUID core substances**
**(midazolam, temazepam, nitrazepam, 7-amino clonazepam, ketamine, and tramadol)**

To 1 ml blood sample 0.5 ml phosphate buffer (pH=9), 10 µl ISTD and 5 ml butyl-acetate were added in a 12 ml capped centrifuge tube (Brand, Germany), and extracted for 30 seconds with a Multi-Pulse Vortexer (Glas-Col, USA). After centrifuge (3000 rpm, 5 minutes) 4.5 ml organic phase was transferred into clean tubes and evaporated at 60 °C by pressed air in a TurboVap LV Concentration Workstation (Caliper LifeSci., USA). The samples were reconstituted with 75 µl acetonitrile (ACN), and 30 – 30 µl were measured into GC vials. To the first sample (S1, used to determine illicit drugs other than amphetamines, plus ketamine, zolpidem, oxazepam, temazepam, and tramadol) 15 µl MSTFA was added, capped, and analyzed by GC-MS in EI mode (on-line derivatization) within 16 hours after sample processing. The other (S2, for analysis of other benzodiazepines and zopiclone) was dried at room temperature with nitrogen stream, capped and stored under nitrogen at –20 °C until derivatization and analysis.

Following the extraction with butyl-acetate the lower phase (what still contained 0.5 ml butyl-acetate) was re-extracted with 4 ml $CH_2Cl_2$. After centrifuge (3000 rpm, 5 minutes) 3.5 ml lower phase was transferred to a clean tube and evaporated at room temperature by pressed

air. The residue was dissolved in 75 µl ACN by vortex, 60 µl was transferred into a GC vial, 30 µl MSTFA was added, and capped. The samples were analyzed by GC-MS in EI mode (S3, benzoyl-ecgonine).

The analysis for benzodiazepines and zopiclone was performed from the S2 samples. After warming to room temperature, 45 µl ACN:MSTFA = 2:1 solution was injected into the vials through the septum by a Hamilton syringe and vortexed six times for 2 seconds. Derivatization was effected at 80 °C in a multi-block heater (Barnstead Int. USA) for 30 minutes. After cooling to room temperature the samples were analyzed by GC-MS in NCI mode within 8 hours after derivatization.

The Institute took part successfully in DRUID proficiency tests twice a year (Round Robin test).

Beside DRUID core substances (except Flunitrazepam, as agreed before starting the project) the following compounds were also measured (cut off): ketamine (10 ng/ml), THC-OH (5 ng/ml), nitrazepam (10 ng/ml), 7-amino-clonazepam (10 ng/ml), midazolam (20 ng/ml), and temazepam (20 ng/ml).

Blood alcohol concentration was measured by head space method (GC-FID) using Agilent 7890A GC equipped with BAC-1 and BAC-2 columns with SeCure "Y" Connector (Resteck, USA), and two FID detectors. 0,4 ml blood and 0,4 ml n-propanol of 0,7% (internal standard) were added into 10 ml head space vial (LaPhaPack, Germany), closed, incubated for 15 minutes at 60 °C, and injected (HP 7694 Head Space Sampler). Chromatographic conditions: inlet temperature: 140 °C, inlet pressure: 21 psi, split injection (1:10 ratio), $N_2$ flow 5.76 ml/min, oven temperature 60 °C, detector temp.: 230 °C, $H_2$ flow: 30 ml/min, air flow: 400 ml/min, make up ($N_2$) flow: 25 ml/min. From each samples two replicates were prepared and averaged.

The laboratory successfully takes part in an international proficiency test (Referenzinstitut für Bioanalytik, Bonn, Germany) in every six months since 1995.

Slovakia

Samples were obtained at autopsy, solely drawn from deceased subjects. They were stored up to the time of analysis in refrigerator (5C±3C up to 7 days max.) and in a freezer (-15 to -20C) for more than 7 days, but for 30 days maximum. Toxicological analysis was performed by Toxicological laboratories of the Institute of Forensic Medicine of the Health Care Surveillance Authority of Slovak Republic in the collaboration with Institute of Forensic Medicine SM CU.

Short description of analytical methods:

- Pre-analytical procedures of samples preparation: centrifugation, deprotination, extraction (L-L, SPE), chemical derivatization;
- Analytical methods: imunoscreening, densitometry, UV-VIS spectrophotometry, TLC, GCMS, LCMS;
- Blood alcohol determination method: gas chromatography (head space); reported are values of a single determination;
- Internal standards, calibration range, LOD and LOG depend on the monitored and analysed substances/groups of substances; individual approach to each substance/group of substances is required.

Regarding the analyzed substances the list of the substances *routinely* monitored at our institute (samples of deceased subjects) does not exceed the list of the core substances for DRUID. In analysis of clinical samples, except of checking drugs abuse, we deal also with monitoring of broad range of the drugs used for treatment of clinical patients on the basis of a doctor's-in-charge requirement related to a concrete case

# ANNEX II – RESULT-TABLES

**Table 2:** Results of toxicological analysis

| Explanatory variable | Number of subjects [%] | | | | |
|---|---|---|---|---|---|
| | **Germany (n=200)** | **Lithuania (n=41)** | **Hungary (n=93)** | **Slovakia (n=149)** | **Total (n=483)** |
| **Only alcohol** | (178) | (40) | (80) | (139) | **(437)** |
| 0 ≤ Alcohol < 0.1 g/L | 132 [66.0] | 15 [36.6] | 43 [46.2] | 87 [58,4] | **277** |
| 0.1 ≤ Alcohol < 0.5 g/L | 15 [7.5] | 0 [0.0] | 12 [12.9] | 11 [7.4] | **38** |
| 0.5 ≤ Alcohol < 0.8 g/L | 4 [2.0] | 0 [0.0] | 0 [0.0] | 4 [2.7] | **8** |
| 0.8 ≤ Alcohol < 1.2 g/L | 5 [2.5] | 1 [2.4] | 0 [0.0] | 1 [0.7] | **7** |
| 1.2 ≤ Alcohol | 22 [11.0] | 24 [58.5] | 25 [26.9] | 36 [24.2] | **107** |
| **Blood concentration of substances (singular)** | (9) | (1) | (9) | (3) | **(22)** |
| Cannabinoids | 3 [1.05] | 1 [2.4] | 2 [2.1] | 1 [0.60] | **7** |
| Amphetamines ≥ 20 ng/mL | 1 [0.5] | 0 [0.0] | 0 [0.0] | 1 [0.60] | **2** |
| Opiates ≥ 10 ng/mL | 1 [0.5] | 0 [0.0] | 0 [0.0] | 1 [0.60] | **2** |
| Benzodiazepines | 2 [1.0] | 0 [0.0] | 7 [7.5] | 0 [0.0] | **10** |
| Z-drugs | 2 [1.0] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **2** |
| **Blood concentration of substances (combination)*** | (6) | (0) | (4) | (6) | **(16)** |
| Alcohol + cannabinoids | 1 [0.5] | 0 [0.0] | 1 [1.1] | 1 [0.60] | **3** |
| Alcohol + benzodiazepines | 1 [0.5] | 0 [0.0] | 2 [2.1] | 1 [0.60] | **4** |
| Alcohol + cocaine | 0 [0.0] | 0 [0.0] | 0 [0.0] | 1 [0.60] | **1** |
| Alcohol + opiates + benzod. | 1 [0.5] | 0 [0.0] | 1 [1.1] | 0 [0.0] | **2** |
| Cannabis + amphetamines | 0 [0.0] | 0 [0.0] | 0 [0.0] | 1 [0.60] | **1** |
| Alcohol + amphetamines | 1 [0.5] | 0 [0.0] | 0 [0.0] | 1 [0.7] | **2** |
| Alcohol + cannabis + amphetamines | 0 [0.0] | 0 [0.0] | 0 [0.0] | 1 [0.60] | **1** |
| Alcohol + Z-drugs | 1 [0.5] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **1** |
| Benzod. + antidepressant | 1 [0.5] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **1** |
| **Extra Substances** | (7) | (0)** | (0)** | (1) | **(8)** |
| Opioid (Tramadol) | 1 [0.5] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **1** |
| Antidepressants | 1 [0.5] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **1** |
| Benzodiazep. + antidepr. | 1 [0.5] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **1** |
| Neuroleptics | 0 [0.0] | 0 [0.0] | 0 [0.0] | 1 [0.60] | **1** |
| Non-opiod analgetika | 1 [0.5] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **1** |
| Antiepileptics | 1 [0.5] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **1** |
| Alcohol + antiepileptics | 1 [0.5] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **1** |
| Alcohol + antihistamines | 1 [0.5] | 0 [0.0] | 0 [0.0] | 0 [0.0] | **1** |
| **Total** | **200** | **41** | **93** | **149** | **483** |

* Blood concentrations of alcohol ≥ 0.1 g/L, **no screening for "extra substances"

**Table 3:** The distribution of cases (CA) and controls (CO) according to the toxicological analysis

| Explanatory variable | Number of cases (CA) and controls (CO) (n) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Germany (n=200) | | Lithuania (n=41) | | Hungary (n=93) | | Slovakia (n=149) | | Total (483) |
| | CA | CO | CA | CO | CA | CO | CA | CO | |
| **Only alcohol** | | | | | | | | | |
| 0 ≤ Alcohol < 0.1 g/L | 106 | 26 | 12 | 3 | 38 | 5 | 68 | 19 | **277** |
| 0.1 ≤ Alcohol < 0.5 g/L | 12 | 3 | 0 | 0 | 10 | 2 | 11 | 0 | **38** |
| 0.5 ≤ Alcohol < 0.8 g/L | 4 | 0 | 0 | 0 | 0 | 0 | 4 | 0 | **8** |
| 0.8 ≤ Alcohol < 1.2 g/L | 4 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | **7** |
| 1.2 ≤ Alcohol | 22 | 0 | 24 | 0 | 25 | 0 | 35 | 1 | **107** |
| **Blood concentration of substances (singular)** | | | | | | | | | |
| THC ≥ 1 ng/mL and 0 ≤ THC-COOH | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | **3** |
| THC-COOH ≥ 5 ng/mL and 0 ≤ THC < 1 ng/mL | 2 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | **4** |
| Amphetamines ≥ 20 ng/mL | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | **2** |
| Opiates ≥ 10 ng/mL | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **2** |
| Benzodiazepines | 2 | 0 | 0 | 0 | 6 | 1 | 0 | 0 | **9** |
| Z-drugs | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **2** |
| **Blood concentration of substances (combination) *** | | | | | | | | | |
| Alcohol + cannabis | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | **3** |
| Alcohol + benzodiazepines | 1 | 0 | 0 | 0 | 2 | 0 | 1 | 0 | **4** |
| Alcohol + cocaine | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **1** |
| Alcohol + opiates + benzodiazepines | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | **2** |
| Cannabis + amphetamines | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **1** |
| Alcohol + amphetamines | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **2** |
| Alcohol + cannabis + amphetamines | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **1** |
| Alcohol + Z-drugs | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Benzodiazepines + antidepressant | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| **Extra substances** | | | | | | | | | |
| Neuroleptics | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | **1** |
| Opioid (Tramadol) | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Antidepressiva | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Benzodiazepines + antidepressant | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Non-opiod analgetika | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Antiepileptika | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Alcohol + antiepileptika | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| Alcohol + antihistaminika | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | **1** |
| **Total number** | **168** | **32** | **38** | **3** | **85** | **8** | **128** | **21** | **483** |

* Blood concentrations of alcohol ≥ 0.1 g/L

# ANNEX III – IN-DEPTH ANALYSIS

*Case descriptions*

**CASE 1**

**Accident pattern characteristics:**

**Number of parties involved:** 3 – 01: killed driver of a Mitsubishi Lancer, male
02: BMW M5, male
03: male driver of a truck

**Accident type classification (GDV number):** 661: accident in lateral traffic: conflict between an overtaking vehicle and a vehicle from oncoming traffic

**Time of day and date:** Saturday, 21.02.2004, 07:20

**Light condition:** Daylight

**Vehicle Type:** 01: 1 = sedan/saloon car (Mitsubishi Lancer)
02: 1 = sedan/saloon car (BMW M5)
03: 10 = truck

**Road classification:** 2 = rural road (Staatsstrasse)

**Collision type:** 1) 9 = side to side (01 vs. 02)
2) 12 = side to front (01 vs. 03)

**Driver manoeuvre prior to accident:** 01: 1 = General driving
02: 2 = Overtaking
03: 1 = General driving

**Driver's task prior to accident:** 01: 1 = Going ahead on a straight road
02: 28 = Overtaking moving vehicle on left
03: 1 = Going ahead on a straight road

**Purpose of trip:** 01 and 02: Unknown
03: Professional Driver

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure“:** 02: Overtaking despite ban on passing and oncoming traffic

**Contributory factors:**

01: Human: A221: Illicit drugs:
THC (21 ng/ml); THC-OH (4.5 ng/mL), THC-COOH (91 ng/mL)
A331: Inadequate perception of a threatening situation

02: Human: C211: Illegal speed

C231: Signs disobeyed: overtaking despite ban on passing

**Belted:** 01: No

02 and 03: Yes

**Ejected:** No driver ejected

**Age:** 01: 37 years

02: 46 years

03: 29 years

**Gender:** All drivers male

**Height:** 01: 179 cm

02+03: unknown

**Weight:** 01: 65 kg

02 + 03: unknown

**Additional parameters:**

- Reckless driving of 02 already before the accident
- Death at the scene of the accident
- Weather conditions: sunny, dry
- Road conditions: dry asphalt
- Probably elongated reaction time of 01 due to THC-impairment

**Description of the accident:**

02, the 46-year-old driver of a BMW M5 attracts attention due to reckless driving at an illegal speed and several risky overtaking manoeuvres despite ban on passing already several kilometres before the accident. On a straight part of the track (he is driving on a rural road, Staatsstrasse), he overtakes again although approaching oncoming traffic and ban on passing. While trying to get back on the right lane, he collides side to side with 01, the male 37-year-old driver of a Mitsubishi Lancer. 01 starts to skid, runs off the lane onto the oncoming lane and collides side to front with 03, a truck driven by a 26-year-old man. The vehicle of 01 is torn in two parts. 01, who has not been belted, dies immediately at the place of the accident. The toxicological analysis of 01 revealed THC (21 ng/mL); THC-OH (4.5 ng/mL) and THC-COOH (91 ng/ml). The technical expert could not find any defects at any of the vehicles that could have lead to the accident. 02 drove with an illegal speed of about 120 km/h (speed limit 80 km/h), 01's speed was approximately at 90 km/h.

**Conclusions: This accident was caused by a misinterpretation of the 02 driver of the driving circumstances while undertaking a risky overtaking manoeuvre at an illegal speed disregarding the oncoming traffic. Although 01 was impaired by THC, 02 was definitely responsible of the accident. 01 might have been able to avoid the accident by decelerating and give way to the oncoming 02. As 01 was impaired by THC (found in blood in a high concentration), his reaction time could be elongated due to the central depressant effect of THC. His fatal injuries might also have been avoided if he had been belted. 03 had no chance to avoid the accident.**

**CASE 2**

**Accident pattern characteristics:**

**Number of parties involved:** 2 - 01: Renault Clio with a 19-year-old male driver
02: Truck with a 49-year-old male driver

**Accident type classification (GDV number):** 682 – Accident in lateral traffic: Conflict between two head-on encountering vehicles

**Time of day and date:** Wednesday, 15.09.2004, 14:15

**Light condition:** Daylight

**Vehicle Type:** 01: 2 = hatchback car (Renault Clio)
02: 10 = truck

**Road classification:** 2 = Rural road (Staatsstrasse)

**Collision type:** 2 = front to front: 01 gets skid on the oncoming lane and collides frontally with 02

**Driver manoeuvre prior to accident:** 1 = general driving (both vehicles)

**Driver's task prior to accident:** 01: 3 = Going ahead on a right bend
02: 2 = Going ahead on a left bend

**Purpose of trip:** 01: 9 = unknown
02: 1 = professional driver

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure“:** Inappropriate speed on a wet street, 01 gets on the oncoming lane

**Contributory factors:**

Human: 01: A221: Illegal drugs: THC (ca. 0.55 ng/mL), THC-COOH (ca. 7.64 ng/mL)
A331: Inadequate perception of a threatening situation
B112: Driving experience: new driver
B146: Little experience with driving on a wet street
C212: Speed: legal but inappropriate

Environment: A11: Road condition: wet

**Belted:** Yes, both drivers

**Ejected:** No, both drivers

**Age:** 01: 19
02: 49

**Gender:** Both drivers male

**Height:** 01: 173 cm

02: unknown

**Weight:** 01: 53.3 kg

02: unknown

**Additional parameters:**

- Novice driver (01); lack of experience
- Weather conditions:
- Road conditions: wet, slippery street
- Risky driving
- 01 death at the scene of the accident

**Description of the accident:**

01, the 19-year-old male driver of a Renault Clio is driving on a wet rural road (Staatsstrasse). He is a novice driver (drivers licence since three weeks), driving at an inappropriate speed (speed limit 100 km/h). In a long right bend, the vehicle gets out of control, starts to skid and moves onto the oncoming lane. 02, a 49-year-old male driver of a truck is approaching on the oncoming lane and has no chance to avoid the front-to-front collision with the skidding 01. 01 dies immediately at the scene of the accident from head injuries. The toxicological analysis of 01 is positive for THC (ca. 0.55 ng/mL) and THC-COOH (ca. 7.64 ng/mL). The technical experts could not find any technical defects at 01's car that could have led to the accident.

**Conclusions:**

**Running off the road in long bends and going ahead on the opposite lane is a typical driving mistake under the influence of THC, the active ingredient in cannabis preparations. The general central depressant effect expresses oneself in an elongated reaction time and impaired power of concentration which results in non-realization of the long bend. The difficult driving circumstances (wet and slippery road) and the low driving experience while driving at a legal but an inappropriate speed contribute further to the incident.**

**CASE 3**

**Accident pattern characteristics:**

**Number of parties involved:** 1 - 01: female, 38-year-old driver of a Mercedes 250 TD Kombi

**Accident type classification (GDV number):** 102 – Driving accident: in a curve to the right

**Time of day and date:** Sunday, 22.08.2004, 07:15

**Light condition:** Daylight

**Vehicle Type:** Station Wagon/Estate car: Mercedes 250 TD Kombi

**Road classification:** 2 = rural road (Bundesstrasse)

**Collision type:** No collision with motor vehicle in transport; collision with a tree

**Driver manoeuvre prior to accident:** General Driving

**Driver's task prior to accident:** Going ahead on a right bend

**Purpose of trip:** Leisure

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure“:** Running off the road in a long right bend

**Contributory factors:**

Human: A240: Fatigue: didn't sleep all night

A211: Alcohol: 1.58 g/L

**Belted:** No

**Ejected:** Yes

**Age:** 38 years

**Gender:** Female

**Height:** 155 cm

**Weight:** 65 kg

**Additional parameters:**

- Driver didn't sleep the whole night before the accident
- Death at the scene of the accident from a polytrauma
- Weather condition: sunshine
- Road condition: a little bit damp
- No illegal speeding (speed limit 100 km/h)

**Description of the accident:**

01, female, 38 years old and her three passengers drive on a rural road (Bundesstrasse) on a Sunday morning. The driver hasn't slept the night before and isn't belted. She is under the

influence of alcohol (1.58 g/L). In a long right bend the driver gets off the road on the left side and hits a tree frontally. 01 is ejected and dies at the scene of the accident from a poly-trauma, leading the head injuries.

**Conclusions: Running off the road in long bends and driving straight on is a typical driving mistake under the influence of central depressant drugs such as alcohol. The driver does not recognize the bend and shows an elongated reaction time. This could result in such a steering mistake.**

**CASE 4**

**Accident pattern characteristics:**

**Number of parties involved:** 2 – 01: BMW 325i, driver 51 years old, male
02: Truck Scania, driver 26 years old, male

**Figure 3:** Setting of case 4, passenger's side.

**Accident type classification (GDV number):** 141 – Driving accident on a straight road

**Time of day and date:** Tuesday, 11.02.2003, 11:25

**Light condition:** Daylight

**Vehicle Type:** 01: 1 = saloon car (BMW 325i)
02: 10 = truck (Scania)

**Road classification:** 2 = rural road

**Collision type:** 2 = front to front

**Driver manoeuvre prior to accident:** 1 = General driving (both drivers)

**Driver's task prior to accident:** 1 = Going ahead on a straight road (both drivers)

**Purpose of trip:** 01: 9 = unknown
02: 1 = professional driver

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure":** 01: running off the own lane on a straight road into the oncoming 02 on the opposite lane

**Contributory factors:**

Human: 01: A223: medication: Diazepam (90 ng/mL), Nordazepam (158.4 ng/mL), Oxazepam (ca. 6.6 ng/mL), Temazepam (9.7 ng/mL), Opipramol (120.6 ng/mL), Citalopram (700.4 ng/mL)

C210: illegal speed (probably)

Environment: A11: Road condition: wet

**Belted:** No (both drivers)

**Ejected:** No, neither driver

**Age:** 01: 51 years

02: 26 years

**Gender:** Both drivers male

**Height:** 01: 175cm

02: 180 cm

**Weight:** 01: 82 kg

02: 85 kg

**Additional parameters:**

- Road condition: wet (after recent snow fall)
- Weather conditions: winter, dry
- Death at the scene of the accident 01
- Pre-existing heart disease 01

**Description of the accident:**

51-year-old male driver of a BMW 325i (01) drives on a wet rural street, not belted. The speed limit is 100 km/h. On a straight part of the track, after passing a long left bend, he loses control over his vehicle which leaves the own lane on the left side. 02 approaches on the oncoming lane, a 26-year-old male driver of a truck, who has no chance to avoid the front-to-front collision with 01. 01 dies immediately at the scene of the accident from head injuries. He had a pre-existing heart disease which might have caused a clouding of consciousness. The toxicological analysis found Opipramol, Citalopram, Diazepam, Nordazepam, Oxazepam and Temazepam. The technical experts could not find any car defects that could have lead to the accident, the speed of 01 could not be reconstructed.

**Conclusions: The 01 driver misinterpreted the driving situation (wet road) while probably driving at an inappropriate speed. The driver was under influence of several benzodiazepines (initially Diazepam, Nordazepam, Oxazepam and Temazepam are metabolites of Diazepam) and the two antidepressants Opipramol and Citalopram. They all are central nervous acting medicinal drugs and could have caused an elongated reaction time and a clouding of consciousness causing the steering mistake which led the vehicle to leave the**

**lane. A possible explanation for the clouding of consciousness might also be the pre-existing heart disease.**

**Figure 4:** Setting of case 4, driver's side.

**CASE 5**

**Accident pattern characteristics:**

**Number of parties involved:** 1 - 01: male, 33-year-old driver of VW Golf

**Figure 5:** Case 5 - Road and light conditions at scene

**Accident type classification (GDV number):** 141 – Driving accident on a straight road

**Time of day and date:** Saturday, 01.10.2005, 03:00

**Light condition:** Night

**Vehicle Type:** 02: hatchback car: VW Golf

**Road classification:** 2 = rural road (Staatsstrasse)

**Collision type:** No collision with motor vehicle in transport

**Driver manoeuvre prior to accident:** 1 = general driving

**Driver's task prior to accident:** 1 = going ahead on a straight road

**Purpose of trip:** 5 = leisure

**Traffic way flow:** 1 = two way traffic divided by a painted line

**„Key event failure“:** Hitting the hard shoulder of the right side of the road

**Contributory factors:**

Human: A211: Alcohol: 1.66 g/L

C211: Illegal speed

Environment: B141: Night

**Belted:** No

**Ejected:** No

**Age:** 33 years

**Gender:** Male

**Height:** 170-180 cm (at autopsy, burnt corpse)

**Weight:** 44 kg (at autopsy, burnt corpse)

**Additional parameters:**

- Driver previously convicted
- No witnesses, accident reconstructed by technical experts
- Driving without licence
- Death at the scene of the accident
- Not belted

**Description of accident:**

After a party 01 drives in his VW Golf on a rural, not lighted road. His blood alcohol is at 1.66 g/L. On a straight part of the track, he gets off the road, hits the hard shoulder on the right hand side, starts to skid and finally gets off the road on the left side. The car overturns several times and catches fire. Both, car and corpse of 01 burn out totally. The speed limit is at 100 km/h, 01 drives at an illegal speed of 125 – 135 km/h. He dies immediately at the scene of the accident.

**Conclusions:**

**The driver misinterpreted the road lay out driving at night at an illegal speed. He was under the influence of alcohol at the time of the accident which probably caused the initial misinterpretation of the driving situation or perhaps microsleep at night. The impairment might also have caused or at least facilitated a steering mistake (snatching of the steering wheel) after the driver recognized that his vehicle was coming of the road.**

**Figure 6:** Case 5 – The burnt out vehicle

**CASE 6**

**Accident pattern characteristics:**

**Number of parties involved**: 1 – 01: 42-year old male driver of an AUDI A8

**Accident type classification (GDV number):** 665 - overtaking: running off the road, hitting a tree

**Figure 7:** Case 6 – Scene of the accident

**Time of day and date:** Saturday, 25.08.2007, 13:50

**Light condition:** Daylight

**Vehicle Type:** Saloon car (AUDI A8 4.2; Type D2)

**Road classification:** 2 = rural road (Staatsstrasse)

**Collision type:** No collision with motor vehicle in transport (collision with a tree).

**Driver manoeuvre prior to accident**: 2 = Overtaking

**Driver's task prior to accident**: 28 = Overtaking moving vehicle on left

**Purpose of trip:** Unknown

**Traffic way flow:** 1 = two way traffic divided by a painted line

**„Key event failure“:** Loss of control while changing the lane after overtaking: steering mistake at an illegal speed

**Contributory factors:**

Human: A211: alcohol: 1.96 g/L

C211: illegal speeding: 150 km/h (speed limit: 60 km/h)

**Belted**: Yes

**Ejected**: Yes, partly

**Age**: 42

**Gender**: Male

**Height**: 195 cm

**Weight**: 85.7 kg

**Additional parameters:**

- Misinterpretation of the ability of own car while trying to change the lane after overtaking
- Death at the scene of the accident
- Risky driving observed by witnesses already before the accident
- Weather and light conditions: daylight, sunshine
- Killed driver was by habit a risky driver (father's statement)

**Figure 8:** Case 6 – Torn apart vehicle

**Description of the accident:**

The fatally injured driver of an Audi A8 attracts attention due to illegal speeding and risky overtaking already several kilometers before the accident happens. He overtakes again in a slight right bend driving at an illegal speed of 130-155 km/h instead of the allowed 60 km/h. While trying to move back towards the right lane, he loses control over the vehicle which starts skidding and rotates 180°. The car runs off the road and the side of the vehicle hits a first tree. It is thrown versus a second tree where the car is torn into two parts. The frontal part of the car including the driver is thrown into its final position 26 meters farther, the rear part comes to rest on the left edge of the street. The driver is partly ejected through the window on the driver's side (the upper part of the body is outside the car while the legs are still inside it) and dies immediately from head injuries.

According to the technical experts there has been no technical defect that could have caused the accident.

**Conclusions: The driver misinterpreted the road lay-out while driving at an illegal speed under the influence of alcohol. The alcohol impairment probably led to the key failure of the accident which was a steering mistake while returning to own lane after overtaking at an illegal speed.**

**CASE 7**

**Accident pattern characteristics:**

**Number of parties involved:** 1 – 01: 21-year-old driver of a Honda Civic

**Accident type classification (GDV number):** 102 – driving accident in a right bend

**Time of day and date:** Saturday, 18.11.2006, 03:35

**Light condition:** Night

**Vehicle Type:** Saloon car (Honda Civic)

**Road classification:** 2 = rural road

**Collision type:** No collision with motor vehicle in transport: lateral collision with crash barrier

**Driver manoeuvre prior to accident:** 1 = general driving

**Driver's task prior to accident:** 3 = going ahead on a right bend

**Purpose of trip:** 5 = leisure

**Traffic way flow:** 1 = Two way traffic, divided by a painted line

**„Key event failure“:** Running off the road on the left side

**Contributory factors:**

Human: A211: Alcohol: 1.92 g/L
C210: speed (probably)

Environment: D132: night

**Belted:** No

**Ejected:** Yes

**Age:** 21 years

**Gender:** Male

**Height:** 183 cm

**Weight:** 100.7 kg

**Additional parameters:**

- Weather condition: Dry
- Light condition: Darkness without artificial light
- Driver under the influence of alcohol
- Night

**Description of the accident:**

The fatally injured driver, a 21-year-old male impaired by alcohol drives his Honda Civic on a rural road and approaches a right bend after a long straight part of the track. He runs off the road on the left side and hits the crash barrier. The car is torn in two parts, the rear part and the part of the crash barrier come to rest on the slope and the front part of the car reaches its final position in a field next to the street. The driver, who is not belted, is ejected. He suffers different fatal injuries and dies immediately at the scene of the accident. The technical expert could not reconstruct the speed of the car.

**Conclusions: The young driver misinterpreted the road lay-out (bend) and the driving circumstances (night). The driver missed the right bend and went on straight across the street. The driver had consumed alcohol which causes central nervous depression with diminished attention and increased reaction time in the detected high concentration. Maybe combined with fatigue this could have resulted in the incident.**

**Figure 9:** Case 7 – State of vehicle after accident

**CASE 8**


**Figure 10:** Case 8 – Road lay-out at scene

**Accident pattern characteristics:**

**Number of parties involved:** 2 – 01: 32 year-old male driver (VW Polo)
02: 27 year-old male driver (VW Golf)

**Accident type classification (GDV number):** 302 – turning accident: conflict between a non priority vehicle and a priority vehicle coming from left, which is not overtaking

**Time of day and date:** Friday, 13.05.2005, 08:11

**Light condition:** Daylight

**Vehicle Type:** 01: 2 = hatchback car: VW Polo
02: 2 = hatchback car: VW Golf

**Road classification:** 2 = rural road (Staatsstrasse)

**Collision type:** 12 = side to front: 02 hits the left side of 01 frontally

**Driver manoeuvre prior to accident:** 01: 4 = Junction turning across traffic
02: 1 = General driving

**Driver's task prior to accident:** 01: 18 = Turning across traffic at a 'give-way' intersection
02: 01 = Going ahead on a straight road

**Purpose of trip:** Unknown (both drivers)

**Traffic way flow:** 01: 2 = Two way traffic with no division markings
02: 1 = Two way traffic divided by a painted line

**„Key event failure“:** 01: Wrong estimation of the approaching 02
02: Illegal speed

**Contributory factors:**

Human: 01: A222: medication: Amitriptylin (1580 µg/L), Opipramol (810 µg/L) in heart blood.

A331: Inadequate perception of a threatening situation

C231: Signs disobeyed: right of way –signs

02: C211: Illegal speed

**Belted:** Yes (both drivers)

**Ejected:** No, neither driver

**Age:** 01: 32 years

02: 27 years

**Gender:** Male (both drivers)

**Height:** 01: 174 cm

02: Unknown

**Weight:** 01: 74.3 kg

02: Unknown

**Additional parameters:**

- Weather condition: sunny
- Road condition: dry

**Description of the accident:**

01, the driver of a VW Polo, male, 32 years old, wants to turn left at a junction into a priority road. He stops at the give-way sign and starts to turn while disobeying the priority of 02, 27-year-old driver of a VW Golf. 02 approaches with an illegal speed of 120 km/h instead of the permitted 80 km/h. He hits the left side of 01 frontally. 01 dies immediately at the scene of the accident from a rupture of the aorta.

**Conclusions: The 01 driver disobeyed the priority of 02. Despite the use of heart blood (Amitriptyline is subject to postmortem redistribution and the heart/peripheral blood ratios averaged 3.1 (Baselt, 8th. edition)), the concentrations of the antidepressants Opipramol and Amitriptylin in blood of 01 are high and probably above the therapeutic range. Both antidepressants have pronounced sedative effects. The ability to respond is impaired and the reaction time is elongated. By following the permitted speed limit, 02 could have avoided the accident according to the technical expert. He would have had enough time to brake and let 01 pass.**

**Figure 11:** Case 8 **-** Final position of vehicles after the accident

**CASE 9**

**Accident pattern characteristics:**

**Number of parties involved:** 2 – 01: 37-year-old male driver of a DB C230
02: 76-year-old male driver of an Opel Frontera

**Accident type classification (GDV number):** 682 – accident in lateral traffic, conflict between two head-on encountering vehicles.


**Figure 12:** Case 9 – Road lay-out (top) and final position of vehicles after the accident

**Time of day and date:** Friday, 21.04.2006, 09:10

**Light condition:** Daylight

**Vehicle Type:** 01: saloon car (Daimler Benz C230)
02: SUV (Opel Frontera)

**Road classification:** 2 = rural road (Staatsstrasse)

**Collision type:** 2 = front to front (left front 01 vs. left front 02)

**Driver manoeuvre prior to accident:** 1 = general driving (both drivers)

**Driver's task prior to accident:** 01: 3 = going ahead on a right bend
02: 2 = going ahead on a left bend

**Purpose of trip:** 9 = unknown (both drivers)

**Traffic way flow:** Two way traffic divided by a painted line

**„Key event failure“:** 01: leaving the own lane due to risky driving and illegal speeding

**Contributory factors:**

Human: 01: A220: Incorrectly used medicaments/illegal drugs:
Diazepam (156 µg/L), Nordazepam (212 µg/L), Oxazepam (ca. 28 µg/L), Temazepam, Metoprolol (84 µg/L), Morphin (19 µg/L), Codein (1.3 µg/L)

A211: Alcohol: 0.67 g/L

C211: Illegal speeding

**Belted:** Yes (both drivers)

**Ejected:** No, neither driver

**Age:** 37 years

**Gender:** Male (both drivers)

**Height:** 01: 172 cm

02: Unknown

**Weight:** 01: 61.3 kg

02: Unknown

**Additional parameters:**

- Weather conditions: sunny
- Road conditions: dry

**Figure 13:** Case 9 – State of 01 vehicle after accident

**Description of the accident:**

01, the 37-year-old male driver of a Daimler Benz C230 drives on a rural road (Staatsstrasse), speeding illegally at 85-95 km/h (speed limit 70 km/h). In a right bend, the car starts to skid, gets out of control and gets on the oncoming lane. There 01 collides front to front with 02, a 76-year-old driver of an oncoming Opel Frontera. 01 is injured severely and dies at the scene of the accident from a polytrauma. According to the technical expert, 02 had no chance to avoid the accident. There weren't any technical defects at both cars. 01 was under influence of alcohol (0.67 g/l) as well as by drugs. The toxicological analysis found Diazepam, Nordazepam, Oxazepam, Temazepam, Metoprolol, Morphin and Codein (probably intake of Heroin).

**Conclusions: The 01 driver misinterpreted the road lay-out (bend) while driving at an illegal speed. The misinterpretation was probably caused by an impairment of driver 01 with Diazepam (Nordiazepam, Oxazepam and Temazepam are active metabolites of Diazepam) and opiates (probably diacetylmorphine (Heroin)) combined with alcohol. The drugs show additive central depressant effect which is reflected in an elongated reaction time and further cognitive impairments.**

**CASE 10**

**Figure 14:** Case 10 – Setting of accident

**Accident pattern characteristics:**

**Number of parties involved:** 1 – 01: 38-year-old male driver of a Honda Civic

**Accident type classification (GDV number):** 141 – Driving accident on a straight road

**Time of day and date:** Saturday, 12.11.2005, 06:21

**Light condition:** Night

**Vehicle Type:** 2 = hatchback car (Honda Civic)

**Road classification:** 2 = rural road (Staatsstrasse)

**Collision type:** No collision with motor vehicle in transport: frontal collision with a tree

**Driver manoeuvre prior to accident:** 1 = general driving

**Driver's task prior to accident:** 1 = going ahead on a straight road

**Purpose of trip:** 9 = Unknown

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure“:** Running off the road on the right side

**Contributory factors:**

Human: A211: Alcohol (1.00 g/L)

A221: Illegal drugs: MDMA (1143 µg/L), MDA (61µg/L),

C211: Illegal speed

C122: Distraction (possibly): adjusting cassette

Environment: D132: Night without artificial light

**Belted:** No

**Ejected:** No

**Age:** 38 years

**Gender:** Male

**Height:** 164 cm

**Weight:** 64.3 kg

**Additional parameters:**

- Weather conditions: darkness, dry weather
- Road conditions: dry road
- "Disco accident": combination of alcohol, drugs and illegal speeding at night
- No witnesses
- Maybe distraction of the driver whilst adjusting a cassette

**Description of the accident:**

01, the driver of a Honda Civic, 38 years old and impaired by alcohol and the stimulant MDMA ("Ecstasy") is driving alone, at night on a rural road with an illegal speed of 117 +/- 8km/h (speed limit 100 km/h). On a straight part of the track, the car gets off the road, hits the hard shoulder on the right side, starts to skid and runs off the road on the left side. It hits a group of trees. The driver, who has not been belted, suffers a multiple trauma and dies at scene of the accident from the serious head injuries. There were no witnesses to the accident. The technical expert could not find any technical defects of the car that could have caused the accident.

**Figure 15:** Case 10 – State of vehicle after accident

**Conclusions: The driver was impaired by alcohol and MDMA/MDA which probably (perhaps combined with fatigue and/or distraction by radio) caused a driving mistake resulting in vehicle leaving the road and hitting the hard shoulder. Distractibility and readiness to assume risk are increased under the influence of the detected drugs. The latter results in e.g. driving at an illegal speed.**

**CASE 11**

**Accident pattern characteristics:**

**Number of parties involved:** 2 – 01: Driver of Peugeot 208 HX, female, 35 years old
02: Truck, male driver, 48 years old

**Figure 16:** Case 11 **-** Final position of vehicle, driver's (left) and passenger's side (right)

**Accident type classification (GDV number):** 661 – accident in lateral traffic; overtaking: conflict between an overtaking vehicle and a vehicle from oncoming traffic

**Time of day and date:** Monday, 07.03.2005, 07:05

**Light condition:** Daylight

**Vehicle Type:** 01: 2 = hatchback car (Peugeot 208 HX)
02: 10 = truck (Scania)

**Road classification:** 2 = rural road

**Collision type:** 16: rear to front (right rear end of 01 collides with right front of 02)

**Driver manoeuvre prior to accident:** 01: 2 = overtaking
02: 1 = general driving

**Driver's task prior to accident:** 01: 28 = overtaking moving vehicle on left
02: 2 = going ahead in a left bend

**Purpose of trip:** 01: unknown
02: professional Driver

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure":** 01 loses the control over the vehicle at trying to get back on the right lane after overtaking.

**Contributory factors:**

Human: 01: A221: Illegal drugs: THC (ca. 0.49 ng/mL) and THC-COOH (ca. 6.64 ng/mL)
C212: Speed legal but inappropriate

Environment: A13: snow → icy road

**Belted:** Yes (both drivers)

**Ejected:** No, neither driver

**Age:** 01: 35 years
02: 48 years

**Gender:** 01: Female
02: Male

**Height:** 01: 152cm
02: unknown

**Weight:** 01: 45.7 kg
02: unknown


**Figure 17:** Case 11 – Front of 02 vehicle

**Additional parameters:**

- Winter
- Road condition: Icy, slippery surface, partly covered with snow
- Weather condition: Dry
- 01 death at the scene of the accident

**Description of the accident:** The driver of a Peugeot 208 HX, a 35-year-old female is overtaking a snowplough on a slippery, partly snow-covered rural road in a long right bend. As she tries to get back on the right track, she loses control over the vehicle which starts to skid. It turns about 180° and skids on the oncoming lane. 02, 48-year-old male driver of an oncoming truck has no chance to avoid the accident and collides frontally with the right rear edge of the car. Technical experts could not find any defects at 01's car, which could have led to the

accident. The toxicological tests of 01 are positive for THC (0.49 ng/mL) and THC-COOH (6.64 ng/mL).

**Conclusions: The driver misinterpreted the road lay-out and the driving circumstances (partly snow-covered, slippery road) during an overtaking manoeuvre while driving at an inappropriate speed. Impairment by THC, also in low concentrations, shows among others things enhanced distractibility and prolonged reaction time, resulting in a not adapted driving behaviour for example like in the present case, with regard to weather conditions.**

**CASE 12**

**Accident pattern characteristics:**

**Number of parties involved:** 2 – 01: 42-year old driver of a BMW C3 with one front passenger
02: 63-year-old driver of a BMW 330 with one front passenger

**Figure 18:** Case 12 – Road lay-out

**Accident type classification (GDV number):** 646 – accident in lateral traffic: conflict between two vehicles, side by side, going in the same direction

**Time of day and date:** Friday, 04.07.2003, 02:46

**Light condition:** Darkness without artificial light

**Vehicle Type:** 01: 1 = sedan/saloon car (BMW C3)
02: 1 = sedan saloon car (BMW 330)

**Road classification:** 1 = Motorway

**Collision type:** 9 = side to side

**Driver manoeuvre prior to accident:** 01: 2 = overtaking
02: 1 = general driving

**Driver's task prior to accident:** 01: 28 = overtaking moving vehicle on left
02: 1 = going ahead on a straight road

**Purpose of trip:** 01: 2 = holiday
02: 9 = unknown

**Traffic way flow:** 4 = Physically divided roadway with traffic barrier

**„Key event failure“:** 01: losing control over the vehicle while overtaking due to illegal speeding

**Contributory factors:** 01:

Human: 01: A223: Misused medication: Diazepam (634 µg/L), Nordazepam (721 µg/L), Oxazepam (ca. 82 µg/L), Temazepam (ca. 59 µg/L) in heart blood

A211: Alcohol: 0.11 g/L

C210: Illegal speed

Environment: D132: night

E214: Road markings insufficient: Tactile markings absent

**Belted:** 01: No

02: Yes

**Ejected:** 01: Yes

02: No

**Age:** 01: 42 years

02: 63 years

**Gender:** Male (both drivers)

**Height:** 01: 180 cm

02: unknown

**Weight:** 01: 81.9 kg

02: unknown

**Figure 19:** Case 12 – State of 01 vehicle after accident

**Additional parameters:**

- Weather conditions: darkness, dry weather
- Road conditions: dry

- Death at the scene of the accident

**Description of the accident:**
01, a 42-year-old male driver of a BMW C3 drives on a highway on the left of three lanes with an illegal speed of 197 +/- 13km/h (speed limit 120 km/h) at night, he is not belted. He overtakes the male driver 02, 63 years old, of a BMW 330, who is moving forward on the medial lane. Probably due to the speeding, 01 loses control over his vehicle, runs off his lane on the right side and touches the left side of 02 with his right side. Vehicle 01 starts to skid, gets on the breakdown lane, back on the street and collides with 02 a second time. Both cars run off the road on the right side, and overturn several times. The driver 01 is ejected since he is not been belted and dies immediately at the scene of the accident from a multiple trauma. His car comes to rest on the slope on the right side of the road. The final position of Vehicle 02 is 6 meters behind 01 also on the slope. Driver 02, who has been belted, is badly injured and is to be taken to hospital. Both front passengers have also been belted and are also injured. The toxicological analysis of 01 is positive for Diazepam, Nordazepam, Oxazepam and Temazepam. The technical expert could not find any technical defects that could have led to the accident.

**Conclusions: The 01 driver misinterpreted the driving circumstances (darkness, road marking insufficient) while overtaking at an illegal speed. The misinterpretation of the 01 driver was probably caused by an impairment of Diazepam (Nordazepam, Oxazepam and Temazepam are active metabolites of Diazepam) resulting in a loss of control over the own vehicle at a high speed. Benzodiazepines are hypnotics and cause dependant on individual tolerance pronounced central depressant effects and elongated reaction times**
**If 01 had been belted, he would probably not have been killed. 02 did not have any chance to avoid the accident. The detected alcohol concentration is very low and should not have relevantly contributed to the impairment.**

**CASE 13**

**Accident pattern characteristics:**

**Number of parties involved:** 2 - 01: male, 38-year-old driver of an Opel Astra
02: female, 34-year-old driver of a Renault Espace

**Figure 20:** Case 13 – Road lay-out with 01 vehicle at its final position after accident

**Accident type classification (GDV number):** 682: Conflict between two head-on encountering vehicles

**Time of day and date:** Monday, 12.05.2003, 12:30

**Light condition:** Daylight

**Vehicle Type:** 01: Station Wagon/Estate car: Opel Astra
02: Van

**Road classification:** 2 = rural road (Staatsstrasse)

**Collision type:** 2 = front to front

**Driver manoeuvre prior to accident:** 1 = general driving (both drivers)

**Driver's task prior to accident:** 01: going ahead on a left bend
02: going ahead on a right bend

**Purpose of trip:** 9 = unknown (both drivers)

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure“:** 01: Leaving the own lane and getting onto the oncoming one in a long left bend

**Contributory factors:**

Human: 01: A211: Alcohol: Blood concentrations of 3.56 g/L

Vehicle: 01: B22: Tires: Air pressure too low

A121: Brakes: partial failure

**Belted:** Yes, both drivers

**Ejected:** No, neither driver

**Age:** 01: 38 years

02: 34 years

**Gender:** 01: Male

02: Female

**Height:** 01: 180cm

02: Unknown

**Weight:** 01: 70 kg

02: Unknown

**Additional parameters:**

- Weather conditions: dry
- Road conditions: dry
- Technical defects vehicle 01
- Pre-existing cardiac disease of 01 could have led to the accident
- Conspicuous way of driving of 01 prior to accident
- 01: Death at the scene of the accident

**Description of the accident:**

01 (male, 38 years old) drives on a rural road (Staatsstrasse), the speed limit is 70 km/h. He is belted and under the influence of alcohol (3.56 g/L). Already a while before the accident takes place, he attracts the attention of other drivers by leaving his own lane towards the oncoming one several times. At the end of a long left bend, he gets over the medial strip again. The oncoming 02 – driver (female, 34 yrs.) has no chance to avoid the front-to-front collision with 01. 01 dies immediately at the scene of the accident from a thoracal compression and heart rupture. He was suffering from a pre-existing cardiac disease. Furthermore the vehicle of 01 had technical defects: The pressure of the tires was too low and a part of the rear brakes was leak. This could have lead to a more difficult way of steering the car and might have been an additional cause of the accident.

**Conclusions: This accident was probably caused by lack of vigilance due to a very severe intoxication with alcohol (blood concentration 3.56 g/L) of driver 01. According to the findings of the autopsy of driver 01 he was suffering from a pre-exsisting heart disease. How-**

**ever, the heavy impairment and the description of the driving behaviour prior to accident make a medical condition as the cause of the accident unlikely. The lack of vigilance resulted in a loss of control over the own vehicle causing it to move onto the oncoming lane where it collided with another car. The technical defects of the 01 – car (leak rear brakes, tire pressure too low) probably facilitated the accident or increased the severity of it.**


**Figure 21:** Case 13 **-** Final position of 01 vehicle (left) and 02 vehicle (right)

**CASE 14**

**Accident pattern characteristics:**

**Number of parties involved:** 2 – 01: 36-year-old female driver of a Fiat Punto, two passengers (males, 9 and 6 years)
02: 37-year-old male driver of a Jeep Wrangler

**Accident type classification (GDV number):** 681 – conflict between two head-on encountering vehicles

**Time of day and date:** Tuesday, 04.03.2003, 14:30

**Light condition:** Daylight

**Vehicle Type:** 01: 2 = hatchback car: Fiat Punto
02: 6 = off-road-car: Jeep Wrangler

**Figure 22:** Case 22 – Road lay-out

**Road classification:** 2 = rural road (Staatsstrasse)

**Collision type:** 2 **=** front to front

**Driver manoeuvre prior to accident:** 1 **=** general driving

**Driver's task prior to accident:** 1 = going ahead on a straight road (both drivers)

**Purpose of trip:** 9 = unknown (both drivers)

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure“:** 01: Running off the own lane onto the oncoming one on a straight part of the track

**Contributory factors:**

Human: 01: A211: Alcohol 2.50 g/L

**Belted:** Yes (both drivers)

**Ejected:** No, neither driver

**Age:** 01: 36 years

02: 37 years

**Gender:** 01: Female

02: Male

**Height:** 01: 163cm

02: Unknown

**Weight:** 01: 49kg

02: Unknown

**Additional parameters:**

- Conspicuous driving of 01 already before the accident
- Weather conditions: sunshine
- Road conditions: dry
- 01: Death at the scene of the accident from cerebral injuries

**Description of the accident:**

01 (female, 36 years old) drives under the influence of alcohol (2.5 g/L) on a rural road (Staatsstrasse). With her in the car are her two children (both males, 9 and 6 years old). Already some time before the accident, other traffic participants notice her conspicuous risky driving. On a straight part of the track, she gets off the own lane onto the oncoming one and collides frontally with the oncoming Jeep Wrangler 02 (male, 37) who has no chance of avoiding the accident (according to the technical expert). 01 is killed immediately at the scene of the accident from craniocerebral injuries. 02 and the two children are seriously injured and taken to the hospital.

**Conclusions: This accident was probably caused by lack of vigilance due to a severe intoxication with alcohol (blood concentration 2.50 g/L) of driver 01. The heavy impairment and the description of the driving behaviour prior to accident makes lack of vigilance the most probable reason for the accident, resulting in a loss of control over the own vehicle causing it to move onto the oncoming lane where it collided with another car.**

**Figure 23:** Case 14 – State of 01 vehicle (top) and 02 vehicle (bottom) after the accident

**CASE 15**

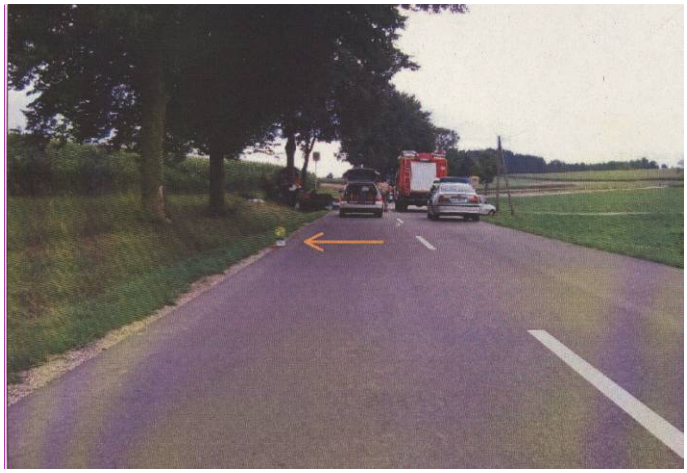

**Figure 24:** Case 15 – Scene of the accident

**Accident pattern characteristics:**

**Number of parties involved:** 1 - 01: 54-year-old male driver of an Opel Astra

**Accident type classification (GDV number):** 141 – Driving accident on a straight road

**Time of day and date:** Friday, 04.08.2006, 15:35

**Light condition:** Daylight

**Vehicle Type:** 03: Station Wagon/ Estate car: Opel Astra Kombi

**Road classification:** 2 = rural road (Staatsstrasse)

**Collision type:** No collision with motor vehicle in transport, collision with a tree

**Driver manoeuvre prior to accident:** 1= general driving

**Driver's task prior to accident:** 1 = going ahead on a straight road

**Purpose of trip:** 9 = unknown

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure“:** Running off the road after a left bend, hitting a tree

**Contributory factors:**

Human: A 211: Alcohol: 1.33 g/L

A111: Heart condition: autopsy detected pathological findings of heart structure

C211: At least inappropriate speed, probably illegal

**Belted:** Yes

**Ejected:** No

**Age:** 45 years

**Gender:** Male

**Height:** 170 cm

**Weight:** 80 kg

**Figure 25:** Case 15 – Final position of vehicle, driver's side

**Additional parameters:**

- Road condition: dry
- Weather condition: dry
- Probably pre-existing cardiac disease
- Inappropriate, possibly illegal speed

**Description of accident:**

01 (male, 54 years) drives an Opel Astra on a rural road at an inappropriate speed, possibly illegal (speed limit 100 km/h). He is under the influence of alcohol (1.33 g/L). In the car is his one-year-old son as a front passenger. Both are belted. 200 meters after a long left bend, he gets off the road on the left hand side and collides frontally with a tree. Both are inclined. 01 dies immediately at the scene of the accident from an internal bleeding, his son is badly injured and taken to the hospital. The autopsy shows a heart with pathological findings with a possible pre-existing cardiac disease which might have influenced the conscience of 01 and could have been an additional reason of the accident.

**Conclusions: The accident was probably caused by a misinterpretation of the driver of the road layout resulting in a loss of control over the own vehicle which gets off the road and hits a tree. He was under the influence of alcohol (1.33 g/L) and findings at the autopsy of the driver showed a pre-exsisting heart disease. Both factors, acting independently or interacting, might have caused the accident, in terms of lack of vigilance.**

**CASE 16**

**Accident pattern characteristics:**

**Number of parties involved**: 1 – 01: The fatally injured 19-year-old driver of an Opel Zafira and his 25-year-old male front passenger

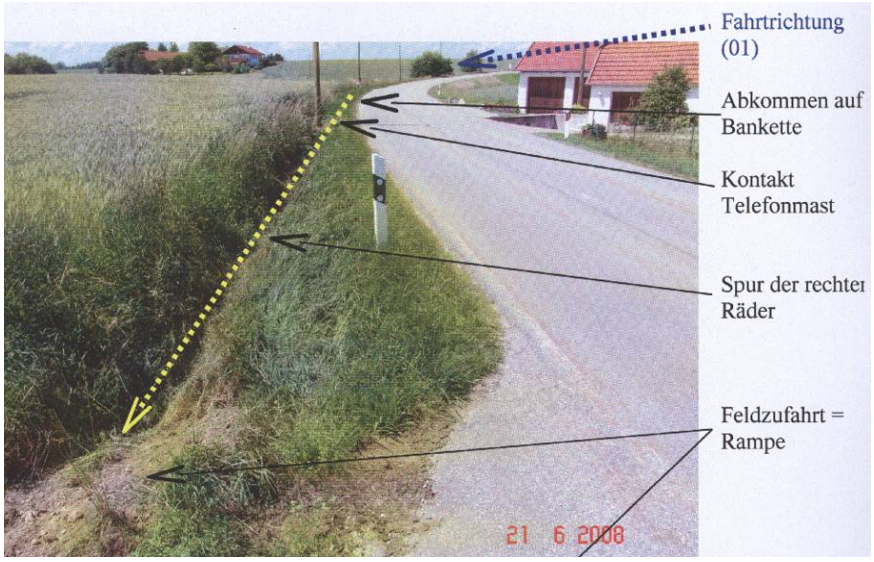


**Figure 26:** Case 16 – Road lay-out

**Accident type classification (GDV number)**: 191: running off the road in a left bend

**Time of day and date**: Saturday, 21.06.2008, 01:25

**Light condition:** Night without artificial light

**Vehicle Type**: 8 (van): Opel Zafira (T98)

**Road classification**: 2 = rural road (Kreisstrasse)

**Collision type**: No collision with motor vehicle in transport – collision with a tree

**Driver manoeuvre prior to accident**: 1 = general driving

**Driver's task prior to accident:** 2 = going ahead on a left bend

**Purpose of trip:** 5 = Leisure: The driver was on his way home from a disco

**Traffic way flow:** 1 = two way traffic divided by a painted line

**„Key event failure“:** Running off the road in a long left bend

**Contributory factors:**

Human: 01: A211: Alcohol (1.58 g/L):
C211: Illegal speed
C212: Speed attested by eyewitnesses

Environment: D132: Night

**Belted:** No

**Ejected**: Yes

**Age**: 19 years

**Gender**: Male

**Height**: 178 cm

**Weight**: 72 kg

**Additional parameters:**

- Very young driver
- Risky driving
- Night without artificial light
- Weather conditions: dry weather
- Road condition: dry

**Description of the accident:**

01, a 19-year-old male driver is on his way home from a disco together with his front passenger, a 25-year-old man. Both are not belted. 01 drives at an illegal speed (speed limit 100 km/h, exact speed unknown). About one minute before the accident, the passenger decides to fasten his seatbelt due to the risky driving of 01. In a left bend the driver loses control over the vehicle and runs off the road on the right hand side. The car hits a telephone mast, gets airborne and overturns several times. The final position of the car is on its left side about 100 m further in a field. 01 is ejected through the rear window and dies immediately from head injuries. The front passenger has been belted and is not injured seriously (only bruises). The technical expert could not find any defects on the car that could have caused the accident.

**Conclusions: The young driver misinterpreted the road lay-out (bend) and the driving circumstances (night) while driving at an illegal speed. He was impaired by alcohol which probably caused the misinterpretation of the situation resulting in a loss of control over the own vehicle.**

**CASE 17**

**Accident pattern characteristics:**

**Number of parties involved:** 1 - 01: male, 18-year-old driver of an Opel Astra Kombi

**Figure 27:** Case 17 – Final position of vehicle

**Accident type classification (GDV number):** 141 – Driving accident on a straight road

**Time of day and date:** Tuesday, 01.11.2005, 03:44

**Light condition:** Night

**Vehicle Type:** 03: Station Wagon/Estate car: Opel Astra Kombi

**Road classification:** 5 = Street (other) (small urban street)

**Collision type:** No collision with motor vehicle in transport; collision with a tree

**Driver manoeuvre prior to accident:** 1 **=** general driving

**Driver's task prior to accident:** 1 **=** going ahead on a straight road

**Purpose of trip:** 5 = leisure

**Traffic way flow:** 2 = Two way traffic with no division marks

**„Key event failure“:** Running off the road in on a straight track, probably due to inattention

**Contributory factors:**

Human: 01: A 211: Alcohol: 1.53 g/L

C211: Illegal speed

B112: Novice driver (18 years)

Environment: B141: Night

**Belted:** Yes

**Ejected:** No

**Age:** 18 years

**Gender:** Male

**Height:** 185 cm

**Weight:** 80 kg

**Additional parameters:**

- Young driver, alcohol, night: disco accident
- Death at the scene of the accident
- Weather condition: dry
- Road condition: dry
- Illegal speeding of > 100 km/h (speed limit  50 km/h)

**Description of the accident:**

01, male, 18 years old and his passenger, a 19 year old male drive at night. 01 is under the influence alcohol and drives at an illegal speed (>100 km/h at a speed limit of 50 km/h) on a dry urban street. At the end of a straight part of the track, he gets off the road on the right hand side. The car hits a tree, overturns and comes to rest on its top. 01 dies immediately at the scene of the accident from suffocation caused by thoracal compression. His passenger is seriously injured, suffers a bilateral lung contusion, a lineal rupture and an open wrist fracture. He was also under the influence of alcohol (1.79 g/L).

**Conclusions: The accident was propably caused by a misinterpretation of the road layout by the young driver (18 years old) driving at an illegal speed of over 100 km/h (speed limit 50 km/h) in a small urban street at night. Causal for the misinterpretation is probably an impairment by alcohol of driver 01 (1.53 g/L). Furthermore his passenger is also severly intoxicated by alcohol (1.79 g/L), however, he survives the accident with serious injuries.**

**CASE 18**

**Accident pattern characteristics:**

**Number of parties involved:** 1 – 01: 67-year-old driver of a Toyota RAV 4

**Accident type classification (GDV number):** 141 – driving on a straight road

**Time of day and date:** Friday, 16.11.2007, 04:50

**Light condition:** Darkness with artificial light

**Vehicle Type:** 7 = sports utility vehicle

**Road classification:** 3 = road (urban)

**Collision type:** No collision with motor vehicle in transport – frontal collision with crash barrier

**Driver manoeuvre prior to accident:** 1 = general driving

**Driver's task prior to accident:** 1 = going ahead on a straight road

**Purpose of trip:** 5 = leisure

**Traffic way flow:** 4 = physically divided roadway with traffic barrier

**„Key event failure“:** Running off the road into the hard shoulder on the left side

**Contributory factors:**

Human: A223: Zolpidem

A111: heart: fibrosis of the myocardium, possible pre-accidental cardiac arrhythmia

Environment: A11: wet street

D133: night with artificial light

**Belted:** Yes

**Ejected:** No

**Age:** 67 years

**Gender:** Female

**Height:** 170 cm

**Weight:** 60.8 kg

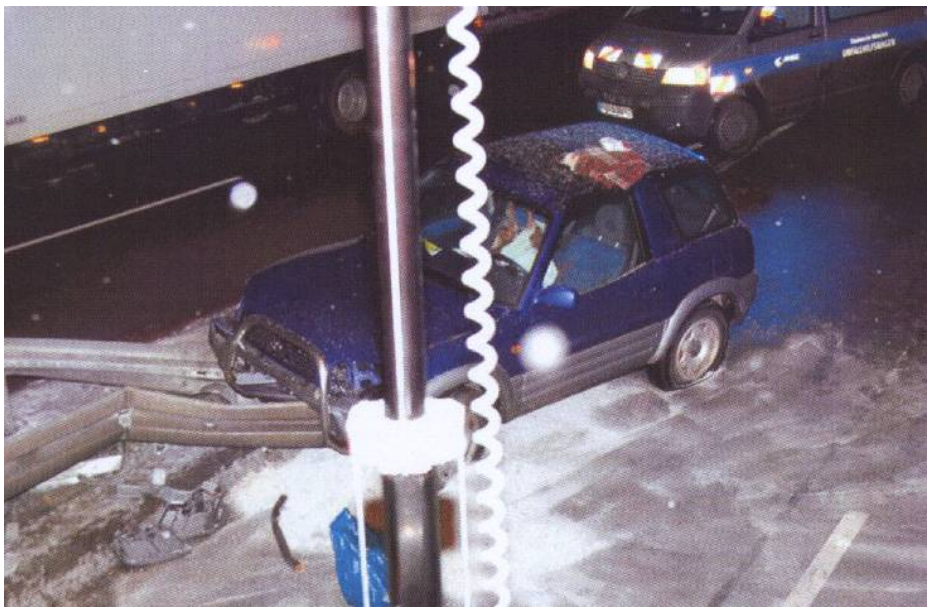

**Figure 28:** Case 18 – Final position of vehicle

**Additional parameters:**

- Night with artificial light in combination with the wet street might have lead to optic irritations
- Zolpidem above usual therapeutical range (ca. 400 µg/L)
- Probably vigilance-impairment due to medication
- Pre-existing heart disease of the driver

**Description of the accident:**

The 67-year-old female driver of a Toyota RAV 4 is driving on a physically divided urban roadway with a traffic barrier and two lanes on each side. The speed limit is 60 km/h. The car runs off the road on the left side about 40 meters before a branch, starts to skid and hits the crash barrier of the branch frontally. The driver dies one hour later in the hospital without external injuries, the autopsy shows heart and lung contusions as well as a fibrosis of the myocardium which could have let to cardiac arrhythmia.

**Conclusions: This accident was probably caused by lack of vigilance due to impairment of Z-drugs or an acute medical condition (cardiac arrhythmia) resulting in loss of control over the own vehicle which leaves the road and hits the crash barrier.**

**CASE 19**

**Accident pattern characteristics:**

**Number of parties involved:** 1 – 01: 23-year-old driver of a Mazda EC, MX-3

**Figure 29:** Case 19 – Road lay-out

**Accident type classification (GDV number):** 102 = driving accident in a right bend

**Time of day and date:** Tuesday, 06.05.2008, 02:20

**Light condition:** Darkness without artificial light

**Vehicle Type:** 2 = hatchback car (Mazda EC, MX-3)

**Road classification:** 2 = rural road (Bundesstrasse)

**Collision type:** No collision with motor vehicle in transport (traffic sign, tree)

**Driver manoeuvre prior to accident:** 1 = general driving

**Driver's task prior to accident:** 3 = going ahead on a right bend

**Purpose of trip:** 9 = unknown

**Traffic way flow:** 1 = Two way traffic divided by a painted line

**„Key event failure“:** Running off the road in a long right bend

**Contributory factors:**

Human: A221: Illegal drugs: THC (5.9 ng/mL) THC-OH (ca. 1.2 ng/mL)
and THC-COOH (43 ng/mL) ,
A211: Alcohol, blood concentration 1.36 g/L

Environment: A11: wet road

**Belted:** Unknown

**Ejected:** No

**Age:** 23 years

**Gender:** Male

**Height:** approx. 180 cm

**Weight:** Unknown

**Figure 30:** Case 19 – Final position of vehicle

**Additional parameters:**

- Young driver
- Night
- Road conditions: wet
- Death at the scene of the accident
- Burnt-out car and corpse of 01

**Description of the accident:**

The 23-year-old male driver of a Mazda EC, MX-3, drives on a wet rural road (Bundesstrasse) at night. On a descending part of the track in a long right bend, the vehicle hits the hard shoulder. The driver tries to countersteer to the left, loses control over the car, which runs off the road on the left side of the road. It initially hits a traffic sign, then runs down the slope next to the road and finally hits a tree. The vehicle catches fire and burns out totally.
The driver dies immediately from serious head injuries, his corpse is burnt beyond recognition. As there are no witnesses of the accident and the technical experts could not find any defects at the car that might have caused the accident and excluded illegal speeding as well (speed limit 100 km/h).

**Conclusions:**

**Running off the road in long bends is a typical driving mistake under the influence of THC, the active ingredient in cannabis preparations. The combination of alcohol and THC intensifies the central depressant effects. An elongated reaction time and impaired power of concentration under difficult driving circumstances (wet road, night time) had contributed to the steering mistake.**

**Figure 31:** Case 19 – State of vehicle after accident

**CASE 20**

**Accident pattern characteristics:**

**Figure 32:** Case 20 – Scene of the accident

**Number of parties involved**: 2 – 01: killed male driver of a motorcycle Kawasaki ZX-900A with pillion rider
02: male driver of a car BMW X5

**Accident Type Classification (GDV number):** 723 = accident due to U-turn

**Time of day and date:** Friday, 17.04.2009, 13:52

**Light condition**: Daylight

**Vehicle Type**: 01: 13 = motorcycle (Kawasaki ZX-900A)
02: 02 = hatchback car

**Road classification**: 4 = main street in urban area

**Collision type**: 4 = front to side 90$^{o}$ degrees

**Driver manoeuvre prior to accident:** 01**:** 1 = General driving
02: 8 = U-turn

**Driver's task prior to accident:** 01: 1 = going ahead on a straight road
02: 41 = u-turn

**Purpose of trip**: 9 = Unknown (both drivers)

**Traffic way flow:** 1 =Two way traffic divided by a painted line

**"Key event failure":** 01: Illegal speed (95 km/h instead of max. 50 km/h)
02: Wrong estimation of the approaching 01

**Contributory factors:**

Human: 01: A221: Illicit drugs: THC (2.37 ng/mL), THC-COOH (23.13 ng/mL)

C211: Illegal speed

02: A331: Inadequate perception of a threatening situation

**Belted:** Unknown

**Ejected**: Unknown

**Age:** 01: 21 years

02: Unknown

**Gender**: Male (both drivers)

**Height:** 01: 185 cm

02: Unknown

**Weight:** Unknown (both drivers)

**Additional parameters:**

- Death at the scene of the accident of driver of PTW and pillion rider
- Speed limit: 50km/h
- Light/Weather conditions – sunny, dry
- Road conditions: dry asphalt
- Probably elongated reaction time of 01 due to THC-impairment

**Description of the accident:**

01, the 21-year-old male driver of a PTW, Kawasaki ZX-900A, accompanied by a pillion rider drives at an illegal speed of 95 km/h (speed limit 50 km/h) on a straight road. On the opposite road side a male driver of a BMW X5 drives in the opposite direction until for an unknown reason he starts to perform an U-turn, turning his vehicle to the left onto the opposite lane. At the time he begin his U-turn manoeuvre the motorcycle is about 73 meters in front of his vehicle. The driver of the motorcycle impedes his PTW about 54 meters from the point of the later collision point. After overcoming another 10 meters the PTW falls on its right side and glides approximately at the speed of 74 km/h until it hits the front right door of the car which at that time is moving at a speed of ca. 20 km/h. The driver of the PTW and his pillion rider die immediately at the scene of the accident.

**Conclusions: The 01 driver was driving a motorcycle at an illegal speed under the influence of THC. The 02 driver disobeyed the priority of 01 by performing a U-turn which did not allow for the 01 driver to pass before the 02 vehicle passed onto the opposite lane. However, according to the technical report if the 01 driver had been following the permitted speed limit he would probably have been able to successfully impede his vehicle and**

**avoid the collision with the 02 vehicle. Impairment by THC, also in low concentrations, shows among others things enhanced distractibility and prolonged reaction time, resulting in a not adapted driving behaviour for like in the present case.**