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Psychoactive substances and road traffic safety in Szczecin, Poland between 2016 and 2020

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ABSTRACT

Introduction: Road traffic safety depends on the road surface, weather, and the driver's behaviour on the road. Safety primarily depends on the behaviour of drivers, who often violate the law and, for example, exceed the speed limit, use a mobile phone while driving, or run red lights at intersections. Another problem for road safety is drivers operating vehicles under the influence of alcohol and/or other psychoactive substances such as amphetamine and its analogues, delta-9-tetrahydrocannabinol (Δ-9-THC), cocaine, opioids and benzodiazepines.

The study aimed to analyze data obtained from blood tests performed on drivers stopped for roadside checks by police officers in Szczecin in the years 2016–2020 (West Pomerania province).

Materials and methods: Secured blood samples were analyzed for the type and concentration of specific psychoactive substances which were initially detected in drivers during roadside checks. Quantitative blood tests were carried out using liquid chromatography mass spectrometry (LC/MS).

Results: In 2016–2020, 1,607 drivers were tested at the Department of Clinical and Forensic Toxicology of the Pomeranian Medical University in Szczecin. Records indicated that each year, the rate of road users who were under the influence of a psychoactive substance as defined by law was increasing. The analysis revealed that the most frequently detected substance was amphetamine in 2017 (61%), 2018 (48%) and 2020 (48%), and Δ-9-THC in 2016 and 2019 (48%).

Conclusions: In the analyzed period, in contrast to the number of drivers testing positive for amphetamine and Δ-9-THC, the rate of road users testing positive for opiates, cocaine or benzodiazepines in blood was relatively low.

Keywords: road traffic safety; psychoactive substances; drug driving.

INTRODUCTION

Road traffic safety depends not only on driving conditions, e.g., the road surface, weather and number of road users, but mainly on the psychophysical status of drivers. The driver's response to specific situations on the road can be influenced by fatigue caused by long travel, health status, and the use of alcohol and/or other psychoactive substances. Psychoactive substances are listed in the Regulations of the Minister of Health of 18 July 2014. These substances include amphetamine and its analogues (e.g., methamphetamine, 3,4-methylenedioxymethamphetamine – MDMA), opioids, cocaine, tetrahydrocannabinols (THC) and benzodiazepine derivatives [1].

Amphetamine acts through the adrenergic and noradrenergic systems, while its analogue MDMA acts through the adrenergic, dopaminergic and serotonergic systems. The effects of amphetamines include psychomotor agitation, dilated pupils, double vision, accommodative dysfunction, photosensitivity, and insomnia. In addition, people who are under the influence of amphetamines have very high self-confidence, overestimate their own abilities, and make risky decisions, as has been confirmed in simulation studies. These studies consistently showed that after using amphetamines, drivers drove vehicles recklessly, going far over the speed limit and did not stop at red lights. Moreover, they also tended to signal road manoeuvres incorrectly [2, 3].

Delta-9-tetrahydrocannabinol (Δ-9-THC) is a biologically active compound found in cannabis. It has an affinity for human CB1 cannabinoid receptors in the cerebral cortex, hippocampus, hypothalamus, cerebellum, amygdala, and CB2 receptors associated with immune cells. The effects of Δ-9-THC include mood elevation, characteristic giggling, synaesthesia, visual disorders, hallucinations, prolonged response time, anxiety, panic attacks, or short-term memory disorders. Simulation tests have shown that the use of Δ-9-THC affects virtually all areas that are important in driving. Drivers under the influence of THC have a prolonged response time, insufficient control over driving in a straight trajectory, change speed for no apparent reason, and are hypersensitive to light stimuli [2, 4].

Cocaine is an alkaloid found in the *Erythroxylum coca* plant and is most commonly available as a hydrochloride salt. Cocaine works primarily by blocking the norepinephrine and dopamine transporters, resulting in an increased concentration of these neurotransmitters in the synaptic clefts of the central and peripheral nervous systems. The effects of cocaine include strong psychomotor agitation, euphoria, dilated pupils, talkativeness, incoherent speech, anxiety, increased blood pressure, tachycardia, sensory disturbances, and light-headedness with episodes of rage. The effects of cocaine on the ability to drive are similar to those produced by amphetamine [5].

As mentioned above, the term "opioids" used in the regulations covers synthetic opioids and natural opiates. This class of substances includes morphine and heroin. The mechanism of action of opioids is based on binding to opioid receptors: μ,

Δ, κ and opioid-receptor-like 1. The activation of the μ receptor results in the constriction of the pupils, euphoria, and analgesia, while the activation of the κ receptor induces drowsiness and has a sedative effect. The activation of the Δ receptor results in hallucinations and delusions. People driving under the influence of opioids have a longer response time, vision disorders, and misjudge reality, which creates a considerable danger on the road [6, 7].

Benzodiazepine derivatives are a group of pharmacological compounds with a psychotropic effect and a broad spectrum of biological activity. These substances produce sedative, hypnotic, anticonvulsant and anxiolytic effects. The mechanism of action of benzodiazepines relies primarily on the formation of a macromolecular complex involving γ-aminobutyric acid type A receptors, benzodiazepine receptors and chloride channels. The effects of benzodiazepines include somnolence, impaired motor coordination, ataxia, anterograde amnesia, accommodative dysfunction, and nystagmus. Because of these effects, drivers under the influence of benzodiazepines pose a real threat to themselves and other road users [8].

MATERIALS AND METHODS

The goal of this article is analyze and present the percentage distribution of substances in blood from drivers stopped by police officers for inspection in the Szczecin area. We present a retrospective statistical analysis of records from toxicology tests performed in the Department of Clinical and Forensic Toxicology at the Pomeranian Medical University in Szczecin (PMU), Poland in the years 2016–2020. The analysis comprised 1,607 tests of biological material (blood samples), collected from male road users in Szczecin (West Pomeranian province, Poland). Material was collected by registered nurses at hospitals on police orders. Secured blood samples were analysed for the levels and type of psychoactive substances which were initially detected in the drivers' saliva during roadside checks by police officers. Saliva testing was done using a Drager Drug Test 5000 immunoassay. Tests to confirm preliminary findings on the type of substance used were carried out within 24 h of the driver being stopped for a roadside check.

Quantitative blood tests were carried out using liquid chromatography mass spectrometry (LC/MS). The material was prepared in accordance with the applicable methods used in regular laboratory work in the Department of Clinical and Forensic Toxicology, PMU.

RESULTS

In the years 2016–2020, a total of 1,607 biological materials were tested for the presence of psychoactive substances. This was performed at the Department of Clinical and Forensic Toxicology, PMU. The material was secured in standard packages from drivers and road users in Szczecin who were stopped by police officers. The number of tests was 101 (6.5%) in 2016, 242 (15%) in 2017, 269 (17%) in 2018, 491 (30.5%) in 2019 and 504 (31%) in 2020 (Fig. 1).

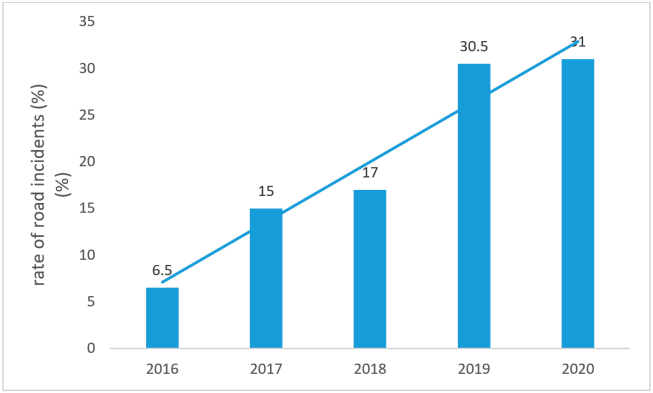


FIGURE 1. Number of blood tests for the presence of psychoactive substances in drivers, 2016–2020

In the analyzed period, the vast majority of blood tests confirmed findings from the initial screening tests. In 2016, 98 (97% of all tests that year) drivers tested positive for the presence of psychoactive substances. The number of positive tests was 225 in 2017 (92%), 257 in 2018 (95.5%), 473 in 2019 (96%), and 492 (98%) in 2020 (Fig. 2).

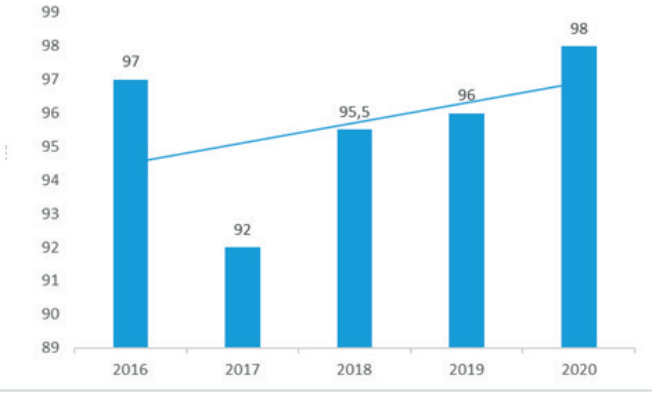


FIGURE 2. Positive blood tests for the presence of psychoactive substances in drivers, 2016–2020

In the analyzed period, the number of tests and the number of tests with positive results, for the presence of psychoactive substances increased consistently (Fig. 1, 2).

A data analysis by type of psychoactive substance revealed that in 2016, the most frequently detected drugs in drivers were amphetamine (45%, 55 tested subjects) and Δ-9-THC (48%, 59). Other detected substances were cocaine (1.6%, 2), methamphetamine (1.4%, 1), and MDMA (4%, 6). Considering the concentration of Δ-9-THC in blood tests, 78% of subjects (46) were under the influence of Δ-9-THC, while 22% (13) of subjects had recently used Δ-9-THC. Similar results were found for amphetamine: 94.5% (52) of subjects were under the influence of amphetamine, and 5.5% (3) had recently used it. Concentrations of MDMA measured in blood samples from drivers indicated that 83% (5) of them were under the influence of this drug, while 17% (1) had recently used it. One road user was under the influence of methamphetamine.

There was also 1 subject under the influence of cocaine (50%) and another who had recently used this drug (50%) – Table 1.

TABLE 1. Psychoactive substances detected in the blood of drivers in 2016

Psychoactive substance	Under the influence (%)	After recent use (%)	Contact with substance (%)
Amphetamine	94.5	5.5	0
Δ-9-THC	78	22	0
Methamphetamine	100	0	0
MDMA	83	17	0
Cocaine	50	50	0
Opioids	0	0	0
Benzodiazepines	0	0	0

Δ-9-THC – delta-9-tetrahydrocannabinol; MDMA – 3,4-methylenedioxymethamphetamine

The analysis of data for 2017 demonstrated that the psychoactive substance most frequently detected in blood samples secured from drivers was amphetamine (237, 61% of tested drivers), followed by Δ-9-THC (125, 32%). Other detected substances were opioids (1, 0.2%), cocaine (15, 4%), benzodiazepines (2, 0.5%), methamphetamine (2, 0.5%), and MDMA (7, 1.8%). Data analysis revealed that 97.5% (231) of tested drivers were under the influence of amphetamine, while 2.1% (5) had recently used this drug. One driver (0.5%) had previous contact with amphetamine (the blood test was positive for amphetamine but the concentration did not indicate that the driver was under the influence or had recently used this substance). In the analysed group of drivers, 64% (80) were under the influence of Δ-9-THC, and 32% (40) had recently used it. Tests also indicated that 4% (5 subjects) had previous contact with Δ-9-THC, but the detected concentrations of this substance did not impair their ability to drive. Of all drivers who tested positive for cocaine, 47% (7) were under the influence of this drug. Another 47% (7) of drivers had recently used it, and 6% (1) of drivers had previous contact with this drug. All drivers who tested positive for methamphetamine, opioids, MDMA or benzodiazepines were under the influence of these substances (Tab. 2).

TABLE 2. Psychoactive substances detected in blood from drivers in 2017

Psychoactive substance	Under the influence (%)	After recent use (%)	Contact with substance (%)
Amphetamine	97.5	2.1	0.5
Δ-9-THC	64	32	4
Methamphetamine	100	0	0
MDMA	100	0	0
Cocaine	47	47	6
Opioids	100	0	0
Benzodiazepines	100	0	0

Δ-9-THC – delta-9-tetrahydrocannabinol; MDMA – 3,4-methylenedioxymethamphetamine

The analysis of data for 2018 again showed that amphetamine was the most frequently detected drug. It was found in 48% (159) of tested subjects. Delta-9-tetrahydrocannabinol was detected in 38% (124) of subjects, opioids in 0.6% (2), cocaine in 6.6% (22), benzodiazepines in 1.2% (4), and MDMA in 5% (17). Considering the concentrations of amphetamine, 98% (156) of tested drivers were under its influence, while 2% (3) had recently used the drug. Concentrations of Δ-9-THC indicated that 80% (99) of drivers were under the influence of it, and 17% (21) had recently used it. Previous contact with Δ-9-THC was established in 3% (5) of the drivers. All drivers who tested positive for opioids, benzodiazepines, MDMA, or methamphetamine were under the influence of these substances. The analysis indicated that 64% (14) of subjects were under the influence of cocaine, 22% (5) had recently used it, and another 14% of drivers (3) had previous contact with this xenobiotic (Tab. 3).

TABLE 3. sychoactive substances detected in blood from drivers in 2018

Psychoactive substance	Under the influence (%)	After recent use (%)	Contact with substance (%)
Amphetamine	98	2	0
Δ-9-THC	80	17	3
Methamphetamine	100	0	0
MDMA	100	0	0
Cocaine	64	22	14
Opioids	100	0	0
Benzodiazepines	100	0	0

Δ-9-THC – delta-9-tetrahydrocannabinol; MDMA 3,4-methylenedioxymethamphetamine

In 2019, the most frequently detected psychoactive substance in blood from drivers was Δ-9-THC (48%, 292 tested subject). Blood tests were positive for amphetamine 42%, (257), methamphetamine (0.3%, 2), MDMA (4.8%, 29), opioids (0.3%, 1), cocaine (4%, 25), and benzodiazepines (0.7%, 4). In the analysed group of drivers, 82% (240) of tested subjects were under the influence of Δ-9-THC, and 1% (29) had recently used it. Previous contact with this substance was established in 8% (23) of drivers. Concentrations of amphetamine indicated that 97% (250) of tested drivers were under the influence of this drug, 1.5% (4) had recently used it, and 1.5% (3) of drivers had previous contact with this substance. As for the MDMA results, 93% (27 subjects) were under the influence of MDMA, and 3.5% (1) had recently used MDMA. Another 3.5% (1) of drivers had previous contact with MDMA. All drivers (2) who tested positive for methamphetamine were under the influence of this substance. A driver who tested positive for opioids was also under the influence of these substances (Tab. 4).

According to records for 2020, amphetamine was the most frequently detected psychoactive substance in the blood of tested drivers (48%, 319 drivers), which corresponds to data for 2016–2018. Delta-9-tetrahydrocannabinol was detected in 42% (279 drivers). Thus, an inverse distribution of rates was found for these substances compared to the previous year.

TABLE 4. Psychoactive substances detected in blood from drivers in 2019

Psychoactive substance	Under the influence (%)	After recent use (%)	Contact with substance (%)
Amphetamine	97	1.5	1.5
Δ-9-THC	82	1	8
Methamphetamine	100	0	0
MDMA	93	3.5	3.5
Cocaine	64	24	12
Opioids	100	0	0
Benzodiazepines	100	0	0

Δ-9-THC – delta-9-tetrahydrocannabinol; MDMA – 3,4-methylenedioxy-methamphetamine

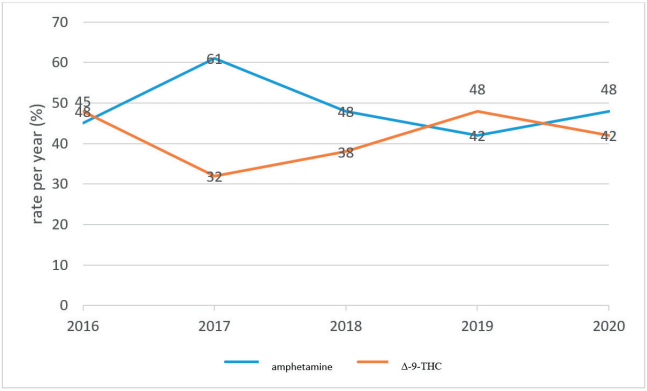
Other substances detected in 2020 in blood samples from drivers were methamphetamine (0.6%, 4), MDMA (3.2%, 22), opioids (0.3%, 2), cocaine (5.2%, 38), and benzodiazepines (0.7%, 5). Considering Δ-9-THC, 90% (252) of tested drivers were under the influence of this substance, 9% (24) had recently used it, and 1% (3) had previous contact with this substance. An analysis of positive testing for amphetamine showed that 98.5% (314) of drivers were under the influence of it, and 1.5% (5) had recently used this substance. An analysis of data on the concentration of amphetamine derivatives indicated that all (100%) drivers who tested positive for MDMA (22) or methamphetamine (4) were under the influence of these substances. The situation was similar in the group of drivers testing positive for opioids (2) or benzodiazepines (5). Considering cocaine, 66% (25) of tested drivers were under the influence of it, 13% (5) had recently used it, and 21% (8) of drivers had previous contact with this substance (Tab. 5).

TABLE 5. Psychoactive substances detected in blood from drivers in 2020

Psychoactive substance	Under the influence (%)	After recent use (%)	Contact with substance (%)
Amphetamine	98.5	1.5	0
Δ-9-THC	90	9	1
Methamphetamine	100	0	0
MDMA	100	0	0
Cocaine	66	13	21
Opioids	100	0	0
Benzodiazepines	100	0	0

Δ-9-THC – delta-9-tetrahydrocannabinol; MDMA – 3,4-methylenedioxy-methamphetamine

The presented data for the years 2016–2020 indicate that the number of drivers testing positive for the 2 major psychoactive substances (Δ-9-THC and amphetamine) changed gradually and clearly. The rate of drivers testing positive for amphetamine was 45% in 2016 and 61% in 2017 (the highest rate of drivers under the influence of amphetamine in the analysed period), while in 2018 and 2020 the rate of drivers under the influence of this substance was stable (48%). In 2019, the rate of drivers under the influence of amphetamine was lower (42%) than the records for Δ-9-THC (48%). The analysis of data for Δ-9-THC revealed that in 2017–2018 and 2020 the rate of drivers under the influence of this xenobiotic was lower (32%, 38%, and 42%, respectively) compared to the rate of drivers under the influence of amphetamine, while in 2016 and 2019 the rate of drivers under the influence of Δ-9-THC was at its highest (48% in each year) – Figure 3.



Δ-9-THC – delta-9-tetrahydrocannabinol

FIGURE 3. Rates of drivers testing positive for psychoactive substances in 2016–2020

DISCUSSION AND CONCLUSIONS

The statistical analysis of results for blood samples collected from drivers stopped for roadside checks in the city of Szczecin (West Pomeranian province) in 2016–2020, carried out at the Department of Clinical and Forensic Toxicology of the PMU, only included tests for psychoactive substances. In the analyzed period, 1,607 samples from drivers stopped by police officers for inspection were tested. The drivers were screened with a roadside saliva test (the Drager Drug Test 5000), and if the result was positive for a psychoactive substance, a further blood sample was taken from the driver. The blood sample was tested by LC/MS to confirm or rule out the presence of a psychoactive substance. In the analyzed period, the rates of positive blood tests were as follows: 97% in 2016, 92% in 2017, 95.5% in 2018, 96% in 2019, and 98% in 2020.

In the analyzed period, the most frequently detected psychoactive substances in drivers' blood were Δ-9-THC and amphetamine. Amphetamine was most frequently detected in 2017, 2018 and 2020, and Δ-9-THC in 2016 and 2019.

In 2016, none of the drivers tested positive for opioids or benzodiazepines. However, since 2017 these substances have been detected in tested blood samples, but the number of drivers testing positive for opioids or benzodiazepines was very low compared to those positive for amphetamines or Δ-9-THC. The rate of drivers testing positive for opiates was highest in 2018 (0.6%), and lowest in 2017 (0.2%). Considering benzodiazepines, the rate was highest in 2018 (1.2%), and lowest in 2017 (0.5%). In the analyzed period, there were also drivers

testing positive for cocaine, but their rate was low compared to records for amphetamine and Δ-9-THC. The rate of drivers testing positive for cocaine was highest in 2018 (6.6%), and lowest in 2016 (1.6%).

The problem that arises when interpreting the concentrations of psychoactive substances in blood concerns determining whether at the time of the incident the driver was under the influence of a psychoactive substance or was after recent use of it. In contrast to the regulations pertaining to ethyl alcohol, current legislation in Poland is lacking a law regulating this issue.

In the present study, the driver's status, i.e., whether they were under the influence of drugs, or had recently used a psychoactive substance, was established based on the concentration of the xenobiotic in the blood, the behaviour of the driver during the roadside check, and the time that elapsed between the incident/roadside check and the moment of blood sampling. An important guideline for the qualification and interpretation of results at our department was the findings from the DRUID project, which was conducted in 11 European countries [9, 10]. Based on these findings, analytical limits which categorised a person as in a state under the influence of a psychoactive substance or state after recent use of it to be applied in forensic reporting were proposed at the 2012 Forensic Toxicologists Conference in Krakow by representatives of the local Institute of Forensic Research (Tab. 6).

TABLE 6. Recommendations of the Institute of Forensic Research on the concentrations of psychoactive substances for the states of 'after recent use' and 'under the influence'

Substance	Analytical limit (ng/mL)	Cut off value (ng/mL) for the status	
		after recent use	under the influence
THC	1	1–2.5	≥2.5
Amphetamine	25	25–50	≥50
Cocaine	10	10–20	>20
Benzoylecognine	100	>100	not established
Morphine	10	10–20	>25

THC – tetrahydrocannabinol

Following this qualification criteria, it was found that among the drivers testing positive for amphetamine or Δ-9-THC between 2016–2020, most were under the influence of amphetamine (94.5% in 2016, 97.5% in 2017, 98% in 2018, 97% in 2019, and 98.5% in 2020). In 2016–2018 and 2020, most drivers were under the influence of Δ-9-THC (22% in 2016, 32% in 2017, 17% in 2018, and 9% in 2020). In 2019, only 1% of drivers were under the influence of Δ-9-THC.

It should be emphasized that drivers have no control over the infrastructure (road surface) or weather conditions on the road. In contrast, drivers can control their psychomotor status (behaviour), which has a considerable impact on road traffic safety. Irresponsible behaviour, including drug driving, increases the risk of road collision or accident by many times, often resulting in fatalities.

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