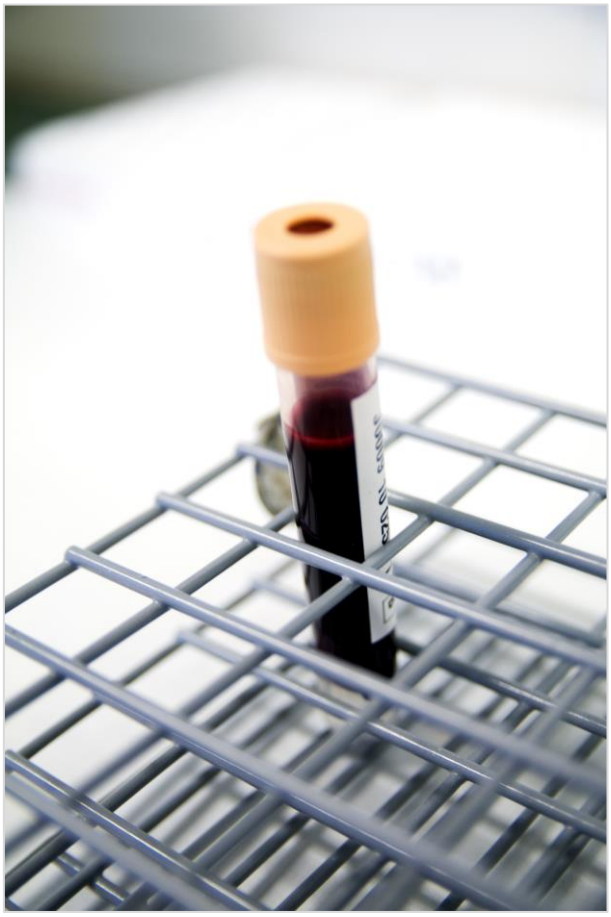

Autopsy Statistics

Findings in Blood Samples from Autopsies Conducted in 2023

Department of Forensic Sciences

OSLO UNIVERSITETSSYKEHUS

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Foreword

This report covers autopsies where forensic toxicological analyses were conducted at the Department of Forensic Sciences, Oslo University Hospital (OUS) in 2023 and the previous nine years. Autopsies performed at local hospitals for medical purposes without toxicological analyses, and autopsies where toxicological analyses were carried out at St. Olav's Hospital, are not included in this report. The purpose of the report is to provide an overview of the scope and the substances detected in autopsies, which reflects trends in prescribed and illegal substance use in Norway. Each annual report will highlight specific trends and present findings that will be discussed in more detail than in previous years.

The cause of death is not included in this report. Concentrations of the detected substances are not assessed. Whether low concentrations or high and lethal concentrations of a substance were detected, is therefore not indicated. The detection of drugs and narcotics in blood cannot alone determine the cause of death. By linking toxicological findings from autopsies with the cause of death register or information from the autopsy report, it is possible to ascertain the contribution of substances to death. The department has research projects investigating this, and these results are published in scientific articles.

Oslo, September 2024

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Introduction

Approximately 95 percent of all toxicological samples from legal autopsies in Norway are analyzed at the Department of Forensic Sciences, OUS. The remaining five percent are analyzed at St. Olav's Hospital in Trondheim and are not included in this report.

Toxicological analyses primarily include the most common psychoactive substances and a selection of medications. In most cases, a routine analysis of about 600 substances is performed. Detection limits, analysis repertoire, and trends will affect which and how many substances are detected. The detection limit for each substance is set by the laboratory and indicates the amount of the substance that must be present in the blood for the sample to be issued as positive ("detected"). Substances present in blood at concentrations below the detection limit will be issued as negative ("not detected"). The analysis repertoire is continuously evolving, and the number of substances analyzed is steadily increasing. An updated overview of the analysis repertoire can be found here: eHåndboksdokument med prøvetakingsinstruks og analyserepertoar. Trends in prescribed medications and the availability of narcotics on the illegal market also affect findings in autopsies.

This report does not present data on combination drug use. Studies based on autopsy data show that multiple substances are often detected at autopsy.

The results in the report are primarily presented as absolute numbers (number of positive cases), and not relative numbers (proportion of positive cases). The number of autopsies where samples are sent for toxicological analysis has increased each year, and the number of positive cases per year must be interpreted accordingly. An increase in the number of positive cases for a substance does not necessarily mean that the proportion of positive cases has increased. The significance of absolute versus relative numbers also depends on the types of autopsy cases analyzed (cause of death). Because we do not have access to the cause of death in the analyzed cases, it is not possible to interpret the proportion of positive cases in light of these causes. However, we observe that the graphical curves and the detection trends appear to correspond regardless of whether the results are presented as absolute or relative numbers.

In previous editions of this report, we have compared findings of medications in autopsy cases with data from the Norwegian Prescription Database (NorPD). However, NorPD's statistical database is currently being phased out as a new system is being established. Thus, there are no newer prescription numbers than for 2020 until the new database is operational, and therefore, no such comparisons are included in this report. However, trends in findings of illegal narcotics and medications with abuse potential from Kripos'* narcotics and doping statistics[1] for 2023 are reported and discussed.

* The National Criminal Investigation Service in Norway

[1] Kripos' Narcotics and Doping Statistics (Kripos' narkotika- og dopingstatistikk) 2023: https://www.politiet.no/globalassets/tall-og-fakta/narkotika/narkotikastatistikk-2023.pdf

Summary

This report discusses the findings of the most common medicinal and recreational drugs in autopsy cases analyzed during the period 2014-2023.

Figure 1 shows the total number of autopsy cases and the number of cases with findings of at least one drug in the blood sample. A total of 2,664 unique autopsy samples were analyzed in 2023, which is the highest number to date. In 2,102 of these autopsy cases, one or more substances were detected. This corresponds to findings of substances in 79% of the cases. The proportion of samples without findings has been 20-25% since 2000.

Throughout the relevant period, more men than women were autopsied, with an average proportion of men at about 70% in 2023 (similar to the previous years). The average age was 54 years, but ranged from infants to individuals over 90 years old. Over the ten-year period from 2014 to 2023, the average age has increased from 51 to 54 years.

From 2022 to 2023, there was an increase in the detection of THC (the main active ingredient in cannabis), amphetamines, cocaine, and alprazolam (a benzodiazepine with significant abuse and dependency potential). These substances have never been detected as frequently before, while Kripos reports very large seizures of these substances. For example, the four largest cocaine seizures in Norwegian history were recorded in 2023. Findings of so-called designer benzodiazepines in autopsy cases were also at a record high in 2023, with almost three times more findings than in the "peak year" of 2018. For heroin (an illegal narcotic), we otherwise see a stable trend in the proportion of positive cases throughout this decade. Other opioids (strong painkillers with significant abuse and dependency potential) available by prescription, however, have gradually increased over the same period, particularly oxycodone. Furthermore, MDMA (Ecstasy) has been detected much more frequently in the last five years compared with the first five years of this ten-year period. Paracetamol alone (without codeine or tramadol) has also never been detected as frequently before and has gradually increased throughout the period.

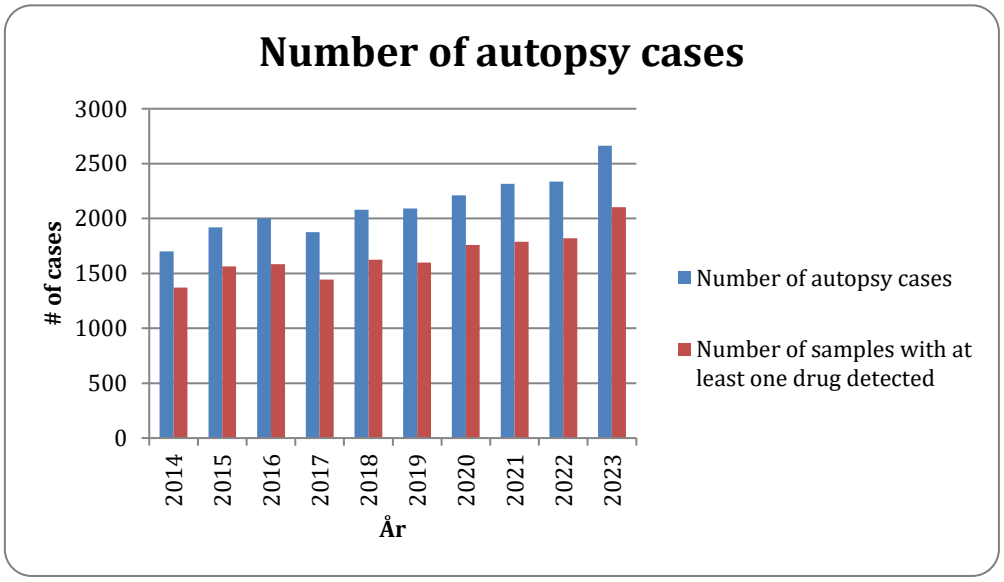

Figure 1: Total number of autopsy cases and number of cases where at least one drug was detected from 2014-2023.

Contents

Chapter 1: Detected Substances

Table 1 shows the 20 most common substances detected in blood samples from autopsies in 2023. A total of 2,664 autopsy cases were analyzed in 2023, compared to 2,335 in 2022. Ethanol is the most frequently detected substance in autopsy cases, and in 2023, alcohol was consumed in 18% of the cases. Most of the other substances in the table fall into two categories of medications: psychopharmaceuticals (used in the treatment of mental disorders) or opioids. Additionally, THC (the main active ingredient in cannabis), amphetamines, paracetamol, and metoprolol were detected.

Table 1: Most Commonly Detected Substances in Blood Samples from Autopsies in 2023.

	Substance	Examples of *Norwegian medications*/drug name	Total number in 2023	Proportion in 2023
1	Ethanol*	Alcohol	488	18%
2	THC	*Sativex,* cannabis	276	10%
3	Paracetamol/ acetaminophen	*Panodil, Paracet, Paramax, Pinex*	274	10%
4	Morphine**	*Dolcontin, Malfin, Oramorph,* heroin	263	9.9%
5	Diazepam	*Stesolid, Valium, Vival*	259	9.7%
6	Alprazolam	*Xanor*	245	9.2%
7	Amphetamines	*Attentin, Elvanse, Aduvanz,* meth(amphetamine)	238	8.9%
8	Zopiclone	*Imovane, Zopitin*	201	7.5%
9	Codeine***	*Altermol, Paralgin Forte, Paramax Comp, Pinex Forte*	168	6.3%
10	Fentanyl	*Abstral, Durogesic, Instanyl, PecFent*	146	5.5%
11	Pregabalin	*Lyrica*	136	5.1%
12	Quetiapine	*Seroquel, Quetiapin(e)*	136	5.1%
13	Mirtazapine	*Remeron, Mirtazapin*	123	4.6%
14	Clonazepam	*Rivotril*	122	4.6%
15	Citalopram	*Cipramil, Cipralex*	121	4.5%
16	Oxykodone	*OxyContin, OxyNorm, Reltebon, Targiniq*	113	4.2%
17	Metoprolol	*Selo-Zok, Seloken, Metopocor, Bloxazoc*	109	4.1%
18	Olanzapine	*ZypAdhera, Zyprexa*	107	4.0%
19	Methadone	*Metadon*	102	3.8%
20	Alimemazine	*Alimemazin Evolan*	91	3.4%

***Ethanol detected along with the metabolites EtG and EtS indicate alcohol consumption before death.**
****Morphine can be formed in the body after the intake of heroin, codeine, and ethylmorphine. Consumption of these substances can therefore also contribute to morphine-positive cases.**
*****Codeine is found in opium/heroin and can be detected in small amounts after heroin intake.**

Chapter 2: Alcohol (ethanol)

Alcohol (ethanol) is a psychoactive substance that elevates mood, increases impulsivity, heightens risk-taking, impairs judgment, and reduces coordination. Alcohol intoxication increases the risk of potentially dangerous impulsive actions and/or accidents. At high concentrations of alcohol in the blood, consciousness is diminished. A blood alcohol level around three or higher can lead to poisoning and death. The risk of fatal outcomes increases with the simultaneous intake of multiple psychoactive substances (especially other substances with depressive effects on the brain, such as opioids and benzodiazepines). Alcohol use also has extensive harmful effects on many of the body's other organs and can cause disease and death.

Ethanol can be formed in the body after death. Therefore, the detection of ethanol in blood samples from autopsies is not always indicative of alcohol consumption. The simultaneous detection of the transformation products ethyl glucuronide (EtG) and/or ethyl sulfate (EtS) indicates that alcohol consumption occurred before death.

Figure 2 shows the number of autopsy cases with consumed ethanol (detected along with EtG and/or EtS) over the period 2014-2023. Ethanol is detected in about 20% of cases annually. Data from the Norwegian Cause of Death Registry[2] indicates that approximately 380 people die from alcohol each year in Norway, among them about 35 people die from acute ethanol poisoning. Most of the deaths are due to mental disorders and behavioral disorders resulting from alcohol abuse and alcoholic liver disease.

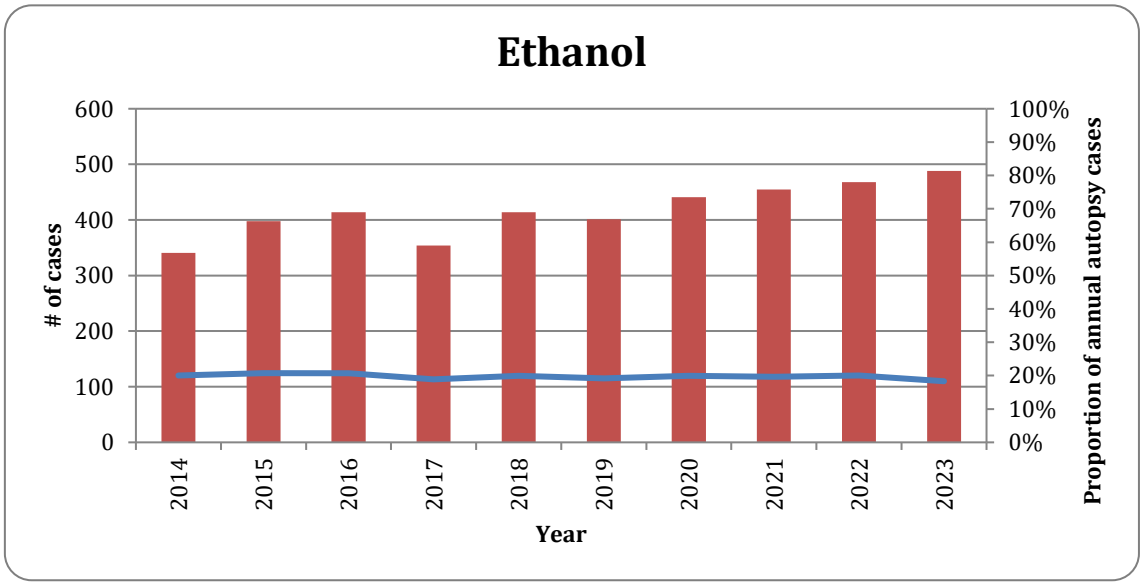

Figure 2: Number of autopsy cases (bars), and proportion of annual autopsy cases (line), with findings of consumed ethanol (detected along with EtG and/or EtS) over the period 2014-2023.

[2] The Norwegian Cause of Death Registry's Statistics Database: https://statistikkbank.fhi.no/dar/

Chapter 3: Opioids

Opioids are pain-relieving drugs with a strong potential for abuse. These substances can be prescribed by a doctor/dentist but are also widely available on the illegal market. Upon the intake of opioids as a recreational drug, a pronounced sense of well-being is experienced, accompanied by sluggishness and drowsiness. Opioids have depressive effects on the brain, which can lead to respiratory suppression and death. Marked tolerance for opioids develops with frequent and regular use over some time, so that higher doses are rapidly needed to achieve the same effect as with previous use. After ceasing opioid use, tolerance diminishes quickly, increasing the risk of overdosing and intoxications with new intake.

Opioids include substances with morphine-like effects. Some opioids are natural and can be derived from the sap of the opium poppy (such as codeine and morphine). Semi-synthetic opioids are not found in opium but can be produced from natural opioids (such as heroin, oxycodone, and buprenorphine). Other opioids are entirely synthetic (such as fentanyl, tramadol, methadone, and ketobemidone). Besides heroin and certain synthetic derivatives (see Chapter 7 on new psychoactive substances), which are only available on the illegal market, all of these substances can be prescribed as medications.

Kripos reports a similar number of heroin seizures in 2023 compared to 2022, but the seized amount of heroin was slightly above average for the last decade. The average potency was 11%, with variations from 4% to 53%. Increasing potency can increase the risk of overdose. In 2023, about 35,000 tablets/capsules etc. were seized. About half were tramadol followed by oxycodone and buprenorphine, which together accounted for the majority of these seizures.

In the USA, the number of opioid overdoses has increased dramatically in recent years and is referred to as an opioid epidemic and national crisis. According to the Centers for Disease Control and Prevention (CDC)[3], annual deaths involving opioids have risen from about 8,000 in 1999 to approximately 80,400 in 2021, and more than one million overdose deaths have occurred during these years in the USA. Fentanyls (very potent synthetic opioids), both pharmaceutically produced and related illegal substances (so-called fentanyl derivatives), have overtaken heroin as the leading cause of overdose deaths. The issues with such strong synthetic opioids also appear to be increasing in Europe. One reason for the many overdose deaths may be that users are unaware that they are consuming fentanyl or fentanyl derivatives (see Chapter 7 on new psychoactive substances). Studies have shown that fentanyls are often sold as heroin or mixed into heroin. They are also sold as counterfeit medications mimicking prescription tablets. Kripos reports that there were 17 seizures of the medication fentanyl in 2023, mainly in the form of depot patches. Another group of highly potent opioids, called nitazenes, has emerged on the national and international drug market. These are discussed further in Chapter 7.

Generally, the number and proportion of autopsies where opioids were detected have been relatively stable in the period 2014-2023. There is currently no indication of an ongoing opioid epidemic in Norway, but changes could quickly occur if, for example, strong synthetic opioids become more widely available on the illegal market.

[3] Centers for Disease Control and Prevention: https://www.cdc.gov/drugoverdose/deaths/index.html

A 20-year perspective on the development of findings of various opioids can be obtained by comparing Figure 3 in the report, which describes the development in the years 2000-2015 (here) with Figures 3 and 4 in this report. From the year 2000 to the present, it appears that heroin and morphine are partially being replaced by medical opioids such as oxycodone and tramadol.

Heroin (Morphine, Codeine, and 6-MAM)

Heroin is an illegal drug with widespread use in Norway. After ingestion, heroin rapidly converts into 6-monoacetylmorphine (6-MAM) and morphine in the body. 6-MAM also quickly disappears from the bloodstream, so the detection of 6-MAM in blood is indicative of heroin intake shortly before death. 6-MAM can be detected slightly longer in urine than in blood. In autopsy samples, both urine and blood are analyzed for 6-MAM to confirm heroin intake. In this report, 6-MAM has been detected in blood and/or urine. Detection of morphine alone can be due to the intake of heroin and/or morphine itself. Morphine can also be detected after the intake of codeine and ethylmorphine because a small amount of these substances is metabolized to morphine in the body. Codeine often appears as a contaminant in heroin. Therefore, the detection of codeine in autopsy blood samples along with morphine and 6-MAM often results from heroin intake but can also be due to the intake of the substance itself.

Figure 3 shows morphine and codeine in blood samples, as well as the transformation product from heroin, 6-MAM, in blood or urine samples from autopsies during the period 2014-2023. In 2023, morphine, codeine, and 6-MAM were detected in 10%, 6.3%, and 3.1% of autopsy cases, respectively.

The very short detection time for 6-MAM may result in missed/negative heroin intake detection. However, studies from this decade have shown that drug users in Norway increasingly combine the intake of various drugs, including other opioids, which may have replaced some heroin use. Additionally, more opioid-dependent individuals (especially heroin users) receive opioid maintenance treatment (OMT) than before. Furthermore, morphine was included as an OAT medication in 2022, and in Bergen and Oslo, heroin is offered as treatment for patients who do not adequately benefit from standard OMT treatments[4].

[4] National professional guideline for opioid use disorders: https://www.helsedirektoratet.no/retningslinjer/behandling-ved-opioidavhengighet/behandling-ved-opioidavhengighet

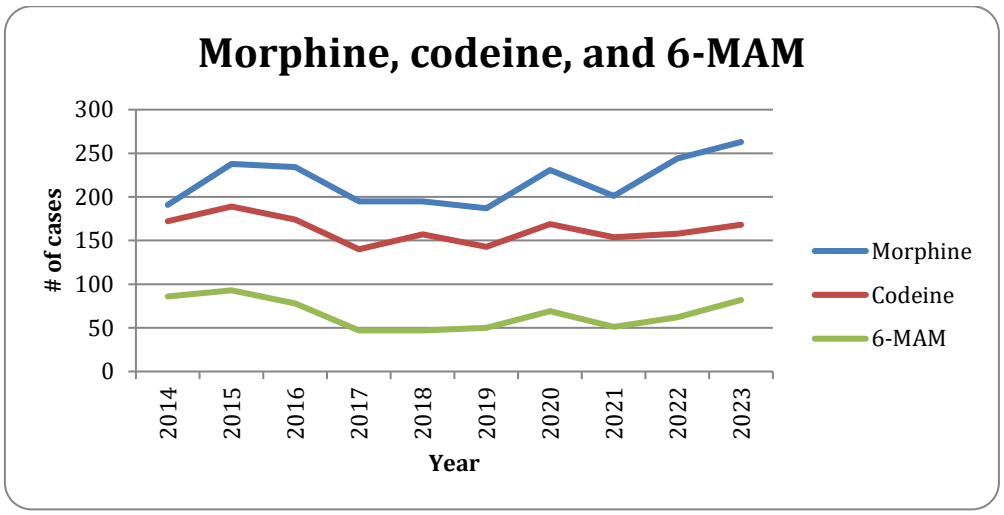

Figure 3: Number of autopsy cases with findings of morphine or codeine in blood, as well as the transformation product 6-MAM from heroin in blood or urine, over the period 2014-2023.

Fentanyl, Oxycodone, and Tramadol

Fentanyl, oxycodone, and tramadol are short-acting opioids used in pain management. The recreational use of several of these substances is significant.

Fentanyl is about 100 times as potent as morphine. It is used in emergency medical treatment, for instance after severe accidents, and during surgeries, where it is administered intravenously as an injection/infusion. Fentanyl is also used in the treatment of chronic and severe pain, often in the form of so-called pain patches. Oxycodone is roughly as potent as morphine and is used both intravenously and in tablet form. Tramadol is significantly less potent than morphine and is only available in tablet form (also discussed in Chapter 8 on paracetamol).

Figure 4 shows the number of cases where fentanyl, tramadol, and oxycodone were detected in blood samples from autopsies conducted from 2014-2023. In 2023, fentanyl was detected in 5.5% of autopsy cases, while oxycodone was detected in 4.2% and tramadol in 3.1% of the cases. In many of the instances where fentanyl was detected, it is reasonable to assume that the medication was administered as pain relief treatment shortly before death. Over this decade, the detection of fentanyl and oxycodone has increased more than tramadol, which appears to have stabilized in number since 2017. As the number of autopsy cases in the same period has increased, the proportion of tramadol in the samples has decreased.

The increase in several of these substances in autopsy cases may reflect increased usage due to accidents, increased prescription, and increased misuse. Data from the Norwegian Institute of Public Health show that more people die from other opioids than heroin in Norway[5].

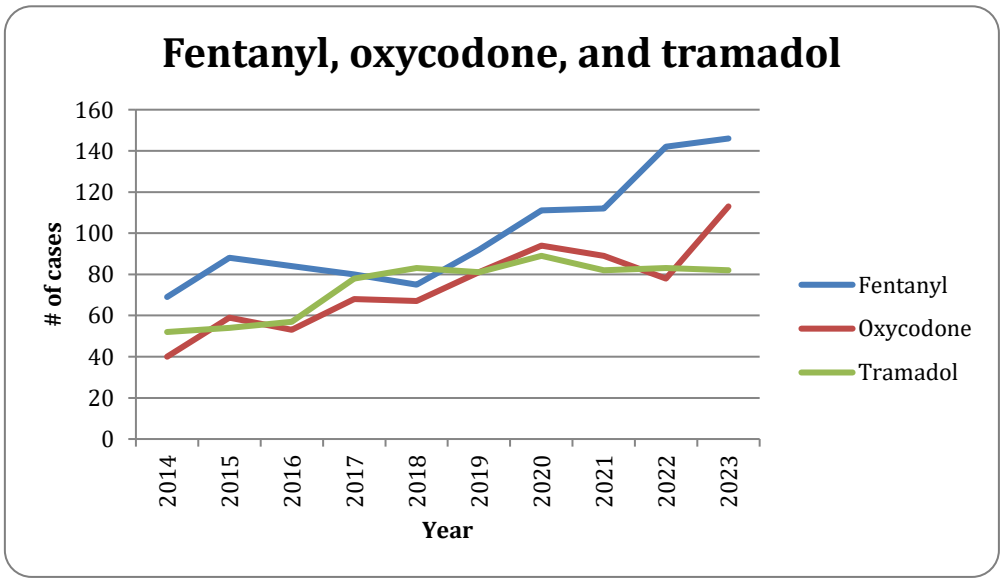

Figure 4: Number of autopsy cases with findings of the most common opioids over the period 2014-2023.

[5] The Norwegian Institute of Public Health. Drug-induced Deaths 2022: https://www.fhi.no/nettpub/narkotikainorge/konsekvenser-av-narkotikabruk/narkotikautloste-dodsfall/

Methadone and Buprenorphine

Methadone and buprenorphine are primarily used in opioid maintenance treatment (OMT) but can also be used for pain management. Buprenorphine, in particular, is extensively used in pain management. Additionally, these substances are available on the illegal market and are increasingly used as recreational drugs. Methadone is more potent than buprenorphine and has properties that increase the risk of fatal overdose compared with buprenorphine.

Figure 5 shows the number of cases where methadone and buprenorphine were detected in blood samples from autopsies conducted over the period 2014-2023. In 2023, methadone and buprenorphine were detected in approximately 3.8% and 3.2% of autopsy samples, respectively; an increase of one percentage point for both since 2021. The detection of these substances in samples likely reflects both prescription and illegal use. Methadone is currently used by about one-third of OMT patients, while the majority receive buprenorphine[6]. The patients who receive methadone are generally an older group, who have used the medication for many years. Findings of methadone in autopsy cases may therefore increasingly represent users with compromised health, who die with, and not necessarily from, methadone. It is also conceivable that there is an increasing incidence of deaths among the population treated with these drugs for chronic pain, who are not OMT patients.

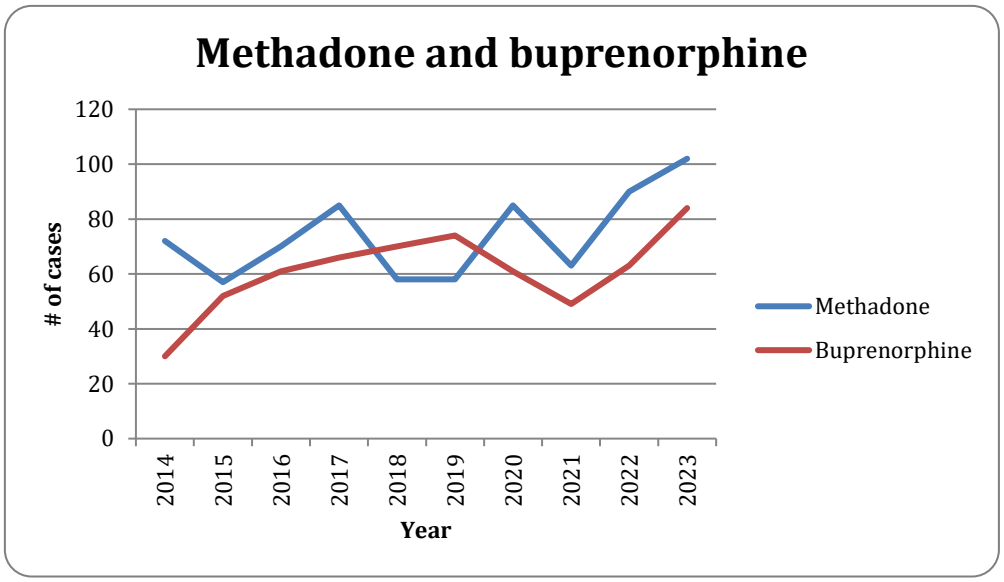

Figure 5: Number of autopsy cases with findings of methadone and buprenorphine over the period 2014-2023.

[6] Norwegian Centre for Addiction Research. Status Report for the First Year With New OMT Guidelines: https://www.med.uio.no/klinmed/forskning/sentre/seraf/publikasjoner/rapporter/2023/seraf-rapport-nr-1-2023-statusrapport-2022.pdf

Chapter 4: Benzodiazepines

Benzodiazepines are medically used as anti-anxiety, sedative, muscle relaxant, and sleep-inducing medications, as well as in the treatment of epilepsy. These substances are also extensively used as recreational drugs and can, among other effects, elevate mood. Intake can additionally lead to the impairment of various skills, such as attention and memory. Experimental studies have shown that use of several benzodiazepines can be accompanied by increased aggression when provoked, even at low doses. The risk of poisoning from the intake of a benzodiazepine alone is considered low, but the risk increases if the intake occurs in combination with other psychoactive substances (especially depressants, such as opioids and alcohol).

Oxazepam and diazepam are the most frequently prescribed benzodiazepines in Norway, with respectively 133,000 and 86,800 individual users in 2020. Nitrazepam, alprazolam, clonazepam, and flunitrazepam have significantly fewer users. There is a large degree of illegal trafficking of these substances. After the change of prescription category, deregistration, and the shutdown of an illegal source of Rohypnol (flunitrazepam) in the mid-2000s, the number of cases involving flunitrazepam has significantly decreased. In 2021, an illegal Rivotril (clonazepam) factory in Hungary was shut down, likely affecting the availability and findings of clonazepam. Both substances have been extensively used as recreational drugs in Norway, but in recent years, alprazolam has dominated the illegal market. According to Kripos' narcotics and doping statistics for 2023, large quantities of benzodiazepine-containing tablets were seized. Alprazolam tablets accounted for more than half of the seizures and quantities in 2023, followed by diazepam and clonazepam with between 18 – 20% of the seizures and quantities.

Figure 6 shows the most commonly occurring benzodiazepines detected in blood samples from autopsies during the period 2014-2023. Diazepam was detected in 9.7%, alprazolam in 9.2%, clonazepam in 4.6%, oxazepam in 2.7%, and nitrazepam in 2.3% of autopsy cases in 2023. Other benzodiazepines are rarely detected (0.1% of cases), and include benzodiazepines that do not have marketing authorization (lorazepam and bromazepam) in Norway, and flunitrazepam.

Figure 6 also shows that clonazepam and diazepam saw a significant decrease from 2020 to 2021, but an increase by 2023. Diazepam and alprazolam are now detected about equally often, and it seems that alprazolam has partially replaced clonazepam. Findings of alprazolam have more than quadrupled from 2018 to 2023 in number, and more than tripled in proportion of positive autopsy cases.

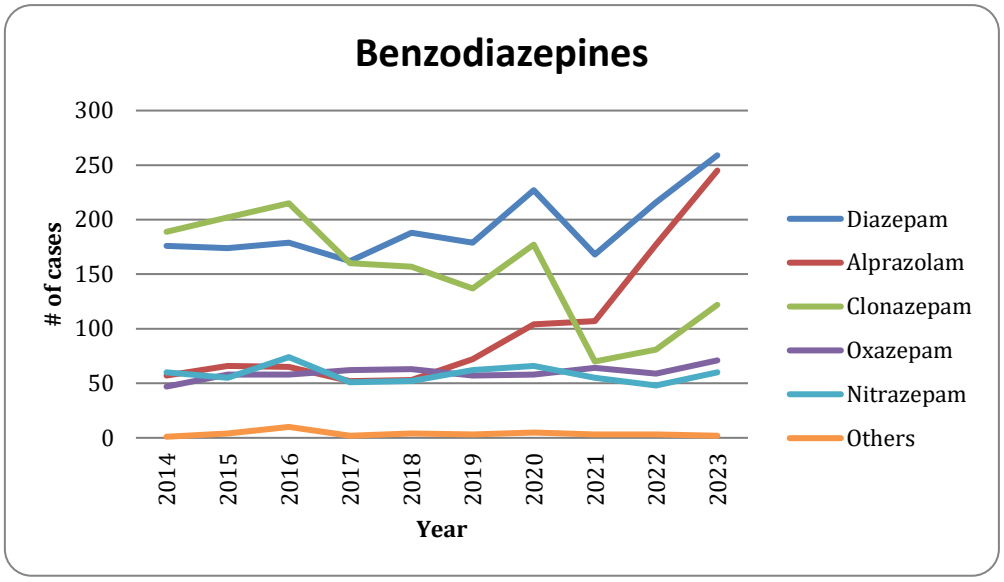

Figure 6: Number of autopsy cases with findings of benzodiazepines over the period 2014-2023. "Others" represents findings of bromazepam, flunitrazepam, and/or lorazepam.

Designer Benzodiazepines

Designer benzodiazepines are illegally manufactured benzodiazepines. Continuous efforts are made to develop analytical methods to detect new variants of designer benzodiazepines in blood and urine samples.

Figure 7 shows cases with designer benzodiazepines detected in blood samples from autopsies for the period 2014-2023. No such substances were detected in 2014 and 2015. In 2018 and 2019, diclazepam accounted for the majority of the cases. In 2021, etizolam was the most frequently occurring, while bromazolam was the most common finding in 2023. The year 2023 saw the highest number of autopsy cases with detected designer benzos ever. The increase may be due to more people using these substances, but also because analytical methods have improved in detecting them. Kripos also reported that bromazolam was the most frequently detected designer benzodiazepine in seizures in 2023. Overall, however, designer benzodiazepines constituted less than 2% of seized benzodiazepines.

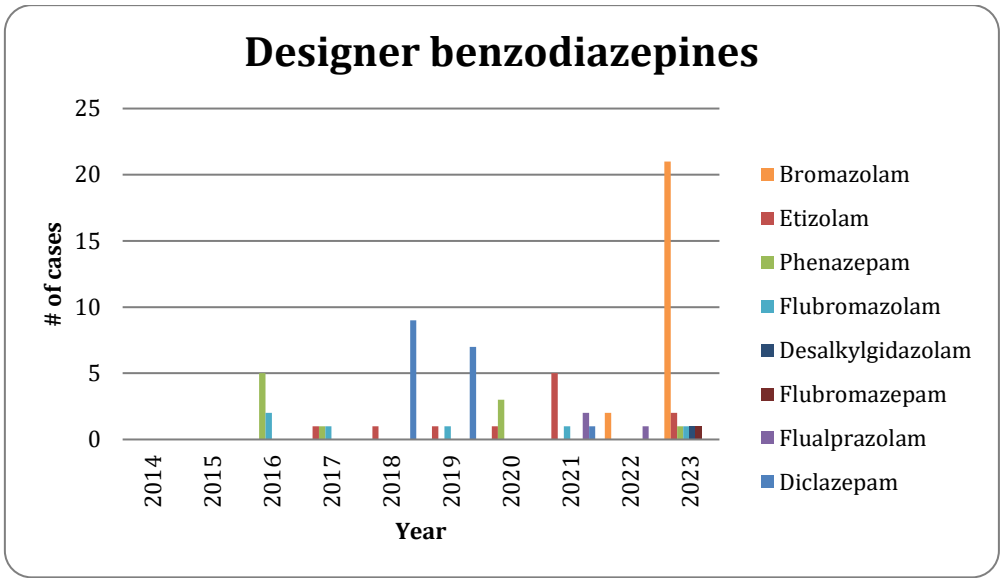

Figure 7: Number of autopsy cases with findings of designer benzodiazepines over the period 2014-2023.

Zopiclone and Zolpidem (Z–hypnotics)

Zopiclone and zolpidem are medications frequently prescribed for insomnia. These substances have potential for misuse and generally resemble benzodiazepines but have a shorter duration of action

Figure 8 shows the number of cases where zopiclone and zolpidem were detected in blood samples from autopsies conducted over the period 2014-2023. In 2023, zopiclone was detected in 7.5% and zolpidem in 1.4% of the autopsy samples. This aligns with the fact that zopiclone is typically prescribed to approximately four times more users than zolpidem.

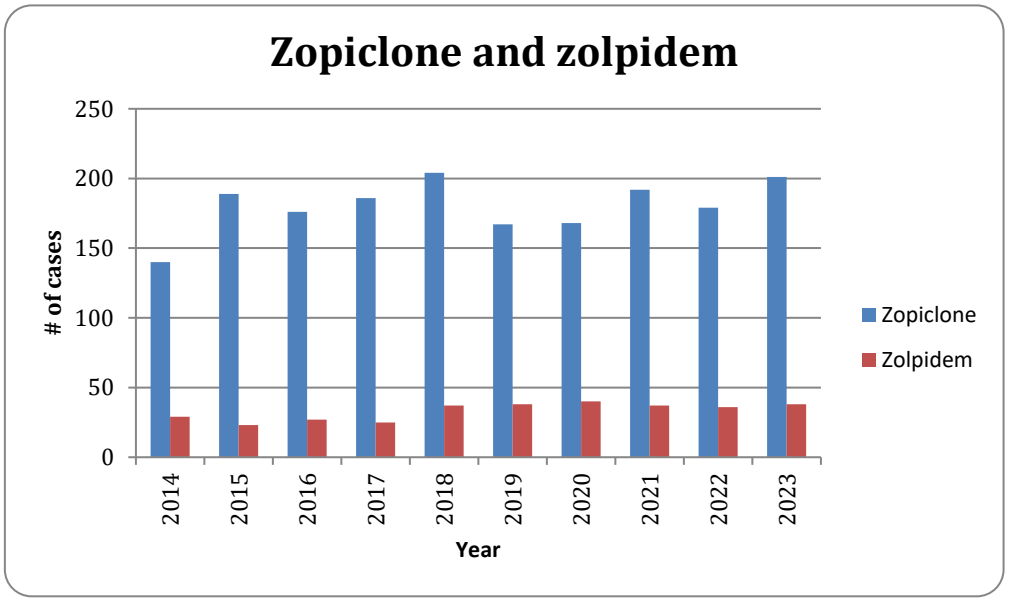

Figure 8: Number of autopsy cases with findings of zopiclone and zolpidem over the period 2014–2023.

Chapter 5: Cannabis

Tetrahydrocannabinol (THC) is the main active ingredient in products made from the cannabis plant, collectively referred to as "cannabis." This compound is also found in the medication Sativex. Cannabis typically appears as marijuana (dried plant parts), hashish (cannabis resin), or cannabis oil. THC has, among other effects, a sedative effect and simultaneously reduces attention and memory. Additionally, THC can in some cases lead to anxiety and psychosis-like symptoms (including affecting the brain's processing of visual and auditory impressions). The risk of poisoning from cannabis use is low, but some cardiac deaths have been linked to cannabis use.

Sativex and medical marijuana are only minimally prescribed in Norway. Sativex had about 940 individual users in 2020, an increase of 400 people from 2018. There are likely even fewer users of "medical" cannabis (which can be prescribed by doctors in Norway but must be ordered from pharmacies abroad). Therefore, the detection of THC will primarily represent illegal use.

Figure 9 shows the number and proportion of cases where THC was detected in blood samples from autopsies conducted from 2014-2023. THC was the second most frequently detected substance in 2023, in 10% of autopsy cases. The number and proportion of autopsy cases with THC have gradually increased over these 10 years. The detection limit at our laboratory was raised in September 2023, which means that the comparison with previous years results in a slight underestimate for 2023 because the lowest concentration measurements are not counted from September 2023 onward.

Kripos reports lower amounts of seizures in 2023 compared with 2022, but the amount was still the second largest compared with the previous nine years. There were also 5% more seizures in 2023 than in 2022. Furthermore, the content of the active ingredient THC has increased significantly in both hash and marijuana in recent years. There were also reports of seizures of cannabis oil, as well as candies and cakes containing THC.

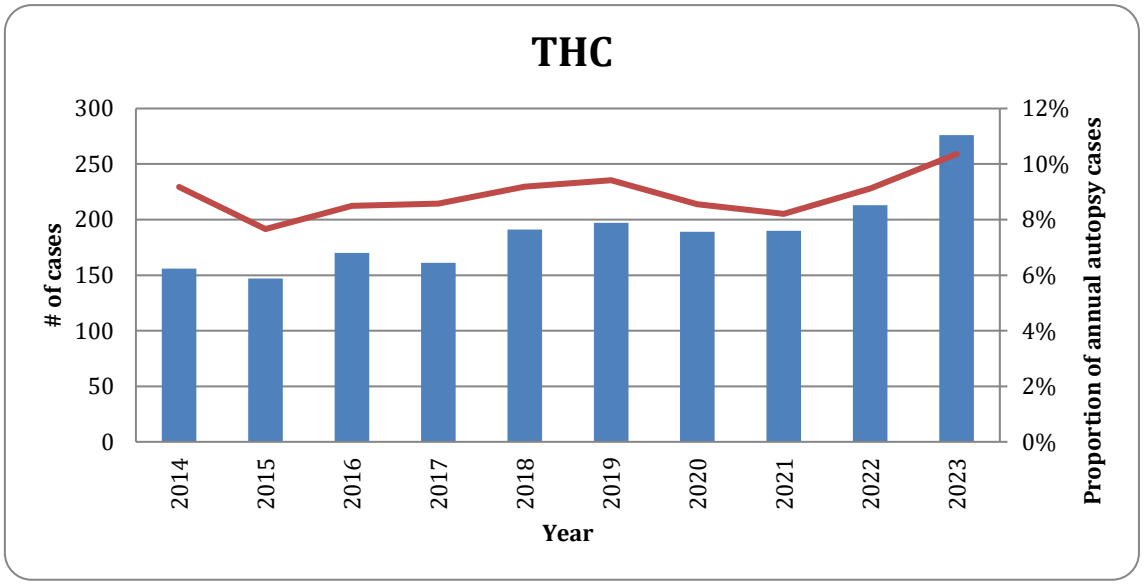

Figure 9: Number of autopsy cases (bars), and proportion of annual autopsy cases (line), with findings of THC over the period 2014-2023.

Chapter 6: Stimulants

Amphetamine and Methamphetamine

Amphetamine and methamphetamine are central stimulants with very similar effects. The body metabolizes a small portion of ingested methamphetamine into amphetamine. Methamphetamine can be found mixed with amphetamine in illegal powdered substances sold under the name "amphetamine." Amphetamine is also the active ingredient in some medications (e.g., Elvanse and Attentin), which are prescribed for the treatment of ADHD. The number of people prescribed amphetamine-containing medicines in Norway is increasing, but still relatively low, with a total of about 19,500 users in 2020. Methamphetamine is not registered as a medication in Norway. Amphetamine and methamphetamine are widely used as recreational drugs, which likely represents the largest share of findings in blood samples from autopsies.

Intake of amphetamines in recreational doses can elevate mood, increase self-esteem, reduce critical sense, suppress the need for sleep, and cause restlessness. Confusion, thought disturbances, sensory distortions, and other psychosis-like symptoms can also occur, usually after more pronounced use. Physical effects of amphetamines include increased heart rate, blood pressure, and body temperature. Additionally, motor restlessness, agitation, and tremors are observed. During the waning effects of the drug and after repeated intakes, lethargy and sleepiness can characterize the experience.

Figure 10 shows cases with amphetamine and methamphetamine in blood samples from autopsies over the period 2014-2023. "Amphetamine" represents cases where amphetamine was detected alone, while "methamphetamine" refers to cases where methamphetamine was detected alone or together with amphetamine. Amphetamines were detected in 8.9% of the autopsy cases in 2023. Previously, findings of methamphetamine dominated the autopsy samples. In 2018, for the first time since 2005, more cases were detected with amphetamine alone than with methamphetamine (alone or together with amphetamine). The number of autopsy cases involving amphetamines increased by 30% from 2022 to 2023. Kripos reports more than double the amount of amphetamine and methamphetamine in 2023 compared with 2022, although less than the peak year 2021. Amphetamine dominated the seizures, accounting for 96% of the number of seizures and 95% of the quantities over methamphetamine. The potency of both substances has also been reported to have decreased over the last ten years.

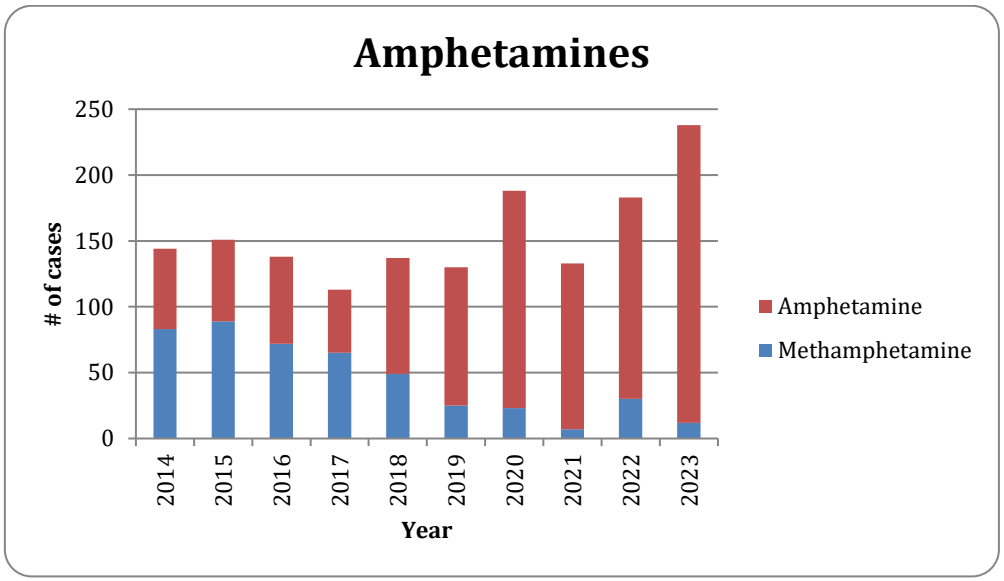

Figure 10: Number of autopsy cases with findings of amphetamine (detected without methamphetamine in the same blood sample) and methamphetamine over the period 2014-2023.

MDMA

Methylenedioxymethamphetamine (MDMA), also known as Ecstasy, is a drug with central stimulant and mild hallucinogenic effects. MDMA's effects resemble those of amphetamines but it produces a greater sense of euphoria and empathy and can induce hallucinations. MDMA is not registered as a medication in Norway.

Figure 11 shows the number and proportion of cases with MDMA in blood samples from autopsies over the period 2014-2023. MDMA was detected in 1.0% of autopsy cases in 2023 (27 cases). Since 2014, there has been an increase in the number of cases. The annual proportion of positive cases is now around 1%, which is more than five times as frequent as the years when MDMA was nearly "gone" from the market. The increase in 2023 aligns with current reports from Kripos. Never before has there been such large amounts of MDMA seized as in 2023, and there were 13% more seizures in 2023 than in 2022. The EMCDDA reports that MDMA use is relatively stable in Europe, and usage has not returned to the same level as before the pandemic[7]. However, the purity (MDMA content) of the products seized by Kripos was high, averaging 91% in 2022. Compared to the early 2000s, seized tablets today have a significantly higher potency.

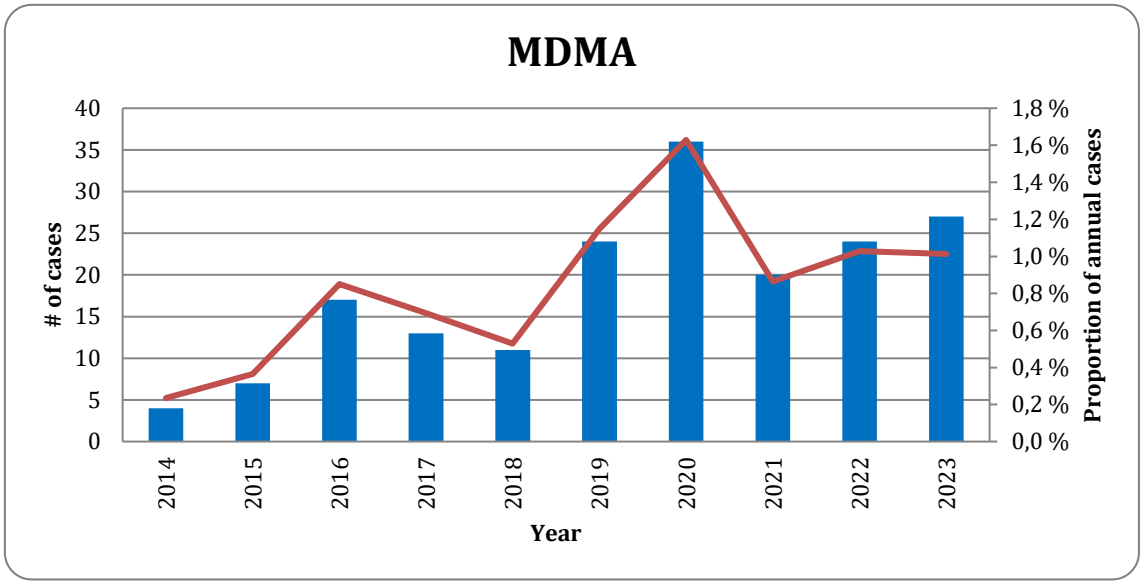

Figure 11: Number of autopsy cases (bars), and proportion of annual autopsy cases (line), with findings of MDMA over the period 2014-2023.

[7] European Monitoring Centre for Drugs and Drug Addiction. European Drug Report 2023: https://www.emcdda.europa.eu/publications/european-drug-report/2023_en

Cocaine

Cocaine is a stimulant drug with effects similar to those of amphetamines, but the high is more intense and sets in faster, which increases the risk of developing addiction. Cocaine also has local anesthetic and vasoconstrictive (blood vessels constrict) effects, and is used as a medication for some surgeries in the ear, nose, and throat area. Cocaine breaks down quickly in the body and can be detected in blood for only a short time after intake, which can result in significant underestimations of cocaine use before death.

Figure 12 shows the number and proportion of cases with cocaine in blood samples from autopsies over the period 2014-2023. Cocaine was detected in 2.0% of autopsy cases in 2023, the highest frequency ever recorded. Meanwhile, the EMCDDA reports that cocaine is now the second most common illegal drug in Europe[8]. Kripos reports that the four largest cocaine seizures in Norwegian history were made in 2023. More cocaine was seized in 2023 than in the years 2000 to 2022 combined. There was also an increase in the number of seizures by 29% from 2022 to 2023. The average potency has increased both in Europe and Norway and was 84% in 2023, a further increase compared to previous years.

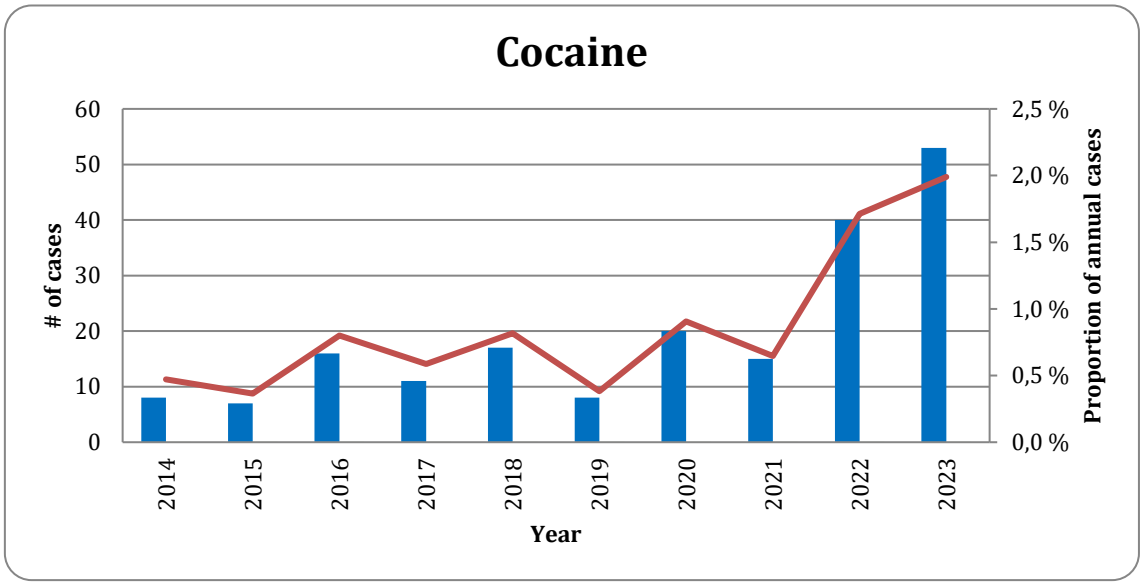

Figure 12: Number of autopsy cases (bars), and proportion of annual autopsy cases (line), with findings of cocaine over the period 2014-2023.

[8] European Monitoring Centre for Drugs and Drug Addiction: https://www.emcdda.europa.eu/publications/european-drug-report/2023/cocaine_en

Chapter 7: New Psychoactive Substances (NPS)

NPS are collectively referred to as new drugs that are not regulated by international narcotics agreements and are considered to be as harmful to health as other drugs. These substances are also known as "designer drugs" and are often chemical imitations of traditional drugs. NPS are produced to circumvent drug legislation and are often termed "legal highs." These substances are commonly purchased over the internet. For many NPS, the effects and dangers are unknown, as they have not been systematically tested in humans. NPS do not constitute a uniform group of drugs and include substances with sedative, hallucinogenic, and/or stimulant effects. Many NPS primarily have one of these properties, while others may produce multiple effects. This can lead to unpredictable and dangerous reactions, and such poisonings can be difficult to treat. NPS include some extremely potent substances that can cause severe psychological reactions and, in the worst cases, fatal poisonings.

As mentioned in Chapter 3, new highly potent synthetic opioids have led to a large number of serious poisonings and deaths in Europe and the USA over the last decade. The first wave of deaths was due to fentanyl-like substances, while the latest wave, from around 2019, also involves nitazenes. Fentanyl-like substances and nitazenes are sold as such, but what is particularly concerning is that they are often found mixed with other drugs or sold under the guise of being something else. The fact that these substances are extremely potent and are consumed without the user's knowledge, poses a significant risk of severe and fatal poisoning.

Efforts are continuously made to develop new analytical methods to detect ever-new variants of NPS in blood and urine samples. Therefore, the analytical repertoire varies somewhat from year to year. There may also be dark figures, partly because some NPS are so potent that they are present in the blood in such minute amounts that they can be challenging to detect. Consequently, we have no overview of the true prevalence of NPS.

In this report, we have chosen to focus primarily on designer benzodiazepines (Chapter 4), nitazenes, and fentanyl-like substances for NPS. However, the Department of Forensic Sciences also analyzes for a significant range of other NPS. In 2023, besides the NPS groups mentioned, 4-OH-DMT (psilocin), a hallucinogenic drug found in Psilocybe mushrooms, LSD (hallucinogen), mephedrone (cathinone), and hexahydrocannabinol (a semi-synthetic THC-like drug) were detected.

Nitazenes

Nitazenes (2-benzylbenzimidazoles) are a group of morphine-like substances (opioids) that were developed by the Swiss pharmaceutical company CIBA in the 1950s. They were intended to be used as pain relievers but were never approved for marketing. Nitazenes appeared on the illegal drug market in Europe and the USA in 2019. Since 2023, nitazenes have been included in the narcotics regulation. A characteristic of nitazenes is their high potency, meaning that a very small amount is highly effective. Depending on the specific nitazene, these substances are 100-1000 times stronger than morphine, and 10-100 times stronger than fentanyl. Therefore, nitazenes can quickly cause respiratory arrest and death if used carelessly. Poisonings ("overdoses") caused by nitazenes must be immediately treated with the antidote naloxone, requiring higher doses and monitoring over a longer period compared to overdoses with heroin. Nitazenes have already caused a significant number of fatal poisonings in Europe and the USA. In Norway, the first nitazene-related death occurred in 2021. During 2023, there were 13 nitazene-related

deaths in Norway, which is extremely concerning. This is on par with what is seen in the United Kingdom in terms of population. Metonitazene is currently the most frequently detected nitazene in Norway.

According to Kripos and customs, nitazenes currently appear in many different forms; including tablets, powders, dropper bottles, capsules, and others. Therefore, it is difficult to warn against one particular form of sale product.

Fentanyl Derivatives

Opioids that resemble the medication fentanyl are called fentanyl derivatives and can be 50-10,000 times more potent than morphine. Fentanyl derivatives were detected in Norway for the first time in October 2016. In Norway, there have been few deaths linked to fentanyl derivatives, but there may be unreported cases because these substances are taken in very low doses and are therefore difficult to detect. Overdoses caused by fentanyl derivatives, similar to nitazenes, can be treated with the antidote naloxone, but in higher doses and with monitoring over a longer period, compared to overdoses with heroin.

No fentanyl-like NPS were detected in 2023.

Kripos reports a decrease in NPS seizures in Norway in recent years. In 2023, NPS accounted for about 1% of all seizures, with 207 seizures involving 39 different substances. The majority of seizures involved kratom, bromazolam (mentioned under benzodiazepines), cathinones, and hexahydrocannabinol. No potent fentanyl derivatives were found in the analyzed seizures in 2023. While there were four seizures of nitazenes in Norway in 2022, there were 14 seizures of three different nitazene substances in 2023: Metonitazene, protonitazene, and metonitazepyn. The nitazene seizures included various types of tablets, liquids in eye drop and nasal spray bottles, powder, and capsules.

Chapter 8: Paracetamol

Paracetamol (also known as acetaminophen) is a medication with analgesic (pain-relieving) and antipyretic (fever-reducing) effects. The substance has no psychoactive effects, but it can be taken in high doses with suicidal intent. Paracetamol is toxic to the liver even in moderate doses. A single over-the-counter package contains enough paracetamol to cause serious poisoning and death. Toxic doses can be even lower in children and adults with various diseases/conditions. Subacute poisonings can also occur if slightly higher than recommended doses are taken over some time.

Liver damage occurs in cases of paracetamol poisoning if adequate treatment with an antidote is not administered early enough. Unfortunately, many underestimate the toxic potential of paracetamol and are unaware that poisoning causes few or no symptoms in the first 10 – 20 hours after ingestion. After this, the effectiveness of the antidote is minimal. Despite several hundred hospital admissions per year with paracetamol poisoning, the number of fatal poisonings in Norway is fortunately low.

Paracetamol can be purchased over the counter at pharmacies, and since November 2003, it has also been available for sale in grocery stores with a license. Paracetamol can be prescribed by a doctor both alone and in combination preparations with opioids, such as codeine and tramadol. The risk of poisoning increases with prescriptions, as these patients may have chronic pain and use paracetamol in high doses over a long period.

Most concentrations of paracetamol detected in blood samples from autopsies fall within a so-called normal range, where toxic effects are not expected. However, paracetamol poisoning cannot always be ruled out, as the concentration may have been significantly higher at an earlier time point. In such cases, it is the findings from the autopsy rather than the toxicological results that determine whether poisoning with paracetamol could have contributed to death.

Figure 13 shows the number of cases where paracetamol alone (without codeine or tramadol), paracetamol with tramadol, and paracetamol with codeine, were detected in blood samples from autopsies conducted from 2014-2023. In 2023, paracetamol was detected in 12% of autopsy cases, making it the third most frequently detected substance. The number of blood samples from autopsies where paracetamol was detected alone was increasing in 2023, with a proportion of 7.6% compared to 6.4% in 2022. Moreover, this proportion has approximately doubled over the period from 2014-2023. The proportion of autopsy cases in 2023 with paracetamol in combination with either tramadol or codeine was 2.7% and 2.1%, respectively. These proportions have remained relatively stable compared to 2022 and the previous eight years.

In cases where paracetamol and codeine are detected in the same sample, it is reasonable to assume that a combination product has been ingested, as codeine is rarely prescribed alone in Norway. The curve for paracetamol and tramadol is also quite stable, despite such combination products only coming onto the market in Norway in 2014. This suggests that the findings of paracetamol and tramadol in the same sample are likely due to the intake of the substances separately. The increase in the proportion of cases with detected paracetamol alone could possibly reflect the general increase in the use of paracetamol in society. The Norwegian Institute of Public Health reports a 16.5% increase in the sale of over-the-counter paracetamol in 2022 compared to 2021, and a 10% increase in prescription sales over the same period[9]. The amount of prescribed paracetamol appears to have nearly doubled since 2013.

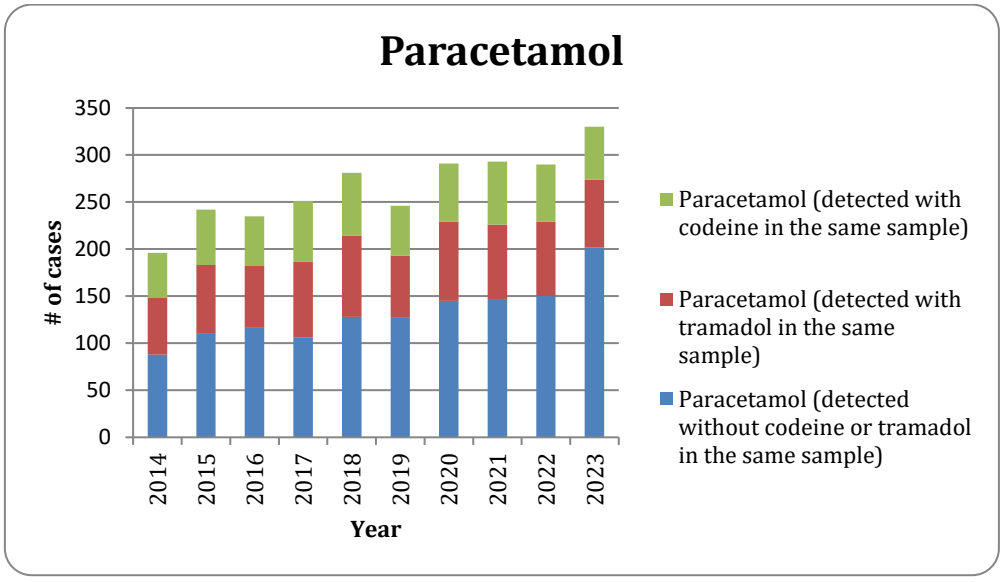

Figure 13: Number of autopsy cases with findings of paracetamol over the period 2014-2023.

[9] Norwegian Institute of Public Health: https://www.fhi.no/contentassets/856ff0c333114637a14978f135803d60/legemiddelforbruket-i-norge-2018-til-2022.pdf

Chapter 9: Antidepressants

Antidepressants are used in the treatment of various mental disorders, primarily depression. These medications can cause a range of undesirable side effects, which may vary among the different groups of antidepressants. Tricyclic antidepressants (TCAs), such as amitriptyline, are effective but also highly toxic. Poisoning with TCAs can lead to cardiac arrhythmias, seizures, and depressive effects on the brain (drowsiness and potential respiratory depression).

Newer antidepressants, such as selective serotonin reuptake inhibitors (SSRIs) (e.g., citalopram) and selective norepinephrine and serotonin reuptake inhibitors (SNRIs) (e.g., venlafaxine), are less toxic and therefore often preferred as the first choice. Additionally, there are several other newer antidepressants on the market (e.g., mirtazapine, mianserin, bupropion, and vortioxetine).

Serotonin syndrome is a potentially lethal condition that can occur with high doses of antidepressants or when multiple drugs and/or substances that affect the brain's serotonergic system are taken simultaneously. Symptoms usually appear quickly, and in severe cases, pronounced muscle rigidity, coma, and high body temperature can occur. Without adequate treatment, this condition can lead to death.

Tricyclic Antidepressants

The detection of tricyclic antidepressants in autopsy samples is of importance because they are considered the most toxic within the large group of psychopharmacological medications.

Figure 14 shows the most commonly occurring tricyclic antidepressants in blood samples from autopsies over the period 2014-2023. In the group labeled "others," the number of cases where doxepin, clomipramine, and/or trimipramine were detected is included. Amitriptyline was detected in 1.8%, nortriptyline (without amitriptyline) in 0.5%, and "others" in 0.2% of the autopsy cases in 2023. These proportions have remained relatively consistent throughout the decade. About 15% of autopsy cases with antidepressants in 2023 contained tricyclic antidepressants.

Nortriptyline is both a separate medication and a metabolic product of amitriptyline. The detection of nortriptyline alone is assumed to be due to the intake of a medication containing only nortriptyline.

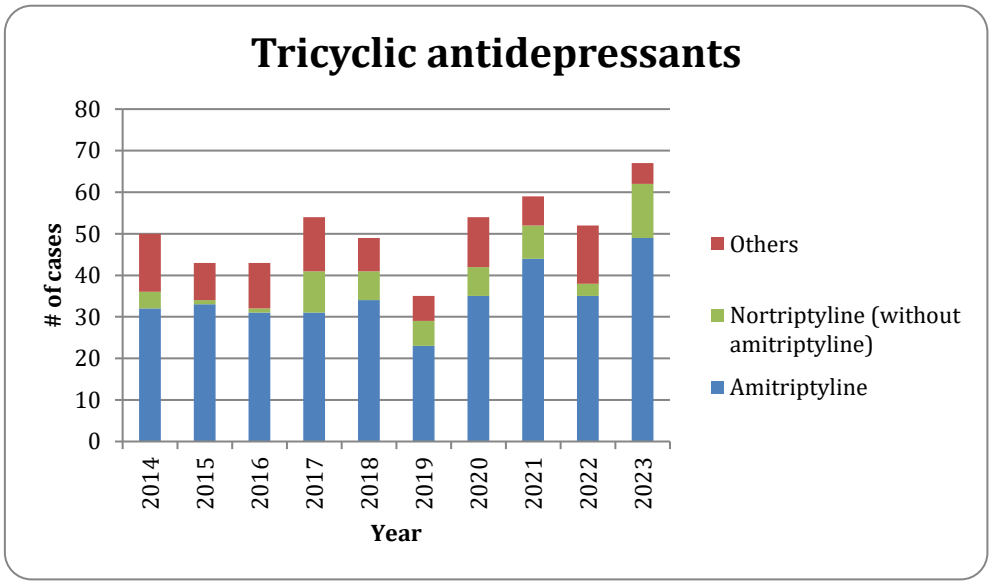

Figure 14: Number of autopsy cases with findings of tricyclic antidepressants over the period 2014-2023. «Others» includes findings of doxepin, clomipramine, and/or trimipramine.

Newer Antidepressants

Among autopsy cases where antidepressants were detected, SSRIs (escitalopram/citalopram, fluoxetine, paroxetine, and sertraline) constituted the largest group, with about 40% of the cases in 2023. In a few cases, multiple antidepressants or SSRIs were detected simultaneously, so the figure may be imprecise.

Figure 15 provides an overview of other antidepressants (all except tricyclics) in blood samples from autopsies over the period 2014-2023. The "others" group includes cases where bupropion, duloxetine, fluoxetine, and/or paroxetine were detected. The number of cases with findings of newer antidepressants has generally increased, in line with the increasing number of autopsy cases. The proportion of cases with citalopram includes both findings of citalopram and escitalopram and has been declining over the ten-year period, while mirtazapine has seen a slight increase. The proportion of cases with venlafaxine or mianserin has remained stable, while the number of cases with findings of sertraline has doubled over the last ten years. Vortioxetine was introduced into the Norwegian market in 2015, and findings in autopsy cases appear to remain at a stable, low level. Overall, such newer antidepressants were detected in approximately 15% of the cases.

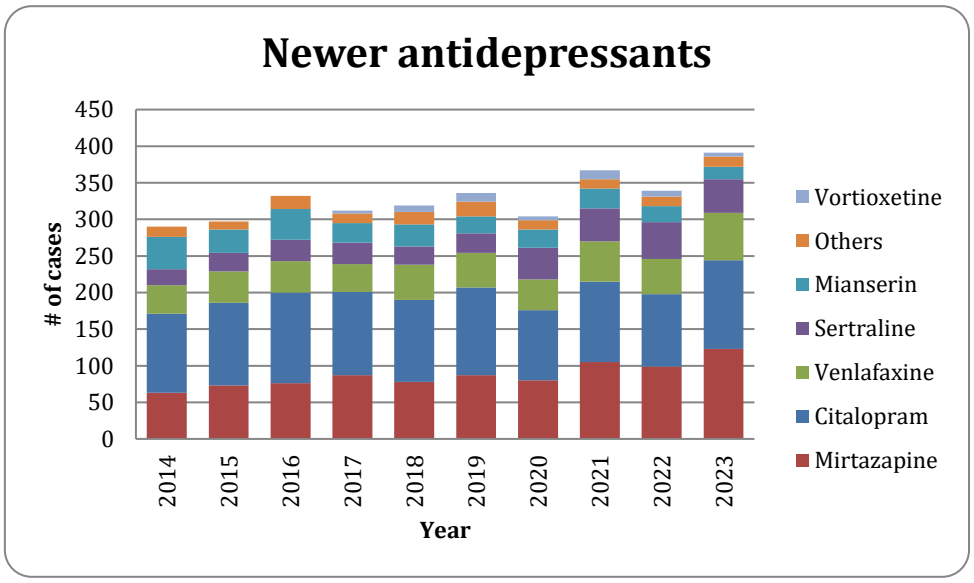

Figure 15: Number of autopsy cases with findings of newer antidepressants over the period 2014-2023. "Others" includes findings of bupropion, duloxetine, fluoxetine, and/or paroxetine.

Chapter 10: Antipsychotics

Antipsychotics are medications used for mental illnesses characterized by hallucinations and delusions. There are two main types of antipsychotics: first-generation antipsychotics (e.g., levomepromazine) and second-generation antipsychotics (e.g., olanzapine). First- and second-generation antipsychotics differ in their effects on various receptor systems in the brain and have somewhat different side effect profiles.

First-generation antipsychotics are known to cause so-called extrapyramidal side effects, which include trembling, uncontrolled movements, and unclear speech (akin to "parkinsonism"). With the use of second-generation antipsychotics, these side effects are less common, but there are more sedative effects on the brain, as well as greater likelihood of weight gain and metabolic side effects. In general, there is a wide range of side effects that can occur with the use of antipsychotics, and effects on heart rhythm and blood pressure, as well as an increased risk of seizures/epilepsy-like attacks, are not uncommon. Malignant neuroleptic syndrome is a rare but severe side effect that can occur with the use of all types of antipsychotics. Characteristics include high body temperature, muscle rigidity, fluctuating blood pressure and pulse, and skeletal muscle damage.

There are significant individual differences in the doses of various antipsychotic medications that can cause side effects, acute toxicity, and mortality.

First-Generation Antipsychotics

Figure 16 shows the first-generation antipsychotics most frequently found in blood samples from autopsies over the period 2014-2023. The "others" category includes cases where flupentixol, haloperidol, perphenazine, prochlorperazine, and/or zuclopenthixol were detected. Throughout this decade, there has been a clear decrease in the number of cases where first-generation antipsychotics were detected. As the total number of cases has significantly increased during the same period, this demonstrates a substantial decrease in the proportion of cases involving these substances. The number of findings in 2023 suggests that these drugs were present in just over 1% of autopsy cases. However, this percentage might be overestimated if the deceased was using multiple such drugs simultaneously.

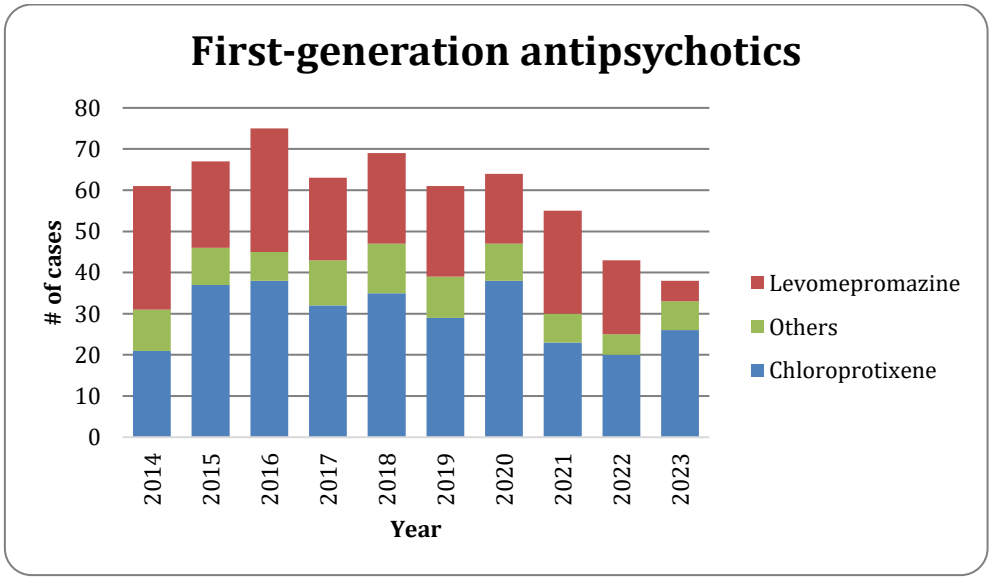

Figure 16: Number of autopsy cases with findings of first-generation antipsychotics over the period 2014-2023. "Others" includes findings of flupentixol, haloperidol, perphenazine, prochlorperazine, and/or zuclopenthixol.

Second-Generation Antipsychotics

Olanzapine and quetiapine are by far the most common antipsychotic drugs detected in autopsy cases. Together, these two substances accounted for approximately 80% of all cases involving antipsychotics in 2023, but the estimate may be inaccurate because some individuals may have used multiple antipsychotics.

Figure 17 shows the second-generation antipsychotics most frequently found in blood samples from autopsies during the period 2014-2023. The "others" category includes the number of cases where aripiprazole, clozapine, and/or risperidone were detected in the autopsy sample. There has been a doubling in the findings of second-generation antipsychotics in this ten-year period, while the proportion of first-generation antipsychotics has decreased (see Figure 16). It appears that quetiapine constitutes the majority of the increase, with a doubling in the proportion of positive cases over this ten-year period.

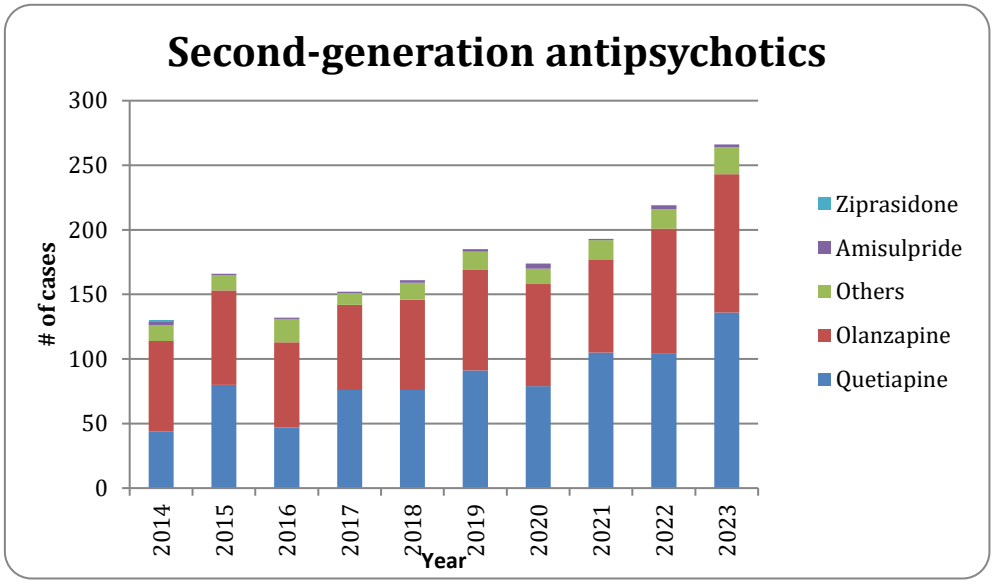

Figure 17: Number of autopsy cases with findings of second-generation (atypical) antipsychotics in the period 2014-2023. "Others" includes findings of aripiprazole, clozapine, and/or risperidone.

Chapter 11: Pregabalin and Gabapentin

Pregabalin and gabapentin are classified as "newer antiepileptics." “Antiepileptics” is a term for medications used in the treatment of epilepsy. These drugs aim to stop, prevent, or reduce the frequency of epileptic seizures (convulsions) and/or absences (brief loss of consciousness) caused by disturbed electrical activity in the brain. "Newer" indicates that they entered the market after the year 2000. The medications are also used for other conditions, such as neuropathic pain (pain originating in the nervous system), and pregabalin has documented effectiveness for anxiety disorders. These drugs are usually taken in tablet/capsule form or as a mixture.

The most common side effects of pregabalin are dizziness and drowsiness, weight gain, swelling, dry mouth, and constipation. Gabapentin has side effects including reduced alertness and concentration, coordination disorders, tremors, speech disturbances, visual disturbances, and double vision. Additionally, gabapentin use can cause upper gastrointestinal discomfort, swelling, reduced production of white blood cells, and itching.

Serious intoxications and fatalities due to the intake of these medications alone are rare. However, concurrent use of multiple types of antiepileptics or use with other types of medications can lead to interactions. Such reactions can cause serious and potentially fatal side effects. For example, there is a significantly increased risk of respiratory depression (risk of respiratory arrest) after the intake of alcohol and/or other depressants when used concurrently with gabapentin and/or pregabalin. Additionally, there have been reports of increased incidence of suicidal thoughts and related behavior associated with the use of antiepileptics. Misuse and addiction to pregabalin and gabapentin occur, partly because these drugs can enhance the intoxicating effects of other substances taken simultaneously.

Treatment with antiepileptics requires careful monitoring to achieve optimal effect and reduce side effects. The same type of medication may have varying effects from person to person, so it is common to try several types of antiepileptic drugs before finding the optimal treatment

Figure 18 shows the prevalence of pregabalin and gabapentin in blood samples from autopsies in the period 2014-2023. Pregabalin and gabapentin were together detected in about 8% of autopsy cases in 2023. Combination intake can occur, so the number may be somewhat overestimated.

Pregabalin has been the most frequently detected antiepileptic drug in autopsy cases since 2012, being found in 5.1% of cases in 2023 compared with 3.1% in 2014. The proportion of cases with gabapentin has also risen, from 1.2% in 2014 to 3.1% in 2023.

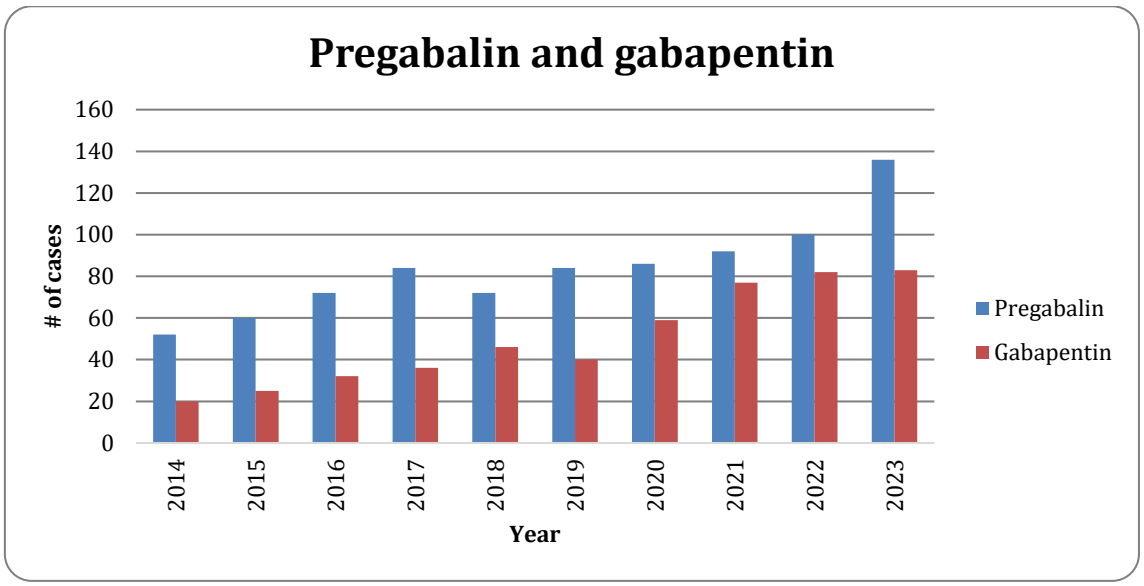

Figure 18: Number of autopsy cases with findings of pregabalin and gabapentin in the period 2014-2023.

Chapter 12: Antihistamines

Antihistamines are medications primarily used for allergies. They counteract symptoms such as itching, sneezing, and a runny nose and eyes. Antihistamines can be administered locally, in the form of nasal sprays or eye drops, but these only work on nasal and eye symptoms. The medications can also be administered systemically (to the whole body) in the form of tablets, mixtures, or injections. In this form, they also address other more general symptoms, such as allergic asthma, throat/mouth itching, and hives (itchy skin swellings).

Regarding systemic use, it is common to differentiate between first-, second-, and third-generation antihistamines. Examples of first-generation antihistamines are alimemazine, dexchlorpheniramine, and promethazine, while examples of second-generation antihistamines are cetirizine, loratadine, and ebastine. Examples of third-generation antihistamines are desloratadine and levocetirizine. The primary difference between these groups is the degree of effect on the brain. First-generation antihistamines have pronounced effects on the brain, typically causing sleep-inducing/sedative effects. This occurs to a lesser extent with second-generation antihistamines and almost not at all with third-generation antihistamines. First-generation antihistamines, in particular, can therefore affect driving ability. In some allergic conditions, this sleep-inducing side effect may be desirable, such as in children who cannot sleep due to itching. First-generation antihistamines also affect other systems in the brain, leading to side effects such as dry mouth, constipation, and dizziness. These side effects, however, make antihistamines (especially first-generation) useful for other conditions, such as nausea, motion sickness (car- or sea-sickness), and sleep difficulties.

Concurrent use of alcohol, medications, and/or substances with sedative effects on the brain will enhance the sedative effect of antihistamines.

First-Generation Antihistamines

At Oslo University Hospital (OUS), alimemazine, dexchlorpheniramine, and promethazine (first-generation antihistamines) are routinely analyzed in autopsy samples.

Figure 19 shows the findings of alimemazine, dexchlorpheniramine, and promethazine in blood samples from autopsies during the period 2014-2023.

Alimemazine is mainly prescribed for sleep disorders, anxiety, alcoholism, and substance abuse. The medication Vallergan (alimemazine) was withdrawn from the market on January 1, 2021. This can be reflected in our findings, which show a decrease in the proportion of cases in 2021 and 2022 to 2.4% and 2.3%, respectively, compared to earlier proportions between 3-4% in this ten-year period. However, the proportion in 2023 was back to 3.4%.

The proportion of cases with detected promethazine has remained essentially unchanged over the last decade, staying below 1%.

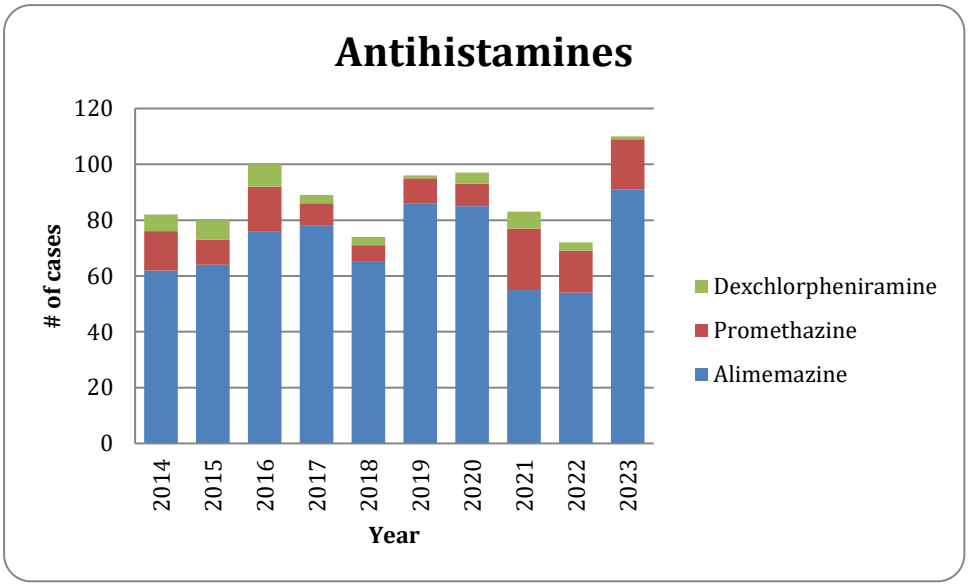

Figure 19: Number of autopsy cases with findings of antihistamines over the period 2014-2023.

Chapter 13: Metoprolol (beta-blocker)

Beta-blockers are medications used for various conditions affecting the heart and blood vessels, such as high blood pressure, angina pectoris ("chest pain"), arrhythmias, heart failure, and post-heart attack care. They are also used for other conditions like essential tremor (shaking). There are several medications within the beta-blocker group. Over the past 9 years, the Department of Forensic Sciences has routinely analyzed for metoprolol and propranolol. Propranolol is very rarely detected and is not further discussed.

Beta-blockers reduce the effects of several signaling substances released in the body during stress reactions, among other things. Since these medications counteract certain bodily reactions to nervousness and stress, misuse of these substances can occur. The World Anti-Doping Agency (WADA) still includes beta-blockers on its doping list as of January 1, 2021. These medications are thus prohibited for use in and out of competition in certain sports and are considered doping agents in that context.

The side effects of using beta-blockers often depend on the dose and can vary between individuals. Some of the most common side effects include cold hands and feet, low pulse, fatigue, sleep disturbances, nausea, and diarrhea.

In autopsy cases where metoprolol is detected, it is often assumed that this is a result of prescribed medication use and not necessarily relevant to the cause of death. However, poisoning with beta-blockers can occur. Symptoms of poisoning typically include a low pulse and low blood pressure. If the poisoning is severe, it can lead to circulatory failure (the circulation does not meet the body's needs). The risk of poisoning is particularly dependent on health status and underlying heart disease. The type and amount of medication taken also matter. For example, metoprolol is considered less toxic than propranolol.

Figure 20 shows the number and percentage of cases where metoprolol was detected in blood samples from autopsies conducted in the period 2014-2023. In 2023, metoprolol was detected in 109 autopsy cases, accounting for 4.1% of the cases.

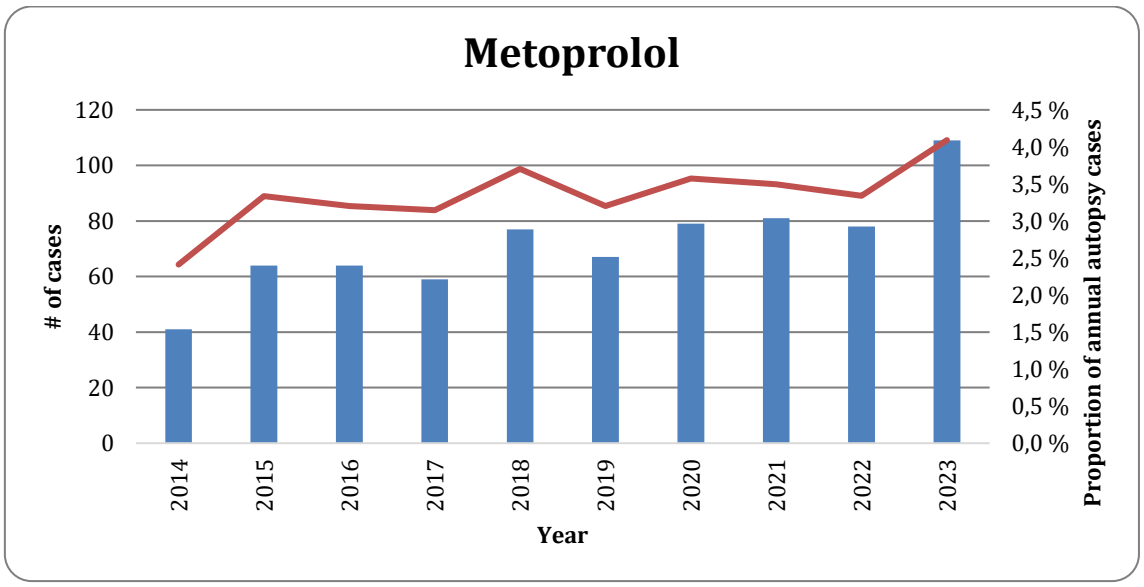

Figure 20: Number of autopsy cases (bars), and percentage of annual autopsy cases (line), with findings of metoprolol over the period 2014-2023.

Chapter 14: Carbon Monoxide (CO)

Carbon monoxide (CO) is a highly toxic gas that is colorless, odorless, and tasteless. CO is produced by the combustion of carbon-containing materials. In an enclosed space with no or limited ventilation, the concentration of CO will increase, leading to poisoning without necessarily being noticed. Potential sources of CO poisoning include cigarettes, fires, propane-powered devices, exhaust fumes, and charcoal grills.

CO poisoning occurs because hemoglobin (Hb) in red blood cells, which transports oxygen in the blood, binds to CO instead, forming carboxyhemoglobin (COHb). The severity of the poisoning is determined by the proportion of hemoglobin's oxygen-binding capacity that is blocked by CO. There are also several other complex mechanisms behind the toxic effects of CO.

COHb is considered present when the proportion exceeds 5% in the blood. Severe and fatal poisonings have been reported at COHb levels of 40% or higher. COHb levels of 10-35% will result in poisoning reactions but are usually not considered fatal. However, individuals with lower tolerance for CO (infants, pregnant women, the elderly, and those with heart/lung disease) can experience life-threatening and fatal poisonings at lower levels.

Previously, COHb was only analyzed when CO poisoning was suspected, but since 2020, it has been routinely analyzed in all autopsy cases at the Department of Forensic Sciences. This is to detect any unknown CO sources. In cases without suspicion of CO poisoning where a high level of COHb is detected, the requesting client is quickly notified of the analytical finding to prevent further poisonings from the same CO source.

COHb was detected in 48 cases, representing 1.8% of autopsy cases, in 2023 (Figure 21).

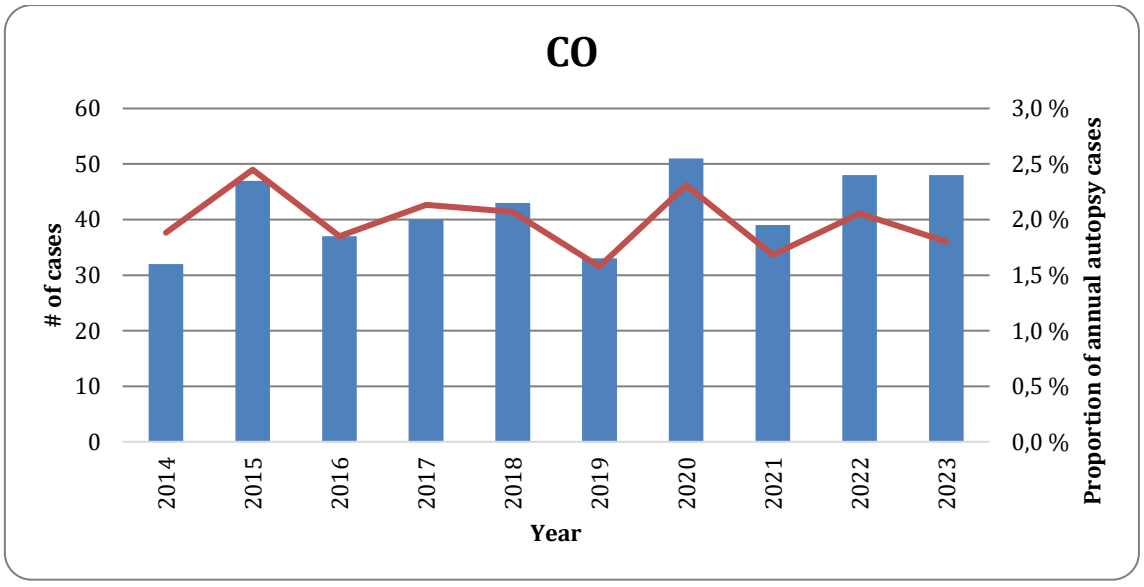

Figure 21: Number of autopsy cases (bars), and percentage of annual autopsy cases (line), with findings of CO in the period 2014-2023.

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