Drug and Alcohol Dependence 282 (2026) 113107

Contents lists available at ScienceDirect

Drug and Alcohol Dependence

journal homepage: www.elsevier.com/locate/drugalcdep

Evaluating the trends and impact of COVID-19 on illicit drug and benzodiazepine use in drivers: A retrospective large-scale study based on oral fluid testing

Miriam Blanco-Ces, Elena Lendoiro, Angelines Cruz, María Cobo-Golpe, Ángela López-Rabuñal, Ana de-Castro-Ríos *

Toxicology Service, Institute of Forensic Sciences, University of Santiago de Compostela, San Francisco, s/n, Santiago de Compostela 15782, Spain

ARTICLE INFO

Keywords:
Illicit drugs
Benzodiazepines
Oral fluid
Roadside drug controls
LC-MS/MS

ABSTRACT

Background: The COVID-19 pandemic disrupted global drug markets, but consumption soon returned to pre-pandemic levels. Continuous monitoring of drug use trends is essential for effective public health responses.
Methods: A total of 29,397 oral fluid specimens from roadside drug tests across Spain (January 2019–July 2024) were sent to the Toxicology Laboratory of the Institute of Forensic Sciences, University of Santiago de Compostela, for LC-MS/MS confirmation of on-site positives. Results were stratified into five periods to assess drug use trends and the impact of COVID-19.
Results: Over 90% of drivers were male, and 85% were under 45 years old. Overall, 69.9% of samples were positive for cannabis, 64.9% for cocaine, 13.7% for amphetamines, 10.6% for opiates, 6.5% for ketamine, 5.4% for methadone and 6.6% for benzodiazepines/zolpidem; 56.3% showed poly-drug use. Cannabis use was higher in men, while amphetamines and benzodiazepines were more frequent in women ($p < 0.001$). Due to regional variability in drug use patterns and sample distribution, trends were analyzed across five geographic regions. Globally, during the strict lockdown, cocaine, opiates, methadone and benzodiazepines peaked, while cannabis and amphetamines declined, and ketamine remained stable. In the final period, cannabis reached its highest levels, and ketamine showed a marked increase. Cocaine and amphetamines returned to pre-COVID levels, while opiates, methadone and benzodiazepines declined. Statistically significant differences across the studied periods were observed in the different regions. Specifically, in the Northwest for opiates, methadone, and benzodiazepines ($p < 0.001$), as well as for cannabis ($p < 0.05$); in the East for opiates, amphetamines, cocaine, and ketamine ($p < 0.001$); in the Center for cocaine ($p < 0.001$) and ketamine ($p < 0.05$); and in the South and Islands for cocaine ($p < 0.05$).
Conclusions: Although a slight impact on drug use was observed during the strict lockdown, consumption increased again for all substances (particularly ketamine), except for opiates, methadone and benzodiazepines.

1. Introduction

The strict mobility restrictions during the COVID-19 pandemic included mandatory home confinement (except for justified reasons explicitly defined in the regulations), strict limitations on movement for essential activities, a total ban on interprovincial and interregional travel, and restrictions on the number of passengers allowed in vehicles (generally limited to one person). Non-compliance with movement restrictions was subject to fines or temporary detention, depending on the severity and recurrence of the infraction. Enforcement was carried out through police controls, with penalties applied based on intent and severity of the violation. These measures disrupted mobility and social interactions, hindering access to illegal drugs and affecting global trafficking routes, which likely prompted individuals to seek alternative means of access (e.g., the internet, cryptomarkets). They also contributed to shifts in the types of drugs consumed, favoring those more easily obtainable through these channels, while reducing the use of substances typically associated with nightlife or party environments. In Europe, a

* Corresponding author.
E-mail addresses: miriamblanco.ces@usc.es (M. Blanco-Ces), elena.lendoiro@usc.es (E. Lendoiro), angelines.cruz@usc.es (A. Cruz), m.cobo@usc.es (M. Cobo-Golpe), angela.lopez@usc.es (Á. López-Rabuñal), ana.decastro@usc.es (A. de-Castro-Ríos).

https://doi.org/10.1016/j.drugalcdep.2026.113107
Received 26 September 2025; Received in revised form 5 February 2026; Accepted 23 February 2026
Available online 26 February 2026

modest decline in drug consumption was observed during the strict lockdown months; however, the relaxation of social distancing measures led to a rapid return to pre-pandemic levels (European Union Drugs Agency (EUDA), 2021). Since 2021, cocaine use has shown an upward trend, accompanied by slight increases in amphetamine and methamphetamine consumption (European Union Drugs Agency (EUDA), 2021, European Union Drugs Agency (EUDA), 2024a, European Union Drugs Agency (EUDA), 2025), whereas heroin seizures have moderately declined (European Union Drugs Agency (EUDA), 2024a). Also noteworthy is the growing variety of novel psychoactive substances on the market (European Union Drugs Agency (EUDA), 2022), along with a marked rise in ketamine, whose seizures doubled between 2022 and 2023 (European Union Drugs Agency (EUDA), 2022, European Union Drugs Agency (EUDA), 2024a, European Union Drugs Agency (EUDA), 2025).

Accurate knowledge of drug use trends is essential for developing public health strategies. Traditionally, such data are obtained through anonymous structured self-reported interviews conducted among the general population, but their subjective nature limits their reliability. Wastewater-based epidemiology (WBE) is a complementary tool, as it serves as an anonymized pooled urine sample from a population, enabling estimation of drug consumption in g/day/inhabitants and supporting regional comparisons (Huizer et al., 2021). Nevertheless, WBE presents limitations (variability depending on weather conditions, seasonal fluctuations, weekends vs. weekdays, quick breakdown of some substances in the sewage system, etc.) (Huizer et al., 2021).

Roadside drug testing in drivers offers another valuable source of objective and real-time data. Since drivers represent a broad segment of the adult and active population, this method serves as a practical indicator for estimating drug use in the general population. It also enables the characterization of consumption profiles, including age, sex and common drug combinations. Although these pre-selected samples (drivers who tested positive on-site) cannot be used to obtain full epidemiological data, they still provide useful information about drug use trends and consumption patterns. In addition, the standardized procedures allow consistent monitoring over time and across different regions. Some earlier studies have demonstrated the value of roadside drug testing (Drummer et al., 2007; Schulze et al., 2012; Herrera-Gómez et al., 2020a)

The aim of the present study was to describe trends in drug consumption and patterns of drug use before, during and after the COVID-19 pandemic. The study was based on over 29,000 oral fluid specimens submitted to our laboratory for confirmation following positive on-site roadside drug tests over a 5.5-year period.

2. Materials and methods

2.1. Oral fluid (OF) specimens

Anonymized OF specimens were sent to our laboratory by the police for confirmation of positive on-site results obtained on driver drug controls between January 2019 and July 2024. These controls are routinely carried out by the police using different commercialized on-site devices in accordance with current Spanish legislation, which requires that any positive on-site result be confirmed in accredited laboratories using reliable techniques (generally LC-MS/MS). Information regarding criteria, timing, circumstances of the controls (e.g., preventive checks, traffic violations, or erratic driving) or the specific on-site screening device employed in each case was not available to the researchers.

All procedures were performed in compliance with relevant laws and institutional guidelines, and the use of the samples for the present study has been approved by the Galician Research Ethics Committee (registration code 2022/373).

2.2. Sample analysis

The LC-MS/MS method included the determination of opiates (morphine, codeine, 6-acetylmorphine (6-AM)), cocaine (cocaine and benzoylecgonine (BE)), amphetamines (amphetamine, methamphetamine, 3,4-methylenedioxyamphetamine (MDA), 3,4-methylenedioxymethamphetamine (MDMA) and 3,4-methylenedioxy-N-ethylamphetamine (MDEA)), cannabis (Δ^9-tetrahydrocannabinol (THC)), ketamine, methadone and benzodiazepines (alprazolam, oxazepam, lorazepam, flunitrazepam, clonazepam, diazepam and nordiazepam) and zolpidem. Cut-off concentrations were 2 ng/mL for 6-AM, THC and ketamine, 5 ng/mL for cocaine, BE, morphine, codeine, methadone, benzodiazepines and zolpidem, and 10 ng/mL for amphetamines. Specific method conditions and validation results are detailed in Supplementary Material-1.

2.3. Evaluation periods

The 5.5 year period of study was stratified in five subperiods to assess the potential impact of the COVID-19 pandemic: a) Pre-COVID period (2019–14th March 2020), before pandemic; b) COVID-1 period (15th March-21st June 2020), complete movement restrictions; c) COVID-2 period (22nd June-31st December 2020), partial movement restrictions; d) Post-COVID-1 (year 2021) and e) Post-COVID-2 (years 2022-2024), both characterized by the disappearance of movement restrictions. The rationale for the selection of the start and end dates is provided in Supplementary Material 2.

2.4. Statistical analysis

Statistical analysis of the results was first conducted using the complete dataset and then considering the different study subperiods. Given the variability in drug use patterns across Spanish regions and the variability in the number of samples collected from each area, data were also stratified into five distinct geographic regions: Northwest (Galicia, Asturias, Cantabria), Centre (Castilla León, La Rioja, Aragón, Madrid, Castilla La Mancha, Extremadura), East (Comunidad Valenciana), South (Andalucía, Murcia) and Islands (Canarias and Baleares).

Statistics were performed using the free R software (R Core Team, 2023), version 4.4.2. A descriptive analysis was performed for sociodemographic variables (sex, age, region). To assess association between variables, the Chi square (more than 20% of the cells had expected frequencies lower than 5) or the Fisher tests were applied as appropriate, considering a bilateral test and a p-value < 0.05 as statistically significant. Additionally, Cramer's V and its 95% confidence interval were estimated as a measure of effect. The interpretation of Cramer's V follows Mangiafico recommendations (Salvatore S. Mangiafico, 2023) (Supplementary Material-3, Table S1). When several variables were simultaneously compared, the Bonferroni test was applied to adjust the p value.

Raw data can be downloaded from: https://zenodo.org/records/17095286.

3. Results

3.1. Global results

The total number of OF samples was 29,397. According to the different regions, 7801 (26.5%) samples came from the Northwest, 4660 (15.9%) from the Center, 12,777 (43.5%) from the East, 2476 (8,4%) from the South and 1683 (5.7%) from the Islands.

3.1.1. Demographic data

Information about the sex was available for 9580 (32.6%) drivers. Males represented 93.4% of the samples. Information about the age was available for 8772 (29.8%) drivers, and most of them (85%) were under 45 years old, with a mean age of 34.4 ± 10.3 years old (median=34,

range=14–81 years) (Fig. 1).

3.1.2. Analytical results

A positive OF result was detected in 97% of the samples, with 69.9% positive for cannabis, 64.9% for cocaine, 13.7% for amphetamines, 10.6% for opiates, 6.5% for ketamine, 5.4% for methadone and 6.6% for benzodiazepines/zolpidem.

Within the cocaine group, 63.5% of the samples were positive for cocaine and 58.9% for BE. For amphetamines, the most predominant were amphetamine (8.2%) and MDMA (8.1%). Regarding the opiates, 6-AM was detected in 9.8% of the samples, confirming heroin consumption, morphine in 9.3%, and codeine in 6.9%; in 90 cases (0.3%), the detection of codeine was attributed to exposure to this medication, and in 112 cases (0.4%) morphine and codeine were detected at similar concentrations, but no 6-AM was identified. Methadone was detected with opiates in most cases (76.8%). In 9 samples (0.03%), ketamine (not included in the on-site testing panel) was detected as the sole analyte, with concentrations ranging from 2.8 to 179.5 ng/mL. Of these, 3 tested positive on-site for cannabis, 2 for cocaine, 1 for both amphetamine and cocaine, and 1 for both amphetamine and methamphetamine. No on-site test information was available for the remaining 2 samples. Finally, the most common benzodiazepines were nordiazepam (2.9%) and alprazolam (2.2%) (Table 1).

Fig. 2 shows the frequency of positive results for the different analytes according to the concentration range. It is worth highlighting that for morphine, amphetamine, MDMA, cocaine and BE, more than 40% of the positive samples showed a concentration > 1000 ng/mL. On the other hand, for methamphetamine, ketamine, benzodiazepines/zolpidem, concentrations ≤ 50 ng/mL were observed for more than 44% of the samples. The higher oral fluid concentrations observed for basic drugs, such as cocaine, amphetamines, and methadone, are consistent with the phenomenon of ion trapping and elevated oral fluid/blood partition ratios reported in the literature. Conversely, benzodiazepines generally demonstrate low oral fluid/blood ratios, indicating limited transfer to oral fluid relative to blood (United Nations Office On Drugs And Crime (ONUDC) (ONUDC), 2014; Bakke et al., 2020). The low concentrations of ketamine and methamphetamine observed in oral fluid may be partly explained by their concomitant use as secondary substances during cocaine or MDMA consumption, or by the adulteration of cocaine or MDMA with low amounts of these compounds (Energy Control, 2025).

Table 1
Oral fluid specimens positive for the different drugs during the whole period of study (n = 29,397).

DRUG GROUP (Frequency, %)	ANALYTE	FREQUENCY n (%)
OPIATES (10.6%)	Morphine	2740 (9.3%)
	6-AM	2885 (9.8%)
	Codeine	2028 (6.9%)
AMPHETAMINES (13.7%)	Amphetamine	2424 (8.2%)
	Methamphetamine	293 (1%)
	MDMA	2372 (8.1%)
	MDA	1254 (4.3%)
COCAINE (64.9%)	Cocaine	18,676 (63.5%)
	Benzoylecgonine	17,331 (58.9%)
CANNABIS (69.9%)	THC	20,549 (69.9%)
KETAMINE (6.5%)	Ketamine	1921 (6.5%)
METHADONE (5.4%)	Methadone	1584 (5.4%)
BENZODIAZEPINES (6.6%)	Alprazolam	660 (2.2%)
	Oxazepam	69 (0.2%)
	Clonazepam	94 (0.3%)
	Lorazepam	333 (1.1%)
	Flunitrazepam	5 (0.02%)
	Diazepam	469 (1.6%)
	Nordiazepam	848 (2.9%)
	Zolpidem	62 (0.2%)

Regional stratification of the results revealed statistically significant differences in the frequency of positive cases for each drug across the various regions (Table 2). Cannabis, closely followed by cocaine, was the most prevalent drug across all regions, except in the Northwest, where the frequencies of these two drugs were reversed. For opiates and methadone, the frequency in the Northwest was more than twice that reported in the other regions. For amphetamines, the frequency was higher in the Center (31%), followed by the East (14%), with rates $< 9\%$ in the other regions. While for ketamine, a much higher percentage of positive cases was found in the East (10.4%), followed by the Center (7.2%) (<3.7% in other regions). Finally, benzodiazepines/zolpidem positivity rate was higher in the South (10.8%), followed by the

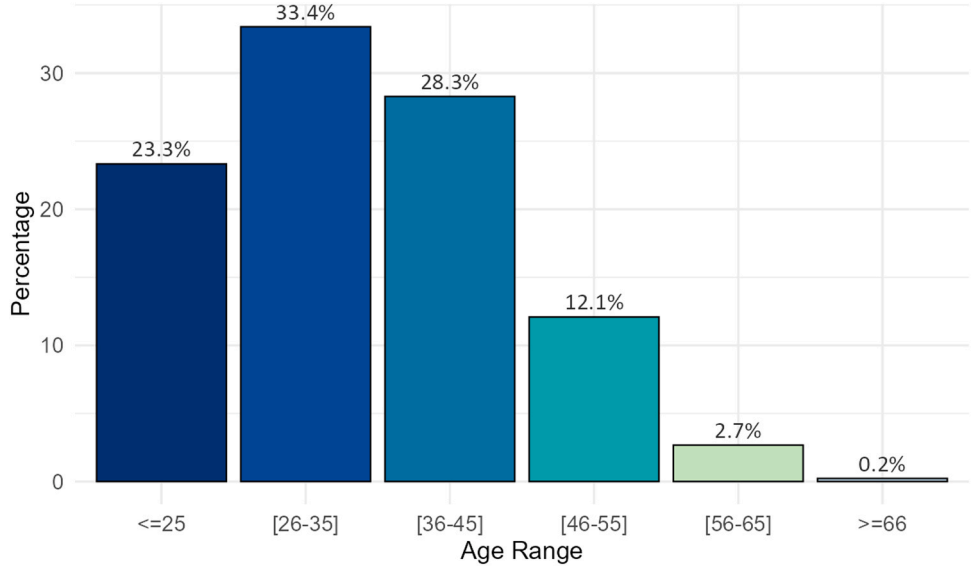

Fig. 1. Frequency (%) of drivers according to the age range for those for whom this information was available (n = 8772).

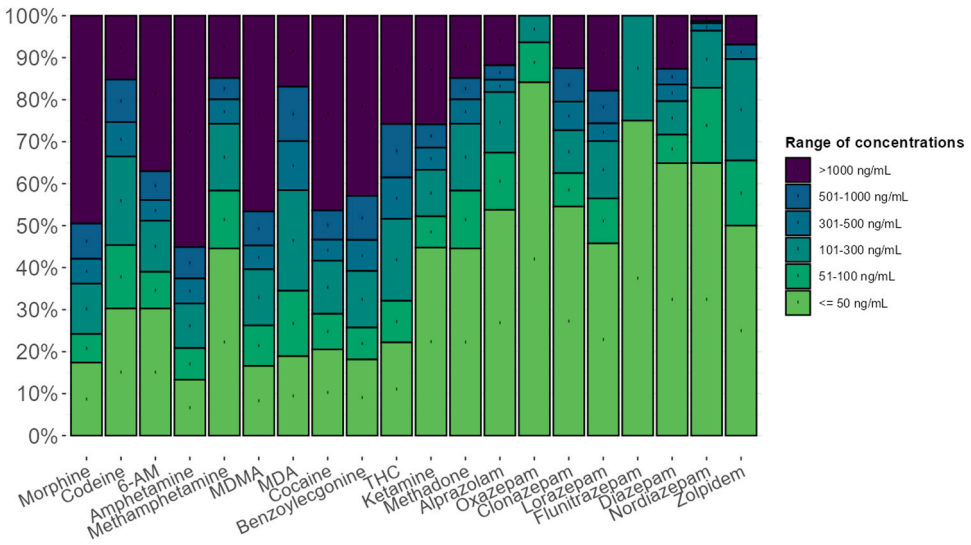

Fig. 2. Percentage of oral fluid positive results for the different analytes according to the concentrations detected for those samples for which a quantitative result was available.

Table 2
Positive cases (%) for each drug group according to the region (whole period of study), and statistical significance.

	NORTHWEST (n = 7801)	EAST (n = 12,777)	CENTER (n = 4660)	SOUTH (n = 2093)	ISLANDS (n = 2476)	$\chi^2_{Pearson}$ (df=4)	Significance	Cramer's V [$CL_{95\%}$]
OPIATES	19.9	6.7	7.4	10.5	5.5	1006.1	***	0.185 [0.173–0.194]
AMPHETAMINES	5.4	14	31	9	8.1	1725.2	***	0.242 [0.225–0.25)
COCAINE	71.3	65	57.3	66.5	53.9	352.2	***	0.109 [0.098–0.119]
CANNABIS	61.5	74	70.3	69.9	76.3	401.1	***	0.117 [0.106–0.124]
KETAMINE	1.8	10.4	7.2	3.7	1.5	714.1	***	0.156 [0.147–0.165]
METHADONE	12	2.4	3.8	3.8	3.8	925.5	***	0.177 [0.169–0.191]
BENZODIAZEPINES	8.3	5	6.5	10.8	5.2	166.3	***	0.075 [0.065–0.09]

***$p < 0.001$; $\chi^2_{Pearson}$: Chi^2; df: degrees of freedom; $CL_{95\%}$: 95% confidence interval

Northwest (8.3%).

3.1.3. Patterns of drug consumption

3.1.3.1. Single vs. poly-drug consumption. Single-drug use was observed in 43.7% of the positive cases, primarily involving cannabis (61.7%) and cocaine (34.5%). However, both substances were more frequently associated with polydrug use, as only 37.4% of cannabis-positive cases and 22.5% of cocaine-positive cases involved single use.

Table 3
Frequency (%) of single-drug vs. poly-drug use for the different drug groups.

COMPOUND GROUP	SINGLE-DRUG USE	POLY-DRUG USE	2 DRUGS	≥ 3 DRUGS
OPIATES	2	98	26.2	71.8
AMPHETAMINES	7.4	92.6	30	62.6
COCAINE	22.5	77.5	49.8	27.7
CANNABIS	37.4	62.6	42	20.6
KETAMINE	0.5	99.5	12.8	86.7
METHADONE	0.6	99.4	11.2	88.2
BENZODIAZEPINES	4.8	95.2	26.1	69.1

Frequency (%) refers to the positive cases within each group

Poly-drug use (56.3%) included the detection of 2 (37%), 3 (12.8%), 4 (5.6%), 5 (0.8%) and even 6 (n = 10) or 7 (n = 1) different drugs.

Regarding the different drug groups, poly-drug use was observed in over 90% of the positive cases for each group, except for cannabis and cocaine (62.5% and 77.5% of the cases, respectively). Furthermore, for all drug groups, except cannabis and cocaine, the most common pattern involved the use of three or more substances (Table 3).

The most commonly associated drugs were cocaine and cannabis (48.1% of poly-drug cases). Other common combinations (<6% of poly-drug cases) are shown in Figure S1A (Supplementary Material-3). As ketamine was not part of the drug panel used in roadside screening devices, it was detected alongside other substances in 99.5% of the cases (n = 1912). Moreover, it was usually identified in combination with 2 or 3 more drugs (43% and 40.7%, respectively, of the ketamine positive cases) (Figure S1B, Supplementary Material-3).

3.1.3.2. Differences among sexes. Globally, there were no significant differences among men and women in the use of illicit drugs (96.9% vs. 95.6%, $p = 0.065$), the proportion of poly-drug use (54.1% vs. 57.2%, $p = 0.325$), or the observed drug profile (cannabis and cocaine were the most commonly used substances) (Figure S3, Supplementary Material-3). However, the use of cannabis was statistically significantly higher in

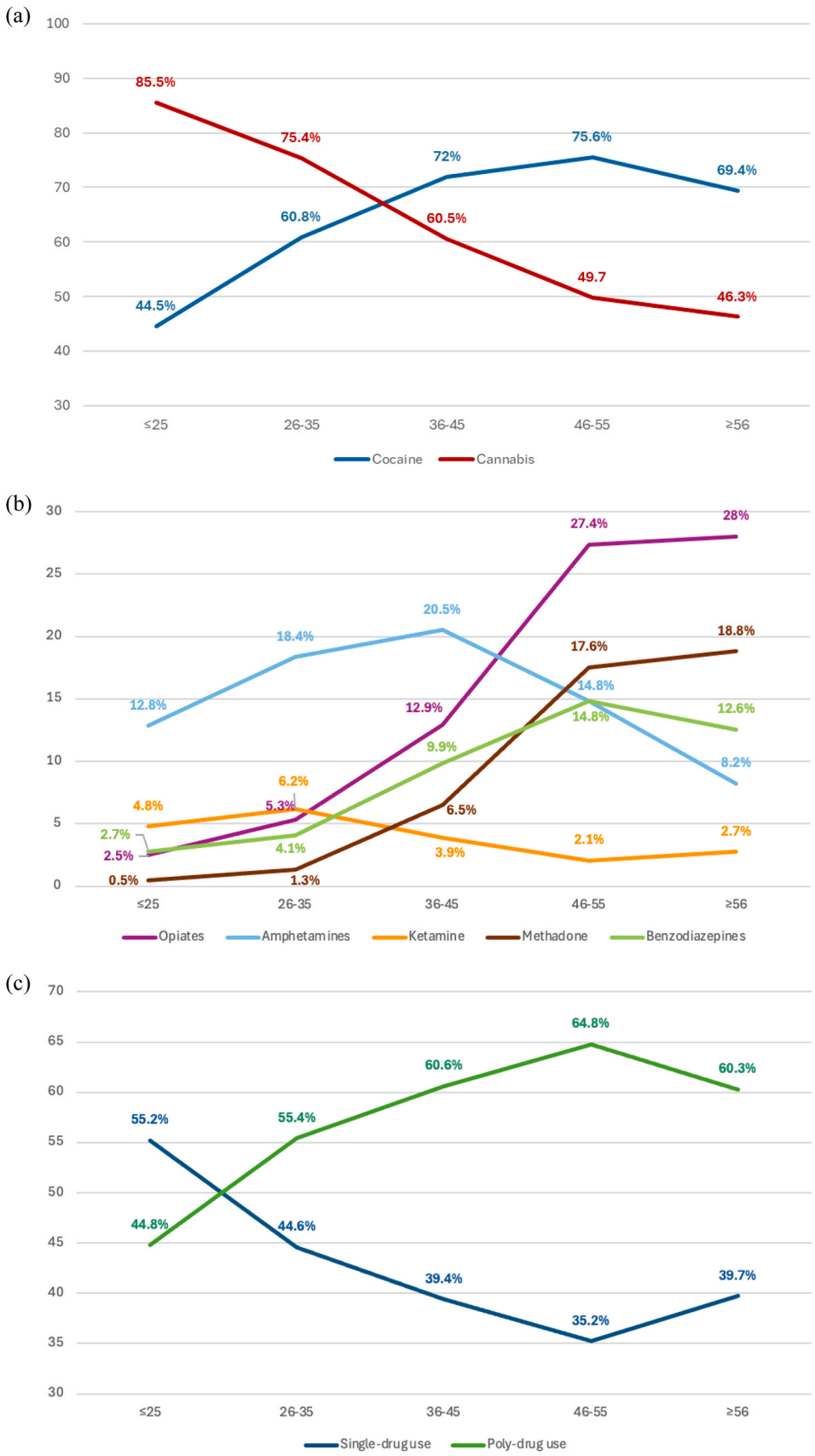

Fig. 3. Frequency (%) of drugs consumption (3 A and 3B) and frequency of single and poly-drug use (3 C) by age group. Percentages were calculated as the proportion of positive cases for each substance relative to the total number of positive cases within each age group.

men than in women (70.3% vs. 63.4%, Chi^2=20.312, $p < 0.001$, Cramer's V=0.046 [0.02–0.068]), while amphetamines (16.5% vs. 23.5%, Chi^2=13.115, $p < 0.001$, Cramer's V=0.037 [0.016–0.057]) and benzodiazepines/zolpidem (6.8% vs. 11.8%, Chi^2=21.590, $p < 0.001$, Cramer's V=0.047 [0.023–0.066]) use were significantly higher among women.

3.1.3.3. Differences among age ranges. Cannabis and cocaine were the most common drugs (Fig. 3A) regardless of the age; however, cannabis use decreased with age, whereas cocaine consumption increased. Opiates, methadone and benzodiazepines also tended to increase with age, while amphetamines and ketamine peaked in the 36–45 and 26–35 age groups, respectively, followed by a decline in older drivers (Fig. 3B).

Poly-drug use was more prevalent across all age groups, except among drivers ≤ 25 years. This trend became more pronounced with increasing age, although a decline was observed among individuals ≥ 56 years (Fig. 3C).

3.2. Results across the different study periods

The following distribution of cases was observed in the defined periods: Pre-COVID, n = 3090; COVID-1, n = 423; COVID-2, n = 1734; Post-COVID-1, n = 5184; and Post-COVID-2, n = 18,966.

3.2.1. Demographic data

Throughout all periods, the percentage of male drivers remained consistently high, ranging from 92.9% to 95.9%, with no statistically significant differences between periods ($p = 0.256$).

Regarding age, most of the drivers (>83%) were < 45 years old in all periods. However, significant differences in driver age group frequencies

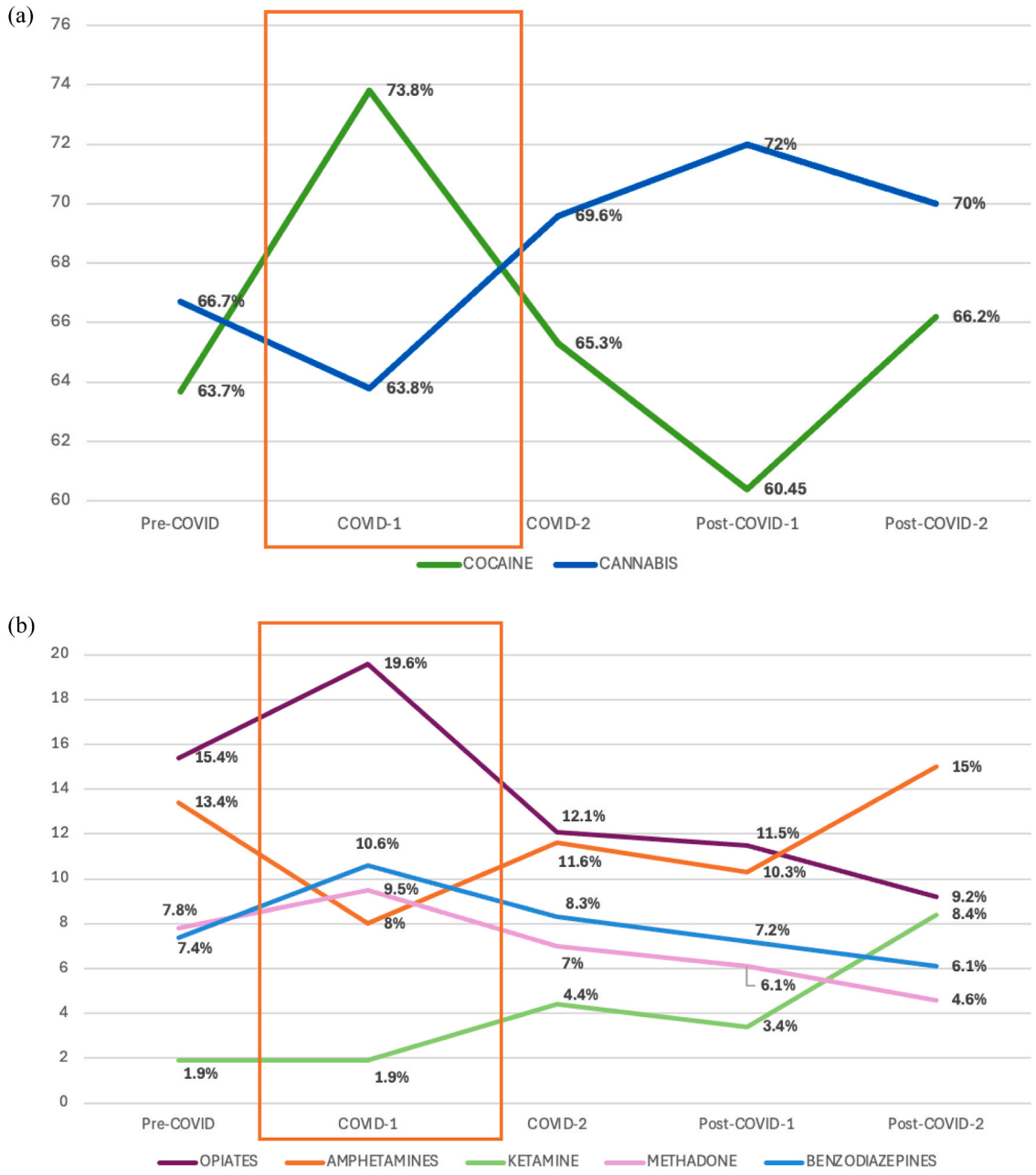

Fig. 4. Trends consumption for the different drug groups (6 A: cocaine and cannabis; 6B: other drugs) across the different study periods. Percentages are normalized to the number of samples in each period, enabling comparison of drug consumption across periods with different sample sizes.

were found across periods ($p < 0.001$) (Figure S3, Supplementary Material-2), with fewer drivers aged ≤ 25 and more aged 36–55 during the strict lockdown.

3.2.2. Analytical results

Globally, cannabis use showed the lowest frequency during the COVID-1 period, followed by a steady increase, and the highest values in the final period. Cocaine use peaked during the strict lockdown (COVID-1), followed by a decrease in the subsequent periods and a later increase in the final period, reaching similar levels to those observed in the pre-COVID period. For opiates, methadone and benzodiazepines/zolpidem, the highest frequency was also observed during the strict lockdown, followed by a decrease in subsequent periods to levels lower than those seen before the pandemic. Amphetamines use decreased during the COVID-1 period, while ketamine use remained stable; however, in the following periods, the use for both substances increased, reaching levels notably higher than those recorded in the pre-COVID period, especially for ketamine (Fig. 4).

The analysis of the results according to the defined regions also showed differences (Table 4). For cocaine, a peak of positive results was recorded during the COVID-1 period in all regions, followed by a decline in subsequent periods and then an increase again in the final period, with values higher than those observed in the pre-COVID period in the Center and Islands, but lower in the South. Statistically significant differences across the different periods were observed in most regions, except for the Northwest. Cannabis use declined during the strict lockdown in the Eastern, Southern and Islands regions, followed by an increase in the subsequent periods. However, statistically significant differences across periods were only observed in the Northwest ($p < 0.05$). Opiates use increased during the strict lockdown period (COVID-1) in the Northwest, Center and Islands, while decreased in the Eastern and Southern regions. A general downward trend in opiate consumption was observed, with the lowest frequencies recorded in the final period of study in most cases, except in the Central and Island regions. However, only the Northwest and East regions showed statistically significant differences across the study periods ($p < 0.001$).

Table 4
Oral fluid positive samples (%) for the different drug groups in the different periods of study.

DRUG GROUP	REGION	PERIOD					$\chi^2_{Pearson}$	Significance	Cramer's V [$Cl_{95\%}$]
		Pre-COVID (n = 3090)	COVID- 1 (n = 423)	COVID-2 (n = 1734)	Post-COVID-1 (n = 5184)	Post-COVID-2 (n = 18966)			
OPIATES	Northwest	24.8	32.2	26.9	19.9	17.4	64.21	***	0.091 [0.077–0.115]
	East	15.4	10.8	6.4	7.1	6.2	66.02	***	0.072 [0.055–0.100]
	Center	6.6	11.9	10.3	7.9	7.3	4.92	ns	-
	South	14.8	9.3	11.4	11	9.1	F	ns	-
	Islands	3.7	9.1	4.2	5.8	5.9	F	ns	-
AMPHETAMINES	Northwest	4.2	3.4	4.4	4.7	6.2	13.4	ns	
	East	10	8.6	10.7	8	16	109.4	***	0.093 [0.082–0.107]
	Center	31.5	26.2	26.6	34.9	30.3	8	ns	-
	South	12.2	9.3	12	7.1	8.7	F	ns	-
	Islands	7.3	4.5	16.7	6.1	8.3	F	ns	-
COCAINE	Northwest	71.9	78	76.8	69.8	70.9	12.17	ns	-
	East	67.2	71.9	62.3	59.2	66.4	45.94	***	0.060 [0.050–0.081]
	Center	51.9	59.5	57	48.5	60.8	46.1	***	0.099 [0.073–0.131]
	South	71.3	83.7	71.5	60.3	66.4	19.82	*	0.089 [0.070–0.132]
	Islands	49.7	59.1	50	45.6	57.8	17.09	*	0.101 [0.061–0.151]
CANNABIS	Northwest	58	61.6	55.1	64.5	61.8	19.35	*	0.05 [0.029–0.072]
	East	72.1	66.9	76.9	76.4	73.4	16.07	ns	-
	Center	69.2	71.4	69.2	74.3	69.8	6.18	ns	-
	South	68.4	55.8	66.5	71.3	70.7	6.18	ns	-
	Islands	82.7	63.6	69.4	77.9	74.8	12.26	ns	-
KETAMINE	Northwest	1	0.6	2.2	1.7	2	F	ns	-
	East	1.2	4.3	5.5	4.5	12.8	206.02	***	0.127 [0.114–0.139]
	Center	3.3	2.4	5.1	5.6	8.9	F	*	0.088 [0.069–0.103]
	South	4.3	0	3.2	2.6	4.1	F	ns	-
	Islands	0	0	2.8	1.4	1.9	F	ns	-
METHADONE	Northwest	14.8	16.9	16.3	12.1	10.6	27.84	***	0.06 [0.047–0.08]
	East	4.8	4.3	1.9	2.6	2.3	15.07	ns	-
	Center	3.7	7.1	8.4	4.8	3.2	F	ns	-
	South	3.2	0	9.5	4.3	3.2	F	ns	-
	Islands	2	4.5	6.9	3.4	4.2	F	ns	-
BENZODIAZEPINES	Northwest	9.9	11.3	12.8	9.3	7.1	27.97	***	0.06 [0.05–0.091]
	East	5.8	9.4	4.4	5	5	6.88	ns	-
	Center	4.7	9.5	12.1	7	6.5	F	ns	-
	South	12.2	18.6	13.9	10	10.2	5.83	ns	-
	Islands	2.7	0	6.9	6.8	5.4	F	ns	-

Significance according to *p*-value. ***: adjusted p < 0.001; **: adjusted p < 0.01; *: adjusted p < 0.05; ns: not significant; $Cl_{95\%}$: 95% interval of confidence; F: the Fisher test was applied; -: Cramers' V value is not indicated as no statistical significance was observed

Methadone showed a similar trend, increasing during the lockdown periods (COVID-1 and COVID-2) and subsequently declining in most regions; nevertheless, statistically significant differences were observed exclusively in the Northwest ($p < 0.001$). In the case of amphetamines, the use decreased during the strict lockdown period, increasing (exceeding pre-COVID levels) in the Northwest, East and Islands in the last period, and remaining lower in the Southern and Central regions. However, statistically significant variations were only detected in the Eastern region ($p < 0.001$). For ketamine, consumption markedly dropped during the strict lockdown (except for the East), but a notable increase was observed between the pre-COVID and post-COVID periods in most regions. Nevertheless, statistically significant differences between periods were only found in the Eastern ($p < 0.001$) and Central ($p < 0.05$) regions. Finally, for benzodiazepines/zolpidem, their use increased during the lockdown periods (COVID-1 and/or COVID-2) across all regions, followed by a decrease in subsequent periods. However, statistical significance was only observed in the Northwest ($p < 0.001$).

4. Discussion

The objective of the present study was to evaluate trends and patterns of illicit drugs and benzodiazepines use among drivers over a 5.5-year period, focusing on the potential impact of the COVID-19 pandemic. This study provides updated and objective data, complementing and extending previously published data, which primarily covered the year 2014 (Lema-Atán et al., 2019). Although the study is based on a pre-selected population (drivers who tested positive during roadside screenings) and, therefore, does not allow for estimation of prevalence rates either among drivers or in the general population, it nonetheless offers valuable insight as an objective indicator of drug consumption trends.

In addition to the initial global analysis of the results, a subsequent regional analysis was conducted to identify potential statistical differences between areas, due to notable variations in the number of specimens received from different regions across Spain.

The majority of drivers were young males, most being under 45 years of age, with the same pattern observed in all periods of study. In Spain, males account for just over 50% of the driving population (Observatorio de Seguridad Vial, 2024a), but drug use in our study is notably higher among men, who are more likely to drive after consuming drugs of abuse (>95% of drivers involved in fatal traffic accidents with a positive result for drugs in Spain were male) (Observatorio Nacional de Seguridad Vial, 2024b). Comparable male overrepresentation was reported in previous studies from Spain and France, where driver selection was also based on on-site positive results for illicit drugs (85–97% males) (Lema-Atán et al., 2019; Herrera-Gómez et al., 2020a; Willeman et al., 2023). However, the mean age of drivers in those studies was somewhat lower, ranging from 26 to 29 years. In contrast, in studies where driver selection was randomized, the proportion of male drivers decreased to 70–76%, and the mean age increased to 39–41 years, reinforcing the finding that illicit drug use is more prevalent among younger male drivers (Herrera-Gómez et al., 2020a; Joye et al., 2022).

Regarding the analytical results, the percentage of confirmed cases slightly decreased from 98.5% in our 2014 study (Lema-Atán et al., 2019) to 97% in the present analysis. Nevertheless, similar general pattern of drug use was observed, being cannabis the most frequently detected substance, followed, in decreasing order of prevalence, by cocaine, amphetamines, opioids, ketamine, methadone and benzodiazepines. However, remarkable trend differences were observed, with a notable decrease in the positive cannabis cases (82% vs. 69.9%), and an increase of positive cases for cocaine and heroin (42.1% vs. 64.9% and 7.9% vs. 9.8%, respectively). Amphetamine cases remained relatively stable (14.2% vs. 13.7%), while a slight increase in methamphetamine detections was observed (0.6% vs. 1%). A higher prevalence of cannabis, followed by cocaine, was also reported in previous studies conducted in Spain, France, Denmark and Italy (Favretto et al., 2018; Herrera-Gómez et al., 2020a; Simonsen et al., 2022; Willeman et al., 2023). In contrast, cocaine was more frequently detected than cannabis in Switzerland (Joye et al., 2022), while in Norway and Hungary, cannabis was followed by amphetamines as the most detected substances (Institóris et al., 2022; Gjerde and Frost, 2023).

Regarding drugs not included in the on-site testing panel (methadone, benzodiazepines, zolpidem and ketamine), their overall incidence more than doubled compared to 2014 (Lema-Atán et al., 2019) (7.5% vs. 16.6%). While methadone cases increased slightly (4.9% vs. 5.4%), a more substantial increase was observed for benzodiazepines/zolpidem (3.8% vs. 6.6%). This upward trend in benzodiazepine/zolpidem detection was reported in a previous study conducted in our country in 2011–2016, where benzodiazepines were found in 4.3% of on-site positive OF samples (Herrera-Gómez et al., 2020b). In our studies, nordiazepam and alprazolam were the most frequently detected compounds. However, the most common benzodiazepines vary depending on the country: diazepam and nordiazepam in Italy (Favretto et al., 2022), or clonazepam in Norway (Gjerde and Frost, 2023) and Denmark (Simonsen et al., 2022). In the general driving population, benzodiazepines prevalence is notably lower, ranging from 0.1% to 2.8% (Herrera-Gómez et al., 2020a; Joye et al., 2022). This contrast supports the frequent co-consumption of these medications among drivers who use illicit drugs, increasing the driving-related risks already associated with benzodiazepines alone.

Also noteworthy is the substantial increase of ketamine-positive cases, rising from 2.1% in 2014–6.5% in the present study. In contrast, a much lower prevalence (2.8%) was reported in a similar study conducted in France between 2020 and 2023 (Aouichi et al., 2025). Our findings align with the exponential increase in ketamine seizures across Europe since 2016 (European Union Drugs Agency (EUDA), 2024b), particularly in Spain and the Netherlands (European Union Drugs Agency (EUDA), 2025), and the increase in the number of individuals receiving treatment for ketamine-related problems by more than 400% from 2018 to 2023 (European Union Drugs Agency (EUDA), 2025). This upward trend was also observed in the USA, as a study conducted in New York reported an increase in ketamine-positive blood samples among drivers involved in fatal traffic accidents from 1.1% in 2015–3.5% in 2020 (Arango et al., 2021).

No overall differences in the general use of illicit drugs were observed between men and women, consistent with findings from our previous study (Lema-Atán et al., 2019). However, in the present work, cannabis use was more prevalent among men, while amphetamines and benzodiazepines were more frequently detected in women. In contrast, our 2014 study only reported sex-related differences for benzodiazepines and methadone, both more common in female drivers. Similar sex-related patterns have been described in other studies. Willeman et al. (Willeman et al., 2023) also found higher cannabis use among men and a greater prevalence of amphetamines in women. Gjerde et al. (Gjerde and Frost, 2023) reported a higher use of illicit drugs among men, and of pharmaceutical substances among women. Regarding age-related trends, cannabis, amphetamines and ketamine were more frequently detected in younger drivers, whereas cocaine and benzodiazepines were more commonly found in those aged $\geq$ 45 years. These patterns are consistent with the trends observed in our 2014 study (Lema-Atán et al., 2019). A higher use of cannabis (Simonsen et al., 2022; Willeman et al., 2023) and amphetamines (Simonsen et al., 2022) among younger drivers, and opiates (Simonsen et al., 2022) and pharmaceuticals (Simonsen et al., 2022; Joye et al., 2022; Gjerde and Frost, 2023) in older drivers has been consistently described. However, data on cocaine use are less consistent, with some studies indicating a greater prevalence among younger drivers (Simonsen et al., 2022), and others in older individuals (Willeman et al., 2023).

In our study, poly-drug use was the most common pattern (56.3%), with a considerable increase (42.7%) compared to our previous study from 2014 (Lema-Atán et al., 2019). Notably, poly-drug use increased

with age, with no significant differences among men and women, consistent with our previous findings (Lema-Atán et al., 2019). On the contrary, only 17.3% of poly-drug use was reported in a French study, also based on on-site positive OF samples (Willeman et al., 2023). In all three studies, the most frequent combination was cannabis and cocaine, which accounted for nearly 50% of poly-drug cases in the present work. Poly-drug use was more frequent for all the drugs, but ketamine deserves particular attention. Although co-use with other substances was expected, given that all samples came from drivers who tested positive for other drugs, these results reflect the typical context of ketamine use. In fact, ketamine is often surreptitiously mixed with MDMA powder or sold as "pink cocaine" or "tucibi" (a combination of ketamine with psychostimulants such as MDMA, cocaine or new psychoactive substances (NPS)), with most reported seizures occurring in Spain and Italy (European Union Drugs Agency (EUDA), 2025). Indeed, in 84.9% of ketamine positive cases in this study, this drug was associated with a stimulant drug.

One of the main objectives of the present study was to evaluate trends in drug use during the period 2019–2024, with particular attention to the potential impact of the COVID-19 pandemic. Although focused on drivers, the findings likely reflect patterns in the general population. As in the European reports on drug use (European Union Drugs Agency (EUDA), 2025), in our study the prevalence of cannabis, cocaine, amphetamines and ketamine in the most recent period was similar to or higher than before the pandemic, while opiates, methadone and benzodiazepines showed a decline. Only amphetamines showed a clear decrease during the strict lockdown, while cocaine and opiates increased. Although these are the trends observed in the global data, regional stratification is essential to avoid bias arising from variations in the OF samples received over time. Indeed, we observed statistically significant differences in the frequency of the different drugs depending on the region (Table 4), as previously reported (Estévez-Danta et al., 2022). The regional analysis showed an increase in cocaine use during lockdown in all regions, although post-lockdown trends varied depending on the region. For cannabis, significant differences across periods were only observed in the Northwest, where a slight increase occurred in the last period. Amphetamine use dropped during lockdown across all regions and rose again in the second half of 2020, but only the Eastern region showed significant variation over time, with an increase in the latest period of study. For opiates, significant temporal differences were only observed in the Northwest and East, both showing a marked decrease compared to pre-COVID levels. Ketamine use increased in all regions during the final period, although differences were only significant in the Eastern and Central regions. Finally, for benzodiazepines, significant changes were seen only in the Northwest, with an increase during lockdown followed by a decrease in the following periods. It should be noted that the statistically significant differences for certain substances in specific regions is more likely related to the baseline prevalence and patterns of drug use in each region (e.g., opiates in the Northwest, or amphetamines or ketamine in the Eastern or Central regions) rather than to regional differences in access to these substances during the study period.

Although this study provides valuable insights into drug use patterns and their evolution over time, several limitations must be considered. First, the data are based on a pre-selected population (drivers who tested positive in on-site roadside controls), which means the findings do not reflect the overall prevalence of drug use among the general driving population, but rather the trends within this specific subgroup. Second, the limited proportion of cases for which age and sex information is available (around 30% of the cases) constrains the assessment of these demographic parameters. Third, comparisons with previous studies are limited due to methodological differences. These include variations in the types of drivers assessed (e.g., random roadside controls, impaired drivers, drivers involved in traffic accidents, or only those testing positive on-site), the biological samples analyzed (oral fluid, blood and/or urine) and the analytical cut-offs applied. Finally, the geographical distribution of samples changed over the study period, which may have introduced regional biases. Although stratified analyses were conducted to account for this, regional differences in enforcement intensity, testing protocols or population characteristics could still influence the results.

5. Conclusions

This study provides an overview of illicit drugs and benzodiazepine use trends between 2019 and 2024, highlighting the impact of the COVID-19 pandemic, based on the analysis of more than 29,000 oral fluid samples from drivers who tested positive in on-site screenings. Cannabis and cocaine use predominated over other substances, with polydrug use being highly prevalent for all the drugs. Cannabis and amphetamines use declined during the strict COVID-19 lockdown, while ketamine remained stable, followed by a subsequent increase, particularly for ketamine. In contrast, cocaine, opiates, methadone and benzodiazepines peaked during the strict lockdown but decreased thereafter, reaching levels below those observed in the pre-pandemic period. Although these overall trends were consistent in the global data, statistically significant regional differences in drug frequency and temporal patterns were also identified.

CRediT authorship contribution statement

Angelines Cruz: Writing – review & editing, Conceptualization. **María Cobo-Golpe:** Writing – review & editing, Methodology. **Ángela López-Rabuñal:** Writing – review & editing, Data curation. **Ana de-Castro-Ríos:** Writing – review & editing, Project administration, Funding acquisition, Conceptualization. **Miriam Blanco-Ces:** Writing – original draft, Investigation, Formal analysis. **Elena Lendoiro:** Writing – review & editing, Supervision, Methodology.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the author(s) used ChatGPT (OpenAI) in order to improve the clarity and grammar of the English language. After using this tool, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the published article.

Funding sources

This work was supported by the Delegación del Gobierno para el Plan Nacional sobre Drogas, Ministerio de Sanidad, Gobierno de España, and the "European Union NextGenerationEU/PRTR" [grant number EXP2022/008675].

Declaration of Competing Interest

The authors have nothing to declare.

Acknowledgements

The authors would like to thank the Delegación del Gobierno para el Plan Nacional sobre Drogas, Ministerio de Sanidad, Gobierno de España, and the European Union NextGenerationEU/PRTR [EXP2022/008675], which funded both this study and the contract of M. Blanco-Ces. The authors also acknowledge the Xunta de Galicia (Galicia, Spain) for the support through the program for the Consolidation and Structuring of Competitive Research Units [2021-PG054].

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.drugalcdep.2026.113107.

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