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A study into the nature and extent of polydrug use in driving recidivism behavior

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ABSTRACT

Objective: Polydrug use has become a frequent pattern of drug consumption in Europe, and this is considered a particularly dangerous risk factor for impaired driving. In Italy, persons whose license has been revoked or suspended due to the use of psychoactive drugs can reapply for a new driving license, depending on the judgment of the relevant local medical committee (CML). To regain a revoked license, offenders must remain drug free throughout an observation period. An important problem with enforcement of impaired driving is recidivism. The aim of the present study is to analyze the influence of polydrug use on driving recidivism.

Method: We report the findings of several years' experience at the forensic toxicology laboratory of the University of Macerata. Hair samples collected over a 7-year period by the CML from drug users were analyzed for cocaine, opiates, and cannabis using gas chromatography–mass spectrometry.

Results: Three hundred thirty-five of the tested subjects were recidivists. Recidivism was more frequent among monodrug users (81%) compared with polydrug users (19%), but logistic regression showed that polydrug use is certainly a risk factor for recidivism compared to monodrug use (odds ratio [OR] = 1.99). The sex and age distribution of recidivist subjects showed a strong predominance of males in both groups, but there were no sex differences. There were more recidivist polydrug users than recidivist monodrug users in the younger age groups (OR = 2.012). Cocaine use was most prevalent in the recidivist monodrug group. All drugs analyzed were demonstrated to be a risk factor for recidivism among monodrug users, whereas only the cocaine and cannabis combination was shown to be a risk factor for recidivism among polydrug users (OR = 1.65 versus cocaine; OR = 1.30 versus Δ^9-tetrahydrocannabinol). Almost all polydrug users became monodrug users, and cocaine was the most frequently detected drug in the subsequent test during the monitoring phase.

Conclusions: Our results show that polydrug use increases the risk of impaired driving recidivism and represents a considerable threat to road safety.

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Recidivism; polydrug use; hair sample; impaired driving; risk factors

Introduction

Under Italian law (art. 187 of the Highway Code, D.L. 285/92), drug dependence and regular drug use are incompatible with safe driving (zero tolerance law). Testing positive for illicit drug use or exceeding the blood alcohol limit constitutes a valid reason for driving disqualification, or revocation of the offender's driving license. According to some authors, rehabilitation program have a stronger deterrent effect than sanctions (Voas and Fisher 2001). Despite impaired driving enforcement, which requires proof of abstinence for a period of observation, a large number of people recidivate and reoffend (Christophersen et al. 2002; Tassoni et al. 2016; Mills et al. 2022). Recidivists may have a higher probability of involvement in fatal motor vehicle accidents, including collisions with pedestrians (NHTSA 2007). To enhance traffic safety, it is important to minimize recidivism rates among drug users. To this end, Italian legislation imposes permanent driving license withdrawal for repeat impaired driving offenders (D.L. 285/92). According to the literature, the most commonly reported risk factors for recidivism are drug use, sex, and age (Christophersen et al. 2002; Snenghi et al. 2018). In particular, it has been shown that many drug-impaired drivers who are apprehended are polydrug users (Christophersen et al. 2002; Snenghi et al. 2018). Polydrug use is the consumption of more than one drug, either simultaneously or sequentially, as defined in the World Health Organization's (1994) *Lexicon of Alcohol and Drug Terms* (Font-Mayolas and Calvo 2002). Polydrug use is considered to be a particularly high-risk factor for dangerous driving (World Health Organization 1994; European Monitoring Centre for Drugs and Drug Addiction 2009; Karjalainen et al. 2010), but data about the correlation of polydrug use and recidivism in impaired driving are limited (Snenghi et al. 2008; Tassoni et al. 2016). Furthermore, most of these studies are related to polydrug use in which one of

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the substances involved is alcohol. Less is known about the impact of polydrug use on driving behavior when other drugs are involved. In Italy, persons whose license has been revoked or suspended due to the use of psychoactive drugs can reapply for a new driving license, depending on the judgment of the relevant local health authority (local medical committee [CML]; art. 119 Highway Code, DPR 495/92). One of the requirements is proof of abstinence from illicit drug use for the duration of an observation period, which is determined by means of toxicological analysis, mainly using urine or hair matrices. Urine analysis screens for recent or current exposure, whereas hair analysis provides information on long-term use of illicit drugs. Hair analysis as a method of testing for drugs has a greater detection window than urinalysis and may offer a better means of monitoring drug abstinence over a long period of time as required by law (Lendoiro et al. 2018; Gili et al. 2021; Tassoni et al. 2021). For this reason, hair analysis is an important part of the process of reinstating a driver's license after impaired driving offenses. According to most CML procedures, in the case of positive hair and/or urine results, driving license suspension ranges from 6 months to 2 years. During this period, the person is generally required to undergo toxicological analysis monitoring every 6 months. To our knowledge, few studies have used the hair matrix to evaluate the role of polydrug use in impaired driving recidivism (Snenghi et al. 2015, 2018).

We report the results of a study conducted at the forensic toxicology laboratory of the University of Macerata to evaluate recidivism rates among polydrug users by examining hair samples from persons whose driving license has been suspended due to positive toxicological test results after a road accident or random screening. All cases were evaluated in relation to the drugs involved, age, and sex. We also analyzed whether these could be risk factors for impaired driving recidivism. We focused on data pertaining to opiates, cocaine, cannabis, and their metabolites, as required by the protocols of the CML in the Marche region. These are the most frequently used illicit substances in Italy; thus, the role of other drugs (such as amphetamines and ecstasy) appears less relevant (Pascali et al. 2019; European Monitoring Centre for Drugs and Drug Addiction 2022).

Methods

Sample selection

All data were from persons registered as permanent residents in Italy. Each was given a unique 16-digit identification number, completely anonymized. These numbers, along with age, sex, and the substances detected in positive drug tests, were entered in a laboratory database containing the results of toxicological analysis of hair samples of people whose driving license was suspended due to positive test results after a road accident or random screening. The drugs monitored by the CML of the Marche region are cocaine, morphine, Δ^9-tetrahydrocannabinol, and their metabolites. The CML may also require testing ethylglucuronide, the biomarker for alcohol abuse. However, because analysis for this marker is not required for all subjects included in this study, data on alcohol consumption are not included. All positive cases registered from January 1, 2016, to December 31, 2022, were used in selection for inclusion based on the number of occurrences in the database. The criterion for recidivism is a positive test result on the second drug control. During the legally required monitoring period, hair samples were tested to demonstrate no drug use.

Chemicals and reagents

Reference standards (cocaine, morphine, Δ^9-tetrahydrocannabinol) and internal standards (nalorphine, proadifen, Δ^9-tetrahydrocannabinol-D_3 [Δ^9THC-D_3], for opiates, cocaine, and cannabinoids, respectively) were purchased from Sigma, along with *N*-methyl,*N*-(trimethylsilyl)trifluoroacetamide, and *N*,*O*-bis(trimethylsilyl)trifluoroacetamide with 1% trimethylchlorosilane. Methanol, dichloromethane, prop-2-ol, ammonium hydroxide, hexane, and ethyl acetate (purchased from Carlo Erba reagents) were of reagent grade. Isolute HCX cartridges (10 mL capacity, 130 mg) were obtained from Thermo.

Hair sample preparation

The hair samples were collected by the CML personnel from the posterior vertex and delivered to our laboratory. After washing, a 3-cm proximal hair segment was manually cut into small fragments (50 mg minimum) for drug detection. The samples were extracted as described by Tassoni et al. (2016).

Gas chromatography–mass spectrometry instrumental and analytical conditions

All analyses were carried out by gas chromatography–mass spectrometry, as described in previous studies (Tassoni et al. 2016, 2021). Drug concentrations in analyzed hair higher than the cutoff values (Cooper et al. 2012) were considered to be positive data. The cutoffs adopted by our laboratory refer to those indicated in the State-Regions Agreement (Conferenza permanente per i rapporti tra lo stato le regioni e le province autonome di Trento e Bolzano 2008) for the same type of analysis (Table 1).

Statistical methods

The data were expressed as absolute values and proportions. Age data for the two groups were expressed as mean ± standard deviation (SD). Pearson's chi-square test (χ^2) and Student's *t* test were used to calculate the statistical significance of the demographic factors. A logistic regression model (odds ratio [OR] with 95% confidence intervals [CIs]) was used to estimate the relationship between recidivism behavior and type of drug consumption (mono or polydrug

Table 1. Out laboratory's cutoff values.

Substance	Cutoff
Cocaine	0.2 ng/mg
Opiates	0.2 ng/mg
Cannabinoids	0.1 ng/mg

use). Then, the same logistic regression was used to examine the association between demographic factors (age and sex), type of drugs taken, and the likelihood of polyaddiction. Person's χ^2 test was used to test the goodness of fit of the logistic regression results. A P value < .05 was considered statistically significant.

Ethics approval and informed consent

This study was approved by the Institutional Review Board of the University of Macerata (protocol code 0018/2021 of April 14, 2021). The collection, processing, and analysis of hair samples were performed according to the Italian law of privacy (DLeg. 196/2003). The samples arrived at the laboratory with a numerical code, and consent to use the data anonymously was given by the CML.

Results

The study used hair analysis data collected by the laboratory of the University of Macerata between 2016 and 2022. A scheme of the results is presented in Figure 1.

A total of 6,234 hair samples were analyzed. Of these, 1,432 hair samples were positive (23%), and most required further toxicological testing of the subjects. For a majority, the results of subsequent tests were negative (1,097, or 77%), or whom 985 were determined to be nonrecidivist monodrug users (90%) and 112 were nonrecidivist polydrug users (10%). Those individuals who tested positive at the second control were considered recidivist (n = 335, 23%). Our analysis showed that the number of recidivist monodrug users (RMDUs; n = 273, 81%) was significantly higher than the number of recidivist polydrug users (RPDUs; n = 62, 19%), χ^2 (df = 1) = 15.32, P < .001. However, logistic regression showed that the RPDU group twice the risk of recidivism compared with the RMDU group (OR =1.99, 95% CI 1.425–2.800, P < .001). This result showed that polydrug use contributes more to reoffending than monodrug use, even though the polydrug use group was small. Monitoring of these recidivist subjects over the years demostrated a progressive decrease in positivity on subsequent testing, with few subjects showing a high rate of repeated recidivism (positive more than 3 times). The RPDU group showed a higher rate of repeat use than the RMDU group (23% versus 18%), although this finding did not reach statistical significance, (χ^2 (df = 1) = 0.399, N.S. Analysis of the demographic characteristics of the 2 groups showed that more males than females drive under the influence of drugs: RMDU group, male versus female, χ^2 (df = 1) = 45,36, P < .01; RPDU group, male versus female, χ^2 (df = 1) = 40,41, P < .01 (Table 2).

Therefore, we examined the data in relation to sex, comparing the rate of female RMDUs with female RPDUs and the rate of male RMDUs with male RPDUs. The statistical analysis showed no significant difference, χ^2 = 3.77, df = 1, P = .06. The age analysis showed that the mean age of the RPDU group was significantly lower than that of the RMDU group (Table 3). We used an arbitrary subdivision of age groups, with categories ranging from 18 to 80 years old. The highest number of positive subjects for both monodrug and polydrug groups, were found for ages 25 to 35, followed by ages 36 to 50 for RMDUs and 18 to 25 years for RPDUs. We then compared younger subjects (18–35) with all older age groups (36–80) for monodrug and polydrug recidivism. The results showed a significant difference, χ^2 = 40.34 df = 1, P < .001, between the 2 groups, confirmed by logistic regression (OR = 2.012, 95% CI 1.04–3.89, P < .03; Table 3).

Cocaine was the most prevalent drug detected in the RMDU group, followed by morphine and Δ^9-THC (Table 4).

All of the drugs considered in the study were a significant risk factor for the RMDU group (cocaine: OR = 1.89, 95% CI 1.36–2.62, P < .001; morphine: OR = 1.59, 95% CI 1.07–2.38, P < .005); Δ9-THC: OR = 0.25, 95% CI

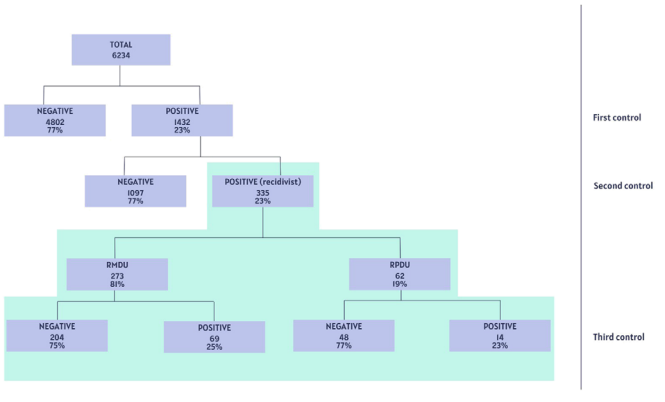

Figure 1. Diagram of the study population results.

Table 2. Characteristics of RMDUs and RPDUs.

	RMDU		RPDU		P		
Characteristics	N	%	N	%		OR	95% CI
Recidivist	273	81	62	19	<.001	1.99	1.425–2.800
Male	254	93	57	92	<.01		
Female	19	7	5	8	<.01		
Mean (SD), age (years)	35.35 (7.87)		33.02 (15.26)		<.05		
Min–max age	18–67		20–58				

Table 3. Age groupings for comparison among RMDUS and RPDUs.

	RMDU (n = 273)		RPDU (n = 62)				
Age groups (years)	N	%	N	%	P	OR	95% CI
18–25	48	18	21	34			
26–35	130	48	28	45			
36–50	88	32	8	13			
>51	7	2	5	8			
18–35	178		49		<.03	2.012	1.039–3.893
>36	95		13				

Table 4. Recidivism behavior among RMDUs and predicted risk factors for drugged driving recidivism.

	RMDU					
	N	%		P	OR	95% CI
Recidivist	273	81	Versus RPDU	.001	1.99	1.43–2.80
Substance						
Cocaine only	195	72		.001	1.89	1.36–2.62
Morphine only	47	17		.005	1.59	1.07–2.38
Δ^9-THC only	31	11		.001	0.25	0.16–0.41

Table 5. Recidivism behavior among RPDUs and predicted risk factors for drugged driving recidivism.

	RPDU					
Characteristics	*N*	%		*P*	OR	95% CI
Recidivist	62	19	Versus RMDU	.001	1.99	1.43–2.80
Cocaine and Δ⁹-THC	37	60	Versus cocaine	.05	1.65	1.04–2.61
			Versus Δ⁹-THC	.001	1.30	1.98–6.92
Cocaine and morphine	19	31	Versus cocaine	N.S.	1.44	0.78–2.61
			Versus morphine	N.S.	1.20	0.61–2.41
Morphine and Δ⁹-THC	5	8	Versus morphine	N.S.	3.15	0.84–12.01
			Versus Δ⁹-THC	N.S.	2.17	0.77–10.83
Morphine, cocaine, and Δ⁹-THC	1	1				

N.S. = not significant.

Table 6. Substances detected in the second test during the observation phase: RMDU group.

Characteristics		*N*	%
Cocaine recidivist	Cocaine	159	81
	Morphine	9	5
	Δ⁹-THC	27	14
Morphine recidivist	Cocaine	13	28
	Morphine	29	62
	Δ⁹-THC	5	10
Δ⁹-THC recidivist	Cocaine	16	52
	Morphine	1	3
	Δ⁹-THC	14	45

Table 7. Substances detected in the second test during the observation phase: RPDU group.

Characteristics		*N*	%
Cocaine and Δ⁹-THC recidivist	Cocaine only	19	50
	Morphine only	1	3
	Δ⁹-THC only	10	26
	Cocaine and Δ⁹-THC	8	21
Cocaine and morphine recidivist	Cocaine only	11	58
	Morphine only	5	26
	Δ⁹-THC only	1	5
	Cocaine and morphine	2	11
Morphine and Δ⁹-THC recidivist	Cocaine only	1	20
	Morphine only	1	20
	Δ⁹-THC only	3	60

0.16–0.41, $P < .001$). For the RPDU group, the combination of cocaine and Δ⁹-THC was the most frequently detected, and it significantly increased the likelihood of recidivism compared with monodrug use (cocaine and Δ9-THC versus cocaine: OR = 1.65, 95% CI 1.04–2.61, $P < .05$, versus Δ9-THC: OR = 1.30, 95% CI 1.098–6.9238, $P < .001$), whereas the other 2 drug combinations did not represent risk factors (Table 5).

The subsequent drug test results for the recidivist RMDU and RPDU groups are reported in Tables 6 and 7. In the RMDU group, among almost all cocaine and opiate users, the drug of abuse detected was the same as the first control. The only exception was the recidivism data for Δ⁹-THC users; the most prevalent substance found in subsequent tests was cocaine, followed by Δ⁹-THC. For the RPDU group, cocaine alone was the prevalent drug of abuse found in almost all cases in subsequent tests. Only 20% of repeat polydrug users who used cocaine and Δ⁹-THC continued to use the same combination of drugs.

Discussion

The aims of this study were to estimate the extent of recidivism among polydrug users, the specificity of drug combinations, and the demographic characteristics of the populations under study (sex and age). Both polydrug use and recidivism are complex phenomena, making it difficult to estimate their real extent. Most studies of polydrug use and repeat misuse are clinical and involve specific populations (e.g. clinical patients, students or adolescents, reoffenders, rearrested and reincarcerated people) or are based solely on cases of drugged driving involving a crash, hospitalizations, and arrests. The current study takes into account a larger and more general population of drivers who were tested for drugs either randomly or following a road accident, using the database of positive hair samples in the forensic toxicology laboratory of the University of Macerata. The substances that can be tested for to regain a driver's license are numerous, and indications vary among different European states and within individual regional units (Holmgren et al. 2007; Rooney et al. 2017). This study focuses on the 3 drugs (cocaine, opiates and cannabinoids) required by the CML of the Marche region, which are also the most widely used substances of abuse in Italy. In Italy, each CML applies personal protocols (choice of matrices to be analyzed and substances to be tested) to assess fitness to drive (Pascali et al. 2019). Although this might seem limiting because many illicit drugs are used, the large number of samples analyzed helps to give a good picture of the situation in the Marche region, and the possibility of applying the same study method in other Italian CMLs is not excluded. Many studies in the literature have focused on examining polydrug use in impaired driving recidivism in which one of the substances involved is alcohol (Christophersen et al. 2002; Snenghi et al. 2018; Gili et al. 2022). Less is known about the impact of polydrug use on impaired driving recidivism when alcohol is not involved (Ojaniemi et al. 2009; Tassoni et al. 2016). Furthermore, these studies used blood or urine as the matrix of choice. We have studied the relationship between polydrug use and recidivism behavior using the hair matrix (Snenghi et al. 2015, 2018). This alternative matrix presents many advantages for studying the effect of polydrug use on the likelihood of recidivism. Hair analysis is able to provide information on long-term use of illicit drugs and is therefore more effective than other matrices as a means of retrospective monitoring over a determined observation period. Furthermore, studying a large, homogeneous, and general population of randomly tested drivers allows for a better understanding of the relevance of the complex phenomenon of polydrug use in repeated misuse, which poses the threat of increased likelihood of recidivism in drugged driving.

Our study showed that drugged driving recidivism represents a significant problem for safe driving (23% of the initial positive data). Other studies have shown that polydrug use is common in cases of repeated impaired driving offenses (Christophersen et al. 2002; Tassoni et al. 2016), although others deny this relationship (Snenghi et al. 2018). Our analysis of the relationship between polydrug use and risk of recidivism showed that polydrug use is an important risk factor for recidivism. From the results of the study, it is evident that the likelihood of repeated substance use increases significantly among polydrug users compared to monodrug users. However, the difference between the 2 groups did not reach statistical significance for high repeat offenders (more than 3 times positive). Males had higher recidivism rates than females in both groups of drug users (Christophersen et al. 2002; Tassoni et al. 2016; Lijarcio et al. 2022). However, the analysis of the data in relation to sex did not show statistical differences between recidivist males and females in either the mono- or polydrug user groups. In contrast, when age was considered, significant differences were found between the 2 recidivist groups. Repeat polydrug users tended to be younger than repeat monodrug users. We found that polydrug users below the age of 36 had a higher recidivism risk than monodrug users, confirming other studies (Christophersen et al. 2002; Tassoni et al. 2016). Hair analysis performed during the observation period (second and subsequent tests) confirmed that cocaine is the most frequently used substance among repeat monodrug users, followed by Δ^9-THC. For repeat polydrug users, the combination of cocaine and Δ^9-THC was prevalent, followed by the concurrent use of cocaine and morphine. All drugs of abuse are associated with a significantly higher likelihood of recidivism among impaired driving offenders in the monodrug group, as supported by data in the literature (Hausken et al. 2004; Impinen et al. 2009). For the polydrug recidivist group, only cocaine and Δ^9-THC co-consumption was associated with a significantly higher risk of recidivism, whereas the combinations of morphine and cocaine and morphine and Δ^9-THC were not risk factors for recidivism. Our results showed that almost all polydrug users became monodrug users after the first positive tests. Cocaine was the most frequently detected drug, and some cocaine and Δ^9-THC users continued to use this combination, confirming the prevalence of cocaine as a primary substance (Kalayasiri et al. 2010; Gómez-Talegón et al. 2012). Polydrug use has been associated with aversive outcomes such as cognitive and motor function decline and increased drug dependence. Until now there have been few studies on the influence of prolonged and/or chronic use of more than one substance on drug dependence (Aharonovich et al. 2005). According to the literature, the consumption of cannabis can help to reduce cocaine dependence (Aharonovich et al. 2005; Crummy et al. 2020). Our results indicate that cannabis use has an effect on cocaine dependence, whereas it does not affect heroin dependence.

In conclusion, the results of this study show that the use of more than one substance among recidivist drug users is very high, and this seems to be a significant problem among males in the younger age group, particularly regarding the co-consumption of cocaine and Δ^9-THC. Studies in the literature are related to polydrug use in particular populations (clinical patterns, interview data) or focus mainly on alcohol co-consumption. To the best of our knowledge, this is the first study to analyze the recidivism rate of polydrug users (excluding alcohol) and the possible risk factors for repeated driving under the influence of drugs (excluding alcohol) in the future. Furthermore, the amount and homogeneity of the data analyzed most likely reflect these phenomena in the general population, thus highlighting the real risk of drugged driving recidivism and the threat this poses to road safety (Movig et al. 2004; Organization for Economic Cooperation and Development 2016).

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Disclosure statement

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Data availability statement

The data used for this article are available on reasonable request to the corresponding author.

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