Biomedical Sciences and Clinical Medicine 2026;65:1-9. [In Press]
doi: 10.12982/BSCM.2026.18
https://he01.tci-thaijo.org/index.php/CMMJ-MedCMJ/index

BSCM
Biomedical Sciences and Clinical Medicine

Original Article

Open Access

Prevalence of Alcohol and Drugs in Fatal Road Traffic Injuries (RTIs) in a Thai Population Between 2018 and 2023

Patcharanun Chulamanee and Peerayuht Phuangphung

Department of Forensic Medicine, Faculty of Medicine, Siriraj Hospital, Mahidol University, Bangkok, Thailand

Correspondence:
Peerayuht Phuangphung, MD,
Department of Forensic Medicine,
Faculty of Medicine, Siriraj
Hospital, Mahidol University,
2 Wanglang Road Bangkoknoi,
Bangkok 10700, Thailand.
E-mail: Peerayuht.phu@mahidol.
ac.th

Received: July 29, 2025;
Revised: October 17, 2025;
Accepted: October 27, 2025

ABSTRACT

OBJECTIVE To determine and compare the prevalence of alcohol, drugs of abuse and medicines in fatal road traffic injuries (RTIs) in Thailand from 2018 through 2023.

METHODS A retrospective study was conducted of fatal RTI cases sent for autopsy at the Department of Forensic Medicine, Siriraj Hospital, Mahidol University from 2018 through 2023. Subject data, including sex, age, type of RTI case, blood alcohol concentration (BAC), and urine drug profile, were collected. Descriptive statistics, Chi-square tests, Mann–Whitney U tests, and Kruskal–Wallis H tests were performed as appropriate.

RESULTS From 2018 through 2023 a total of 1,979 fatal RTI cases were included in this study. Of those cases, 1,649 were male (83.3%) and the mean subject age was 37.3 years. The yearly prevalence of driving under the influence (DUI) of alcohol (BAC > 50 mg/dL) during the study period was between 45.80% and 53.40% with the exception of 2022, which showed a significant increase at 57.10% ($p < 0.05$). The prevalence of drugs in 2023 was 21.00%, a significant difference compared with the prevalence in 2018 of 13.70% ($p < 0.05$). The prevalence of cannabis use showed an increasing trend, with a statistically significant increase in 2023 ($p < 0.05$). The prevalence of multiple drug use also significantly increased over the study period, particularly in 2023 ($p < 0.05$).

CONCLUSIONS The prevalence of drugs of abuse and medication in fatal RTI cases markedly increased over the study period, particularly in 2023. There was a significant increase in cannabis use and poly-drug use in fatal RTI cases over the period, especially in 2023.

KEYWORDS road traffic injury, alcohol, drugs, Thai, postmortem

INTRODUCTION

Road traffic injuries (RTIs) are among the leading causes of death worldwide. In Thailand, RTIs were reported to be among the top five causes of death (1). The annual number of RTI deaths from 2011 through 2021 ranged from 18.7 to 34.3 per 100,000 per year, with an average number of RTI deaths of 30.3 per 100,000 population per year (1). Driving under the influence (DUI) of alcohol and drugs has been well-studied as one of the major causes of RTI, other than roadway geometric features, light, and weather conditions (2). A previous study suggested that an increased blood alcohol concentration (BAC) was associated with a higher risk of fatal RTIs, and the odds ratio (OR) for a BAC of 20 and 80 mg/dL was estimated to be 3.64 and 13.0, respectively (3). A meta-analysis study indicated that a BAC above 20 mg/dL was

associated with impairment of driving performance when assessed on a simulated driving platform (4). Among DUIs involving drugs, alcohol-drug combinations were found to be strongly correlated with severe RTIs (adjusted OR = 39.15), followed by drug-drug combinations (adjusted OR = 7.02) (5).

The prevalence of DUI of alcohol and drugs and the drug types in the RTI population can be different in each country. In Thailand, Sribanditmongkol et al. reported that the alcohol-positive rate in autopsied fatal RTI cases during the period 2007-2019 was 48.47% and the median BAC among those alcohol-positive blood samples was 192 mg/dL (6). Another study in Thailand found that the prevalence of psychoactive drugs present in urine samples from drivers in Thailand tested between 2005 and 2006 was 9.70%, and the most common drugs found were antihistamines, amphetamine, and cannabis (7). These figures differ from those reported in some European countries. For example, in Italy, it was reported that the average prevalence of BAC > 50 mg/dL for all driver types from 2011 to 2018 was 16.2% (13.80%-17.30%) (8). Similarly, the overall prevalence of BAC > 50 mg/dL in Norway between 2011 and 2020 was found to be 14.40% (9). For cases of DUI of drugs, the prevalence of drug-positive injured drivers ranged from 16.80%-24.10% in Italy (8), while the overall prevalence of drug-positive drivers and illicit drug-positive fatal driver cases in Norway were 15.80% and 10.70%, respectively (9).

Based on published accounts and other available data, it is noteworthy that there has seemingly been a critical transformation in the world in recent years, and especially in Thailand, the focus of this study, since the COVID-19 pandemic outbreak in 2020 and since the implementation of new drug policies in Thailand. Specifically, the Thai government-initiated endorsement of a legalized medical cannabis policy in 2019 and subsequently enacted legislation that allowed cannabis and mitragynine to be used legally by the general population beginning in 2020 and 2021, respectively (10). It has been suggested that the effects of the COVID-19 pandemic on changing Thai people's behaviors and the decriminalization of cannabis and mitragynine as official Thai government policy may have had an impact on alcohol and drug use trends in RTI cases in Thailand. The objective of this study was to determine the prevalence of alcohol, drugs of abuse, and medicines in fatal RTI cases in Thailand from 2018 through 2023 to test this hypothesis. Our findings provide essential insights which are important for achieving greater awareness of current alcohol and drug use trends in fatal RTI cases in Thailand for forensic pathologists which will be fundamental for informed consideration of Thailand's public policies on drugs and traffic accident prevention.

METHODS

A retrospective study was conducted on fatal RTI cases sent for autopsy at the Department of Forensic Medicine, Faculty of Medicine, Siriraj Hospital, between 2018 and 2023. The inclusion criteria were Thai people who were 15 years old or over at death, and who had died within 3 hours of sustaining an RTI. The exclusion criteria were cadavers that had signs of decomposition and RTI cases of vehicles hitting pedestrians. Femoral blood samples were obtained for analysis of the BAC following the Thai legislation Ministerial Regu-lations B.E. 2567 (2024) by virtue of the provisions of Section 5 of the Road Traffic Act B.E. 2522 (1979). In addition, urine samples were collected for analysis of illicit drugs and medications based on the relevant statement in the Thai legislation in Ministerial Regulations B.E. 2548 (2005) for urine analysis in RTI cases.

The subjects' data, including sex, age, type of RTI case, BAC, and urine drug profile, were collected by year of death from 2018 through 2023 for assessing annual statistics. Analysis of the BAC was performed using headspace gas chromatography with a flame ionization detector (HS-GC-FID). The method used for alcohol analysis was adapted from previous studies performed elsewhere (11). The limit of detection (LOD) and lower limit of quantitation (LLOQ) for blood ethanol analysis were 2.5 mg/dL and 10 mg/dL, respectively. The definition of alcohol-positive cases (following the new Thai legislation) applies to subjects with a BAC ≥ 20 mg/dL. The urine drug profiles were obtained by a drug screening panel using liquid chromatography quadrupole time-of-flight mass spectrometry (LC-QTOF/MS) and gas chromatography triple quadrupole tandem mass spectrometry (GC-MS/MS). Urinary drug

profiles obtained from LC-QTOF/MS analysis had a LOD and a LLOQ of 10 ng/mL and 20 ng/mL, respectively. Urinary cannabis profiles were analyzed by GC-MS/MS and LOD and LLOQ of delta 9-tetrahydrocannabinol (THC), 11-hydroxy-delta 9-tetrahydrocannabinol (11-OH-THC) and 11-Nor-9-carboxy- delta 9-tetrahydrocannabinol (THC-COOH) set at 0.1 ng/mL and 0.2 ng/mL, respectively (12). All analytical methods used in the present study were validated using the Standard Guidelines in Forensic Toxicology (13).

Statistical analysis was conducted using IBM SPSS® Statistics for Windows version 25. Descriptive statistics were used for the descriptive data, including mean, median, and standard deviation (SD). Comparisons between the prevalence of DUI of alcohol and drug use were performed using the chi-square test. Comparisons of the BAC over the six-year study period were performed using the Mann-Whitney U test and Kruskal-Wallis H test.

RESULTS

From 2018 to 2023, the total number of fatal RTIs sent for autopsy at the Department of Forensic Medicine, Faculty of Medicine, Siriraj Hospital and were recruited into this study was 1,979, divided into study years as follows: 348 (2018), 366 (2019), 316 (2020), 325 (2021), 314 (2022), and 310 (2023). Among the total cases, 330 were female (16.70%) and 1,649 were male (83.30%). The average ages of the female and male subjects at death were 42.12 and 36.37 years old, respectively. The most frequent category of RTI subject was motorcycle riders (72.06%), followed by pedestrians (13.44%), and car drivers (6.01%). The three types of RTI cases classified by each year are provided in Table 1.

Table 1. The three main types of RTI cases (motorcycle riders, car drivers, and pedestrians) classified by year

Year	Motorcycle rider	Car driver	Pedestrian
2018	238 (68.39)	33 (9.48)	50 (14.37)
2019	256 (69.95)	20 (5.46)	52 (14.21)
2020	229 (72.45)	9 (2.85)	51 (16.14)
2021	243 (74.77)	18 (5.54)	44 (13.54)
2022	227 (72.29)	20 (6.37)	39 (12.42)
2023	233 (75.16)	19 (6.13)	30 (9.68)
Total	1426 (72.06)	119 (6.01)	266 (13.44)

RTI, road traffic injury

The average BAC levels for all RTI cases and for the driver-only cases (motorcycle riders and car drivers) in each of the years of the study period (2018-2023) are shown in Figure 1. The annual mean BAC in both the total RTI cases and rider/driver-only cases did not show any significant difference, except in 2022 ($p = 0.008$). The overall results for the alcohol-positive cases are shown in Table 2. The majority of the DUI of alcohol cases were men and most were motorcycle riders. Overall, the male subjects had a significantly higher BAC than the female subjects ($p < 0.001$). When considering BAC > 50 mg/dL, however, the BAC of the male subjects was not significantly different from that of the female subjects ($p = 0.344$). Overall, pedestrians had a significantly lower BAC than motorcycle riders and car drivers ($p = 0.031$). However, when considering cases with BAC > 50 mg/dL, the pedestrians had a significantly higher BAC than both the motorcycle riders and car drivers ($p < 0.001$). Comparing cases of only alcohol use and cases with a combination of alcohol and drug use, subjects who were positive only for alcohol had a significantly higher BAC than subjects who

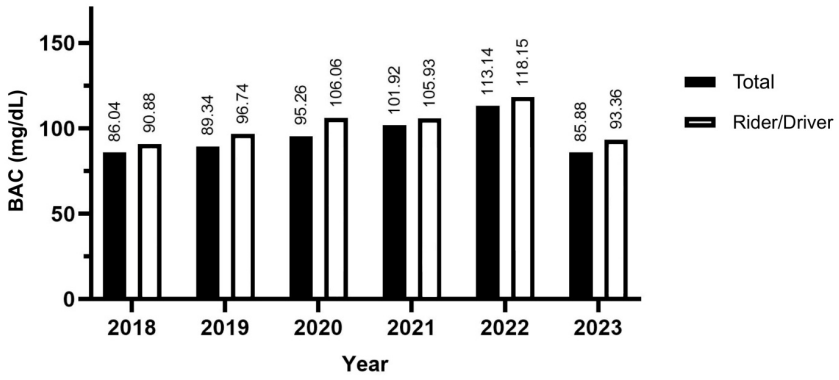

Figure 1. Mean blood alcohol concentration levels of all road traffic injury cases and rider/driver cases over the study period 2018-2023

Table 2. Prevalence of alcohol-positive cases and BAC by sex, type of RTI case, and patterns of drugs found in subjects

Parameters	Alcohol positive N (%)	Alcohol > 50 mg/dL N (%)	BAC Mean, SD	BAC > 50 mg/dL Mean, SD
Total (N = 1979)	994 (50.23)	907 (45.83)	95.01, 114.01	204.35, 78.69
Sex				
Male	920 (92.56)	848 (93.50)	106.77*, 115.89	205.03, 78.43
Female	74 (7.44)	59 (6.50)	36.20, 81.95	194.50, 82.34
Types of RTI case				
motorcycle rider	780 (78.47)	715 (78.83)	101.53, 111.78	198.50, 75.56
Car driver	68 (6.84)	59 (6.50)	102.08, 108.59	200.66, 64.93
Pedestrian	90 (9.05)	85 (9.37)	83.02*,130.76	258.73*,89.47
Pattern				
Alcohol only	897 (90.24)	822 (90.63)	102.24*, 89.14	207.14*, 77.84
Alcohol and drugs	97 (9.76)	85 (9.37)	53.05, 90.98	177.32, 82.14

BAC, blood alcohol concentration; RTI, road traffic injury

*at each parameter indicated that the parameter was significantly different from the other parameter(s) in the other row(s) at $p < 0.05$

had used alcohol with drugs in both the alcohol-positive cases ($p < 0.001$) and BAC > 50 mg/dL cases ($p = 0.002$).

The most frequent drug substance found in the RTI cases was methamphetamine (4.80%), followed by cannabis (3.80%), and benzodiazepines (3.50%). Diazepam (2.90%) was the dominant drug in the benzodiazepine group. Mitragynine (3.10%) was another drug frequently found in this study. Tramadol and antihistamine were found at similar rates (2.50%). Chlorpheniramine (0.90%) and diphenhydramine (0.80%) were frequently found drugs in the antihistamine group. The other drugs that were detected, albeit at a relatively low rate, were ketamine (1.30%), heroin (0.90%), antidepressants (0.70%), and 3,4 methylenedioxy-N-methamphetamine (MDMA) (0.40%).

In total, 1,188 cases (60.03%) were positive for alcohol, drugs of abuse and/or medicines, of which 1,010 (51.04%) were motorcycle riders or car drivers. The positive RTI cases were predominantly males, with 1,096 cases (92.26%). The prevalence of alcohol (BAC over the legal limit of 50 mg/dL) and drugs in the total RTI cases and in the rider/driver cases during the study period, 2018-2023, are summarized in Figure 2. The number of RTI cases and DUI cases who had a BAC greater than 50 mg/dL was significantly higher in 2022 than in the other five years ($p = 0.033$), whereas the prevalence of RTI and DUI cases that had a BAC greater than 50 mg/dL in the other five years did not show any statistically significant difference. Urine analysis revealed that 14.70% of the samples were positive for drugs of abuse or medication. The trend of RTI subjects who tested positive for drugs of abuse or medication escalated from 2018 to 2023, with a significant increase noted in 2023 (p = 0.023). Similarly, the riders and drivers cases also showed a similar increasing trend of drug use, with a significantly higher number observed in 2023 ($p = 0.017$). Figure 2A and 2B shows the trends in the prevalence of alcohol and drugs found in all RTI cases and for driver cases, both of which showed a similar trend over the study period.

Methamphetamine and benzodiazepine in fatal RTI cases did not show significant differences over the six-year study period. The average positive rates (range) for methamphetamine and benzodiazepines were 4.84% (2.53-6.69%) and 3.50% (2.46-4.75%), respectively. Cannabis use gradually increased over the same period, with statistical significance only in 2023 ($p = 0.012$), as shown in Figure 3A. Mitragynine, tramadol, and ketamine use also gradually increased, although the figures were still not significantly different over the six years (Figure 3A and 3B). The number of antihistamine and 3,4 methylenedioxy-N-methamphetamine (MDMA) users significantly increased, particularly in 2022 and 2023 ($p = 0.002$) (Figure 3A and 3B).

The most common pattern of drug use in the fatal RTI cases remained single drug use (9.30%), a pattern which was relatively stable over the six-year study period. However, use of more than one drug was also reported in many cases, with

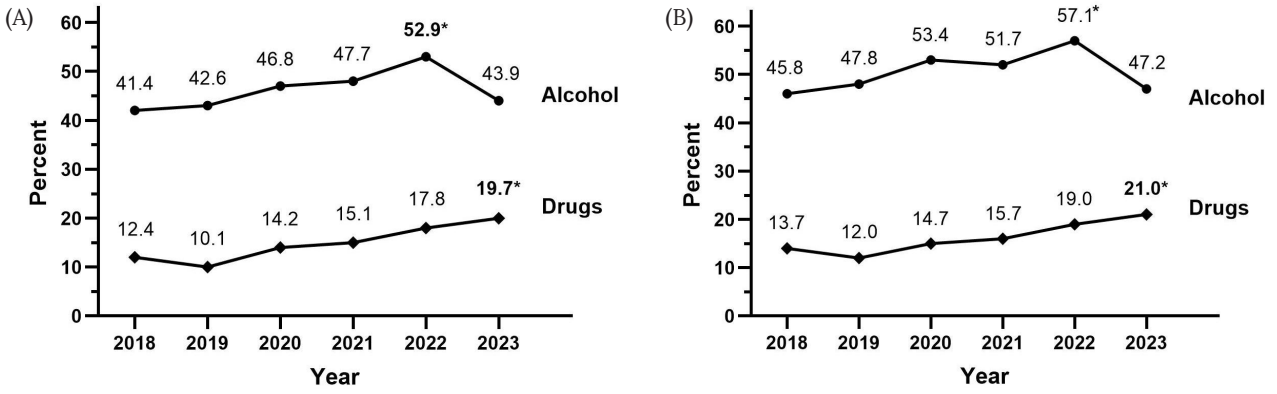

Figure 2. Prevalence of alcohol and drug use in fatal road traffic injury (RTI) cases over the study period 2018–2023 (Figure 2A: all RTI cases, Figure 2B: riders/drivers) *significant at $p < 0.05$

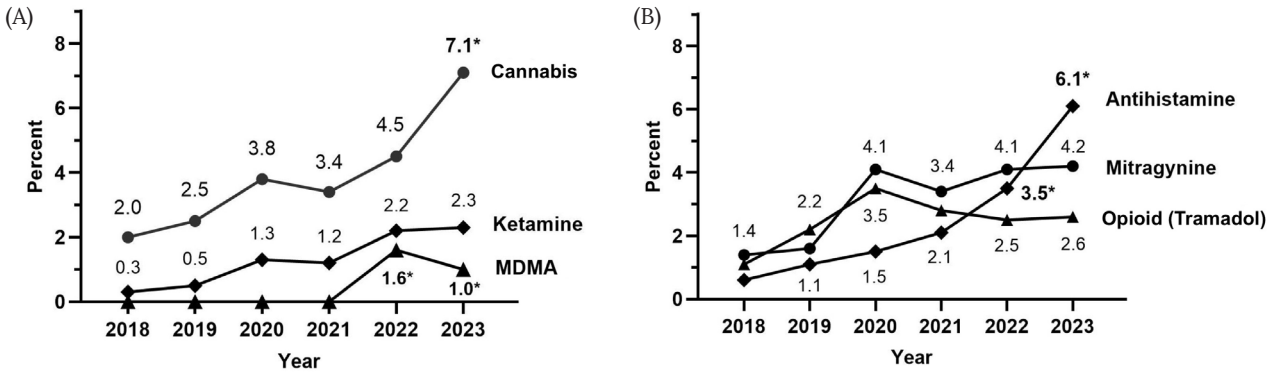

Figure 3. Prevalence of specific drugs of abuse and medication in the fatal rider/driver cases over the study period 2018–2023 (Figure 3A: cannabis, ketamine, and MDMA; Figure 3B: mitragynine, antihistamine, and tramadol) *significant at $p < 0.05$

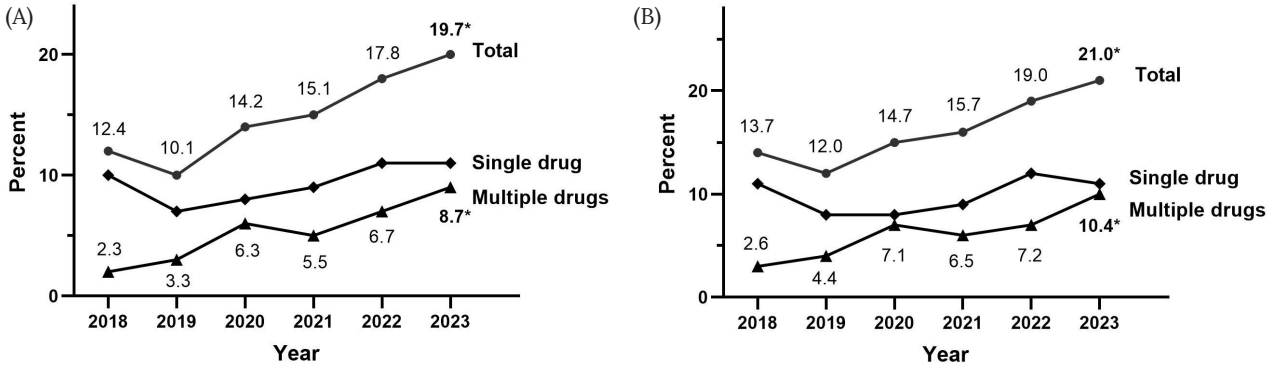

Figure 4. Prevalence of single and multiple drug use in fatal road traffic injury (RTI) cases over the study period 2018-2023 (Figure 4A: all RTI cases, Figure 4B: riders/drivers) *significant at $p < 0.05$

combinations of two or more drugs becoming increasingly prevalent. The maximum number of drugs found per case was nine in 2020; however, the number of cases with multiple drug use (two or more drugs) significantly increased, particularly in 2023 ($p = 0.027$), as shown in Figure 4A. A similar trend of multiple drug use was also found in riders and drivers, and it also significantly increased in 2023 ($p = 0.013$) (Figure 4B).

DISCUSSION

This study investigated the prevalence of alcohol, drugs of abuse, and medicines in fatal RTI cases corresponding to a study period covering the COVID-19 pandemic outbreak and the recent legalization of certain drugs in Thailand. The first positive COVID-19 case in Thailand was reported in January 2020, resulting in the government declaring a state of emergency in March 2020 and

an intense lockdown. This period coincided with a decrease in the number of fatal road traffic injuries from 348 (2018) and 366 (2019) prior to the COVID-19 outbreak to 316 (2020) during the COVID-19 lockdown period. Interestingly, the number remained relatively constant from 2020 through 2023. However, looking at the finer details, it was found that the number of motorcycle rider RTI fatalities, which were the majority of our subjects, remained relatively constant throughout the study period of 2018-2023 (Table 1). This suggests that the government measures did not have an obvious impact on motorcycle use in Thailand.

The prevalence of BAC > 50 mg/dL cases among the total fatal RTI cases and rider/driver cases from 2018 to 2023 ranged from 41.70% to 52.90% and from 45.80% to 57.10%, respectively. These figures are consistent with the findings of Sribanditmongkol et al., who studied Thai medicolegal cases and reported an overall prevalence of alcohol-positive RTI cases of 48.47% (6). In addition, a previous study reported a similar prevalence of DUI of alcohol in Brazil of 43.00%-48.00% (14). However, our figures differ from trends of DUI of alcohol in European countries, Australia, and USA, which have reported prevalences ranging from 2.90% to 19.30% (14). Moreover, most of the trends of DUI of alcohol in the aforementioned developed countries have shown a decline in recent years (14), whereas the trend in Thailand for the period 2018-2023 was relatively stable with the exception of 2022. A spike we observed in DUI of alcohol in 2022 after the COVID-19 lockdown in Thailand which corresponds with the findings of Mehranbod et al., who reported an increasing proportion of DUI of alcohol cases after lockdown (15). Sribanditmongkol et al. reported that the median BAC in alcohol-positive cases in RTI cases was 192 mg/dL (6). Walters et al. also reported mean BAC levels in DUI of alcohol cases (BAC cut-off > 80 mg/dL) ranging from 151 to 199 mg/dL over the period 2019-2021 (16). These figures were consistent with our study, where the mean BAC levels among motorcycle riders and car drivers who had BAC > 50 mg/dL were 198.41 and 200.66 mg/dL, respectively. These findings show that although the BAC levels in those subjects were much higher than the legal limit in Thailand, they were not significantly different from the levels found in other studies. However, the proportion of cases that had a BAC greater than the legal limit in Thailand was significantly higher than in other developed countries. Thus, further law enforcement might be required to reduce the fatal RTI cases associated with DUI of alcohol.

Regarding the prevalence of drug use in RTI cases in Thailand, a previous study stated that the proportion of drug-positive urine samples in drivers in Thailand was 9.70% in 2005-2006 (7). This figure was slightly lower than the prevalence of drug-positive urine samples in drivers in 2018 and 2019 found in this study (13.70% and 12.00%, respectively). However, we did find an increasing trend from 2019 to 2023, with a significant increase to 21.0% in 2023. The prevalence of drug-impaired drivers in fatal RTI cases in Norway, Australia, and USA were reported to be 15.80%, 26.70%, and 27.70%, respectively (9, 17, 18). However, care should be exercised when comparing the figures related to DUI of drugs as our study concentrated on the detection of drugs in urine, whereas in most previous studies the figures were based on the detection of drugs in blood (9, 17, 18). Our results thus only suggest that the prevalence of drug-positive drivers in Thailand has shown an increasing trend recently compared with the trend observed in 2005-2006 (7). Although the latest recommendation for the toxicological investigation of DUI cases suggests blood or oral fluid collection as specimens of choice (19), the current Thai legislation still requires the use of urine samples for the detection of drugs in DUI cases, especially for methamphetamine. Thus, further study should be conducted related to the detection of drugs in blood or oral fluids in DUI cases to bridge this gap.

A previous study stated that the most common drugs found in Thai drivers were antihistamine, amphetamine, and cannabis (7). However, the present study found that the most common drugs detected in riders/drivers in Thai postmortem cases were methamphetamine, cannabis, and benzodiazepine. Undoubtedly, the drug use trends in Thailand are different from in other countries in Europe, Australia, and USA, because the common drugs found in those countries are relatively similar and consist mostly of cannabis, stimulants (methamphetamine and cocaine), and benzodiazepine (9, 14, 17, 18, 20). However,

the most common drugs found in DUI of drugs in Italy have been reported to be cocaine, opiates/opioids, and cannabis in descending order (8). Meanwhile in Hong Kong, cocaine, ketamine, and methamphetamine (in that order) were found to be the most prevalent drugs in DUI of drugs cases (21). In contrast, our study did not identify cocaine use in any of the RTI cases. This finding suggests that the common drugs found in RTI cases depend on the geographical area, local drug prevalence and drug availability.

An increasing trend of cannabis use was observed in Thai riders/drivers in this study, and this trend is consistent with the initiation of cannabis legalization in Thailand in 2019, with a significant surge of 7.1% seen in 2023, a subject which needs further investigation. This pattern is consistent with a study in the USA that showed an increased prevalence of cannabis use in fatally injured drivers in 12 states in the USA after the implementation of legalized medical marijuana laws in those states (22). These findings suggest that legalization might result in an increase in the prevalence of cannabis use in the future, as well as in both RTI cases and other causes of death. This trend should be closely observed as the current Thai government plans to re-consider changing the cannabis law under pressure from the public sector. In addition, an increasing trend of multiple drug use in fatal RTI cases was found in this study, even though single drug use was still the most common pattern found in RTI cases. Poly-drug use in DUI drug cases is more common in Europe, Australia, and USA, with reported figures of around 20.00%-40.00% of DUI of drugs cases (9, 14, 18, 23, 24).

Although multiple drug use in our study was lower, at 10.4%, a continuously increasing trend was observed. This trend should be closely monitored because drug-drug combinations can have a more significant impact on driving ability (5).

The main limitation of this study is related to the area where the RTI cases were recruited in this study, because the Department of Forensic Medicine, Siriraj Hospital is responsible for medico-legal cases only in the western area of Bangkok (western side of the Chao Phraya river). The trends observed in this area may not reflect the trends for the whole or other parts of Thailand as the prevalence of the use of some drugs may differ in other areas, leading to potentially different laboratory results. In addition, there were only a small number of female subjects (16.70%), so gender-related findings should be carefully interpreted. Therefore, we recommend that further study should be conducted in multicentered settings and should inlcude more female subjects to supplement our findings.

CONCLUSIONS

This study showed there was a relatively steady trend in the prevalence of DUI of alcohol over the study period (2018-2023) with the exception of a significantly higher prevalence in 2022. Additionally, the prevalence of drugs of abuse and medication in fatal RTI cases significantly increased over the study period, especially in 2023. In particular, a significant increase in cannabis use was observed which coincides with the recent legalization of cannabis in Thailand. In addition, the prevalence of multiple drug use in fatal RTI cases also significantly increased in 2023.

ACKNOWLEDGMENTS

The authors sincerely acknowledge the assistance of Asst. Prof. Dr. Chulaluk Komoltri for her constructive support and advice on the statistical analysis.

CONFLICTS OF INTEREST

The authors have no conflicts of interest to report.

FUNDING

This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

AUTHOR CONTRIBUTIONS

P.C.: conceptualization, literature review, methodology, data curation, data analysis, writing – original draft preparation; P.P.: conceptualization, literature review, methodology, review & editing, supervision.

All authors read and approved the final version of this manuscript that was submitted for publication.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

INSTITUTIONAL REVIEW BOARD STATEMENT

This study was conducted in accordance with the Declaration of Helsinki and approved by the Institutional Review Board of the Faculty of Medicine Siriraj Hospital with COA no. Si 184/2024 (SIRB Protocol No. 131/2567 (IRB2), approval date March 3, 2024).

INFORMED CONSENT STATEMENT

Informed consent was waived due to the retrospective nature of the study and the analysis used anonymous data.

REFERENCES

1. Seresirikachorn K, Singhanetr P, Soonthornworasiri N, Amornpetchsathaporn A, Theeramunkong T. Characteristics of road traffic mortality and distribution of healthcare resources in Thailand. Sci Rep. 2022;12:20255. PubMed PMID: 36424407.
2. Behnood A, Mannering FL. The effects of drug and alcohol consumption on driver injury severities in single-vehicle crashes. Traffic Inj Prev. 2017;18:456-62.
3. Taylor B, Rehm J. The relationship between alcohol consumption and fatal motor vehicle injury: high risk at low alcohol levels. Alcohol Clin Exp Res. 2012;36: 1827-34.
4. Irwin C, Iudakhina E, Desbrow B, McCartney D. Effects of acute alcohol consumption on measures of simulated driving: a systematic review and meta-analysis. Accid Anal Prev. 2017;102:248-66.
5. Hels T, Lyckegaard A, Simonsen KW, Steentoft A, Bernhoft IM. Risk of severe driver injury by driving with psychoactive substances. Accid Anal Prev. 2013; 59:346-56.
6. Sribanditmongkol P, Junkuy A, Homkham N, Worasuwannarak W, Hess JA. Autopsy study of alcohol-associated unnatural deaths in Thailand, 2007-2019. Alcohol Clin Exp Res (Hoboken). 2023;47:2056-67.
7. Ingsathit A, Woratanarat P, Anukarahanonta T, Rattanasiri S, Chatchaipun P, Wattayakorn K, et al. Prevalence of psychoactive drug use among drivers in Thailand: a roadside survey. Accid Anal Prev. 2009;41: 474-8.
8. Barone R, Pelletti G, Garagnani M, Giusti A, Marzi M, Rossi F, et al. Alcohol and illicit drugs in drivers involved in road traffic crashes in Italy. An 8-year retrospective study. Forensic Sci Int. 2019;305:110004. PubMed PMID: 31707239
9. Gjerde H, Frost J. Prevalence of alcohol and drugs among drivers killed in road traffic crashes in Norway during 2011-2020. Traffic Inj Prev. 2023;24:256-61.
10. Kalayasiri R, Boonthae S. Trends of cannabis use and related harms before and after legalization for recreational purpose in a developing country in Asia. BMC Public Health. 2023;23(1):911. PubMed PMID: 37208663
11. Wongchanapai W, Dokpuang D, Sasithonrojanachai S, Tamtakerngkit S. Stability of postmortem blood ethanol under experimental conditions. Siriraj Med J. 2008;60:62-65.
12. Charatprakai P, Sukata S, Phuangphung P. Comparison of blood and urinary cannabis profiles between road traffic injury (RTI) and other causes of death in Thai postmortem cases. Biomedical Sciences and Clinical Medicine. 2025;64:182-92.
13. Scientific Working Group for Forensic Toxicology. Scientific Working Group for Forensic Toxicology (SWGTOX) standard practices for method validation in forensic toxicology. J Anal Toxicol. 2013;37:452-74.
14. Christophersen AS, Mørland J, Stewart K, Gjerde H. International trends in alcohol and drug use among vehicle drivers. Forensic Sci Rev. 2016;28:37-66.
15. Mehranbod CA, Gobaud AN, Branas CC, Chen Q, Giovenco DP, Humphreys DK et al. Trends in alcohol-impaired crashes in California, 2016 to 2021: A time series analysis for alcohol involvement and crash distribution among demographic subgroups. Alcohol Clin Exp Res (Hoboken). 2023;47:1119-31.
16. Walters JK, Repp KK, Mew MC. Alcohol and drug presence in traffic crash fatalities before and after the COVID-19 pandemic: evaluation of the fatality analysis reporting system (FARS) and linked medical examiner-vital records data in Clackamas, Multnomah, and Washington County, Oregon, 2019-2021. Forensic Sci Int Synerg. 2024;8:100468. PubMed PMID: 38707715
17. Schumann J, Perkins M, Dietze P, Nambiar D, Mitra B, Gerostamoulos D, et al. The prevalence of alcohol and other drugs in fatal road crashes in Victoria, Australia. Accid Anal Prev. 2021;153:105905. PubMed PMID: 33631704
18. Beirness DJ, Gu KW, Lowe NJ, Woodall KL, Desrosiers NA, Cahill B, et al. Cannabis, alcohol and other drug findings in fatally injured drivers in Ontario. Traffic Inj Prev. 2021;22:1-6.
19. D'Orazio AL, Mohr ALA, Chan-Hosokawa A, Harper C, Huestis MA, Limoges JF, et al. Recommendations for toxicological investigation of drug-impaired driving and motor vehicle fatalities-2021 Update. J Anal Toxicol. 2021;45:529-36.
20. Gjerde H, Jamt REG, Stenehjem JS, Bogstrand ST. Substance use and driver fatality in Norway: an expanded case-control study. Traffic Inj Prev. 2024;26:1-9.
21. Ji Kwon N, Han E. A review of drug abuse in recently reported cases of driving under the influence of drugs (DUID) in Asia, USA, and Europe. Forensic Sci Int. 2019;302:109854. PubMed PMID: 31255839

22. Masten SV, Guenzburger GV. Changes in driver cannabinoid prevalence in 12 U.S. states after implementing medical marijuana laws. J Safety Res. 2014;50:35-52.
23. Carfora A, Campobasso CP, Cassandro P, Petrella R, Borriello R. Alcohol and drugs use among drivers injured in road accidents in Campania (Italy): A 8-years retrospective analysis. Forensic Sci Int. 2018;288:291-96.
24. Simonsen KW, Hasselstrøm JB, Hermansen SK, Rasmussen BS, Andreasen MF, Christoffersen DJ, et al. The incidence of psychoactive substances and alcohol among impaired drivers in Denmark in 2015-2019. Forensic Sci Int. 2022;333:111207. PubMed PMID: 35144220