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# Characteristics of violent deaths in the autopsy material of the Pathology and Forensic Medicine Institute of the Military Medical Academy in Belgrade

## Karakteristike nasilne smrti u obdukcionom materijalu Instituta za patologiju i sudsku medicinu Vojnomedicinske akademije u Beogradu

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**Abstract**

**Background/Aim.** Violent death is caused by external factors. The aim of this study was to determine certain characteristics of violent deaths in the autopsy material of the Pathology and Forensic Medicine Institute of the Military Medical Academy in Belgrade, Serbia. **Methods.** A retrospective study of autopsy reports from forensic autopsies performed from 2010 until 2019 at the Pathology and Forensic Medicine Institute identified certain characteristics of violent death. **Results.** Out of 2,763 forensic autopsies performed during that period, violent death was established in 43.68% of the deceased. The majority of those who died violently were men (73.73%). Violent death was most common in people aged 21–40 years (34.96%). The most dominant cause of violent death was mechanical injuries, followed by chemical and asphyxiation injuries, while physical injuries were the rarest. In 59.32% of violent death cases, toxicological analysis of blood and urine samples showed individual or combined presence of alcohol, drugs, and illegal substances. **Conclusion.** The presented results may be significant for taking measures that will prevent and reduce the number of violent deaths.

**Key words:**
**autopsy; death; forensic medicine; poisoning; serbia; suicide; wounds and injuries.**

**Apstrakt**

**Uvod/Cilj.** Nasilna smrt nastaje delovanjem spoljašnjih činilaca. Cilj rada bio je da se utvrde određene karakteristike nasilnih smrti na obdukcionom materijalu na Institutu za patologiju i sudsku medicinu Vojnomedicinske akademije u Beogradu, Srbija. **Metode.** Retrospektivnom studijom obdukcionih nalaza sudskomedicinskih obdukcija koji su obavljeni u periodu od 2010. do 2019. godine na Institutu za patologiju i sudsku medicinu, utvrđene su određene karakteristike nasilne smrti. **Rezultati.** Od 2 763 sudskomedicinskih obdukcija u tom periodu, nasilna smrt je ustanovljena kod 43,68% obdukovanih. Najveći broj umrlih nasilnom smrću bili su muškarci (73,73%). Nasilna smrt je bila najčešća kod osoba starosti 21–40 godina (34,96%). Najdominantniji uzrok nasilne smrti bile su mehaničke povrede, zatim hemijske i asfiktične, dok su fizičke povrede bile najređe. U 59,32% slučajeva nasilnih smrti toksikološkom analizom uzoraka krvi i urina ustanovljeno je pojedinačno ili kombinovano prisustvo prisustvo alkohola, lekova i nedozvoljenih sredstava. **Zaključak.** Prikazani rezultati mogu biti značajni za preduzimanje mera koje će sprečiti i smanjiti broj nasilnih smrti.

**Ključne reči:**
**autopsija; smrt; medicina, sudska; trovanje; srbija; samoubistvo; povrede.**

### Introduction

At the Pathology and Forensic Medicine Institute (PFMI) of the Military Medical Academy (MMA) in Belgrade, Serbia, forensic autopsies are performed based on the order of the Public Prosecutor's Office in Belgrade, but also the public prosecutor's offices throughout Serbia, on patients who were transported to the MMA after suffering injuries and treated there until their death. A public prosecutor's office issues an order to perform the autopsy in case of violent death, but also in case of sudden, suspicious, and unclear death, which may be natural or violent. Violent deaths may

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be caused by injuries from all groups of standard classification, and may be homicidal, suicidal, or accidental by their origin. In forensic terminology, the concepts of manner—natural vs. violent—as well as the classification of violent deaths into accidental, suicidal, and homicidal, were defined by Prof. Milovan Milovanović in the first half of the 20th century. After the autopsy and based on the police investigation report, in some cases, it is possible to determine which of the three types of death has occurred. Such determination is sometimes impossible, and the judiciary ultimately renders a final decision [1, 2]. From 2002 to 2019, the number of deaths in Serbia decreased by 1.29%. The number of violent deaths *per* 100,000 residents of Serbia dropped from 52.3% to 40.9% from 2002 until 2019. The percentage of violent deaths was 3.82% in 2002 and 2.79% of the total number of deaths in Serbia in 2019 [3]. Violent death occurs as a result of external factors, and it is possible to reduce the number of deaths by pointing out certain factors that lead to such deaths.

The aim of this study was to determine certain characteristics of violent deaths in the autopsy material of PFMI of MMA in Belgrade, and thus indicate the need for the development of certain preventive measures designed to reduce the number of violent deaths.

## Methods

The autopsy reports from the autopsies performed at PFMI of MMA in Belgrade from 2010 until 2019 were analyzed. Additionally, toxicological analyses of blood and urine samples collected during these autopsies were conducted by the Department of Toxicological Chemistry of the MMA, and were reviewed alongside police reports submitted to PFMI before the autopsy. The study was approved by the Ethics Committee of MMA (No. 56/2024, from June 10, 2024).

The toxicological analyses of blood, urine samples, and stomach content, aimed at detecting the presence of alcohol, drugs, and psychoactive substances, were conducted using several methods: gas chromatography with a flame ionization detector (head space technique), liquid chromatography with ultraviolet (UV) spectrum detection and comparison of UV spectrum retention time with the UV spectra toxicology library, and liquid chromatography with mass spectrometry and comparison of mass spectrum with the standard spectrum.

Age representation was determined by grouping individuals into five categories based on their years of life: 0–20, 21–40, 41–60, 61–80, and 81 years or older.

The results were processed by applying descriptive statistics: average, minimum, maximum, and percentage.

## Results

A total of 2,763 forensic autopsies were performed at PFMI of MMA from 2010 to 2019. Violent death was confirmed in 1,207 (43.68%) of autopsied victims. The highest number of violent deaths, 121, occurred in September, and the lowest, 79, in May. The majority of victims of violent deaths, 890 (73.73%), were male. The highest number of victims of violent death (34.96%) were aged 21–40 years (Figure 1). The mean age of violent death victims was 52.12 years. The youngest victim of violent death was a male newborn, while the oldest male victim was 96 years old, and the oldest female victim was 92 years old.

In the majority of cases, 488 (40.43%), the death was a result of mechanical injuries. The leading cause of injuries was blunt force trauma caused by mechanical tools in 330

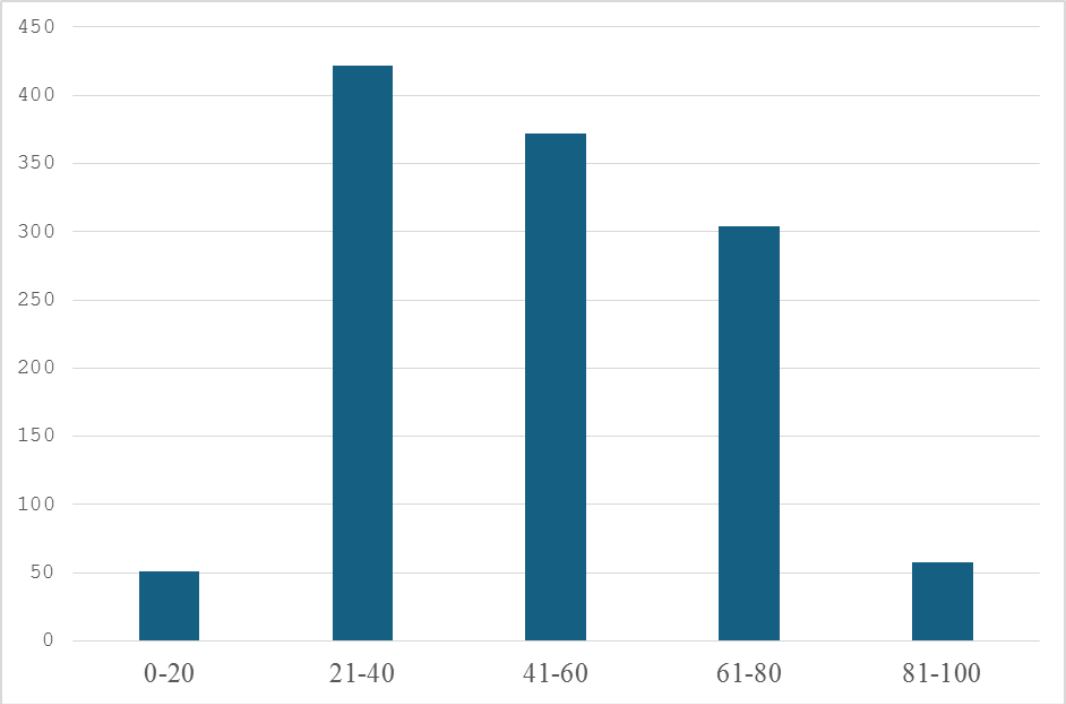


**Fig. 1 – Number of violent death victims by age (years).**

(27.34%) cases (Table 1). These injuries often occur in road traffic accidents, at work while operating machines, or can be caused by physical attack, falling at the same level, or falling from a height.

**Table 1**

**Distribution of types of injuries**

| Types of injuries | n |
|---|---|
| Mechanical | |
| Blunt force trauma | 330 |
| falling from a height | 150 |
| falling at the same level | 73 |
| traffic accidents | 83 |
| trauma at work | 12 |
| trauma by another person | 12 |
| Firearms, explosives | 115 |
| gunshot wounds | 98 |
| explosive injuries | 17 |
| Spikes and blades | 43 |
| Total | 488 |
| Asphyxial | |
| hanging | 217 |
| drowning | 33 |
| manual or ligature strangulation | 6 |
| *mors e bolo* | 20 |
| aspiration of vomit or other contents | 16 |
| Total | 292 |
| Chemical | |
| heroin | 164 |
| cocaine | 4 |
| MDMA | 3 |
| methadone | 11 |
| alcohol | 41 |
| drug | 89 |
| pesticide | 7 |
| corrosive agent | 52 |
| mushrooms | 3 |
| Total | 374 |
| Physical | |
| burns | 23 |
| carbon monoxide poisoning | 19 |
| electrocution | 7 |
| freezing | 4 |
| Total | 53 |

**MDMA – 3,4-methylenedioxymethamphetamine; n – number.**

Mechanical injuries caused by blunt force in traffic accidents resulted in fatalities in 83 cases (6.88% out of all 1,207 violent deaths). The pedestrians injured in an impact with a passenger vehicle and train account for 5.21% of the total number of violent deaths, but also the largest portion of fatalities in traffic accidents, i.e., 55.42%. Pedestrians killed in an impact with a passenger vehicle account for 35 (42.17%) of all traffic accident victims, and such deaths were all accidental. The average age of pedestrian victims was 55.98 years, with a predominance of males (71.43%). Among all the victims of traffic accidents, 11 (13.25%) were pedestrians injured by a train. All cases involved suicides of males with an average age of 54.27 years. The fatally injured drivers, front seat and back seat passengers in passenger cars, buses, or motorcycle riders account for 28 (33.74%) of all fatalities in traffic accidents. All injuries were accidental, with the average age of victims being 56.93 years, and with a predominance of males with 78.57%. There were 9 fatally injured persons (10.84% of all fatalities in traffic accidents) in airplane or helicopter accidents. The average age of victims of air traffic accidents was 38.11 years. The youngest victim in this study was a 5-day-old newborn, and there was only one female victim.

The mechanical blunt force traumas at work were all accidental and accounted for 12 (0.99%) cases of violent deaths, with the average age of victims being 47.67 years, all of them male.

Blunt force homicide, caused by a mechanical tool swung by another person, was determined as the cause of death in 12 (0.99%) cases. The average age of victims was 55.33 years, with a slight predominance of males (58.33%).

Mechanical blunt force trauma due to accidental falls at the same level led to fatalities in 73 (6.05%) cases of all cases of violent deaths. All deaths were accidental, with the average age of victims being 69.15 years, and with a higher percentage of males, 73.60%.

Mechanical blunt force trauma from falls from a height was identified in 150 (12.43%) cases of violent deaths, accounting for 30.74% of all deaths caused by mechanical blunt force trauma (Figure 2). The average age was 47.92 years, with the youngest victim being 15 years old and the oldest victim being 91 years old. Males account for 61.33% of all the victims of falls from a height. In 8 (5.33%) cases, the accidents occurred due to falls from scaffolding or windows during work activities, 68 (45.34%) were suicides, and all other cases, 74 (49.33%) of them, were of undetermined origin by the time of conclusion of the court proceedings.

In cases of mechanical blunt force injuries, head injuries were the most common, occurring in 187 (56.67%) cases. The cause of death was identified as damage to vital brain centers (contusions, haemorrhages, fractures). Thoracic injuries were identified in 83 (25.15%) cases, abdominal injuries in 7 (2.12%), and multiple injuries and injuries to the entire body in 53 (16.06%) cases.

Mechanical injuries caused by firearms were identified in 98 (8.12%) cases, with a predominance of male victims at 94.90%. The mean age of firearms victims was 52.92 years. The youngest victim who died from a gunshot wound was 16, while the oldest was 87 years old. Suicidal intentions in cases of gun-related deaths were identified in 89 (90.82%) cases, all of them men. In nine cases, there was murder with a firearm, and the victims were women in 66.67%. In 79 (80.61%) cases, gunshot wounds were localized on the head. Explosive injuries with the destruction of entire body parts were found in 17 (1.41%) cases of violent death victims, with the predominance of men at 88.24% and the mean age of victims was 44.38 years. The majority of deaths caused by explosive injuries were suicides in 12 (70.59%) cases, accidents in 3 (17.65%), and homicides in 2 (11.76%) cases.

Mechanical injuries caused by spikes and blades of mechanical tools were identified in 43 (3.56%) cases, with a predominance of men at 74.41%. The average age of victims injured by spikes and blades of mechanical tools was 52.74

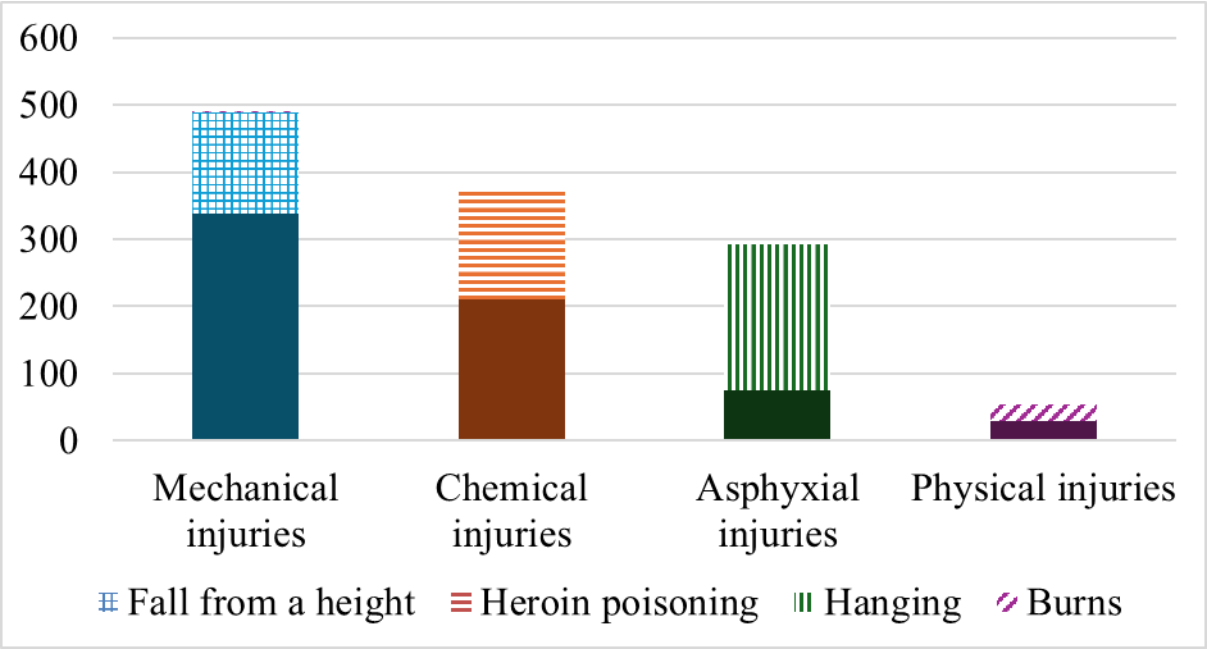


**Fig. 2 – Number of lethal injuries by type.**

years, with the youngest victim being 25 years old and the oldest 92 years old. The death was classified as homicide in 10 (23.36%) cases, with equal representation of male and female victims. Suicides caused by spikes or blades of mechanical tools were identified in 33 (76.74%) cases, with a predominance of men at 84.88%. The most frequent locations of injuries were in the thorax region (48.84%), neck (20.93%), limbs (18.60%), and abdomen (11.63%).

The chemical and toxicological analyses of blood and urine samples taken during the autopsy were performed in 1,003 (83.10%) cases, and in 716 (59.32%) cases, a positive toxicological result was found for the presence of alcohol, drugs, and illegal substances, individually or in combination. In 287 (23.78%) cases, no tested substances were found. In 204 (16.90%) cases of all violent deaths, toxicological analyses were not performed either due to instructions from the prosecutor's office or because of the specific duration of survival and treatment at the hospital after suffering the injury.

Chemical injuries were found to be the cause of death in 374 (30.99%) autopsied cases, with the dominance of heroin poisoning in 164 cases, 13.59% out of all violent deaths or 43.85% of all deaths due to chemical injuries (Figure 2). The average age of those whose cause of death was heroin overdose was 33.51 years, with the youngest victim being 22 and the oldest 47 years of age. Here, there is also a noticeable predominance of males (86.58%). Methadone poisoning was found in 11 (0.91%) cases, cocaine in 4 (0.33%), and 3,4-methylenedioxymethamphetamine (MDMA) in 3 (0.25%) cases of all violent death cases, and all cases were predominated by men. There were no cases of heroin, cocaine, methadone, or MDMA poisoning with the elements that would indicate the homicidal origin of poisoning; most victims were long-term addicts, and the answer to the question of whether it was a suicide or an accident would be given by the judicial authorities. Ethanol and methanol poisoning were found to be the cause of death in 41 (3.40%) cases of violent deaths. The average age of victims of alcohol poisoning was 45.34 years, with the predominance of men (87.80%). The ethanol concentration in cases of poisoning was from 3.87 to 6.58 mg/mL, while the methanol concentration was from 0.21 to 2.41 mg/mL. Drug poisoning was found in 89 (7.37%) cases, with the predominance of psychotropic drugs from the group of benzodiazepines, antidepressants, and antiepileptics in 85 (95.50%) cases, and the poisoning with antiarrhythmics in 4 (4.50%) cases. Toxicological analyses showed that the number of drugs found in body fluid samples of those who died due to drug poisoning ranged from 1 to a maximum of 13, and the mean value of the number of drugs was 3.73. Women (64.05%) are more often the victims of drug poisoning compared to men, with the average age of victims being 49.57 years. Corrosive agent poisoning (hydrochloric or acetic acid) was found in 52 (4.31%) cases, with the predominance of women (59.61%) (Table 1). The mean age of autopsied victims of corrosive agent poisoning was 73.00 years. The youngest victim was 35 years old, and the oldest was 88 years old. Pesticide poisoning was found in 7 (0.58%) cases, and mushroom poisoning in 3 (0.25%) cases, with a predominance of males. Alcohol, pesticide, and mushroom poisonings were accidental, while poisonings with corrosive agents were all of suicidal origin. Drug poisonings were suicidal in 70 (78.65%) cases and of undetermined origin in 19 (21.35%) cases.

Asphyxial injuries were the cause of violent deaths in 292 (24.19%) cases. The majority of deaths, 223 cases (18.48% out of all violent deaths), were caused by strangulation, accounting for 76.37% of all deaths caused by asphyxiation. Hanging accounted for the largest portion, 217 (17.98% of all violent death cases or 74.31% of the total number of deaths caused by asphyxiation) (Figure 2). The

average age of hanging victims was 50.74 years, with a strong predominance of men (78.80%). The youngest victim of hanging was 17 years old, while the oldest was 94. All cases of hanging were committed with suicidal intentions. Tightening the noose or hands around the neck is of homicidal origin and was found to be the cause of death in 6 (0.50%) cases of all violent death cases. The mean age of these victims was 53.5 years, with equal representation of both genders. Suffocation was the leading cause of death in 69 (5.71%) cases or 23.63% of all violent deaths due to asphyxiation. Drowning was identified in 33 (2.73%) cases, with the average age of victims being 48.61 years. Accidental drowning was found in 7 (21.21%) cases, while other cases of drowning were of suicidal origin. Choking on a piece of food (*mors e bolo*) accounted for 20 (1.65%) cases of all violent deaths, with a mean age of 56.69 years. Aspiration of vomit or other contents was the cause of death in 16 (1.33%) cases of all violent deaths, and the average age was 46.77 years (Table 1). Cases of choking on a piece of food and aspiration of vomit were accidental. All forms of suffocative asphyxiation are also dominated by men (71.01%).

Physical injuries were identified as the cause of death in 53 (4.39%) cases (Figure 2). Death due to fire was confirmed in 42 cases, namely 19 (1.57%) cases of carbon monoxide poisoning and 23 (1.91%) cases of third-degree burns. Exposure to fires was also predominated by men (69.04%) compared to women. The average age of fire victims was 60.19 years. Electrocution was found in 7 (0.58%) cases of all violent death cases, all in males with an average age of 37.68 years. Freezing led to a fatal outcome in 4 (0.33%) cases of violent deaths (Table 1). The average age of victims of freezing to death was 69.8 years, and all victims were men. All physical injuries were accidental.

The monthly frequency of fatal injuries, the body parts where such injuries were inflicted, and the results of toxicological analyses of body fluid samples taken during autopsies were analyzed for the three most common types of injuries leading to violent death, namely asphyxiation injuries by hanging (17.98%), chemical injuries from heroin poisoning (13.59%), and mechanical blunt force injuries due to a fall from a height (12.43%).

Cases of hanging were the most prevalent in July (14.75%) and the least in February (4.60%). The largest number of hangings occurred in the victim's apartment (59.91%), then, at the auxiliary building and the yard of the house where the victim lived (28.11%), in public spaces (7.83%), at hospitals (2.77%), and workplaces (1.38%). In 193 hanging cases, toxicological analyses were performed. The blood and urine samples in 107 (54.44%) cases revealed the presence of alcohol, drugs, or illegal substances, either isolated or combined. In 24 (12.43%) hanging cases, the toxicological analysis of blood and urine samples showed only the presence of various types of medications. The presence of alcohol was detected in 53 (24.46%) cases, with methanol content in addition to ethanol found in 28 of those cases. The combination of drugs and alcohol was found in 25 (12.95%) cases. Among the drugs found, in isolation or combined with alcohol, the most frequent were the benzodiazepines in 35 (16.13%) cases, painkillers and antipyretics in 14 (6.45%) cases, and antiepileptics in 9 (4.15%) cases. Antipsychotics, antidepressants, and cardiotropic drugs are less frequent. A combination of alcohol, drugs, and heroin metabolites was found in four cases, while narcotic analgesic methadone was found in one case.

Heroin overdoses were most prevalent in February (14.02%) and the least prevalent in July (3.04%). Death most often occurred in the victim's apartment (59.15%), in public spaces (32.93%), in someone else's apartment (7.32%), and, in one case, in prison (0.60%). Only heroin and its metabolites were found in 4.89% of cases, heroin and alcohol in 11.58%, heroin and psychotropic drugs in 37.80%, and heroin, alcohol, and psychotropic drugs in 45.73% of cases. When it comes to psychotropic substances, the most frequent were benzodiazepines (62.80%), antiepileptics (3.04%), and antidepressants (0.61%). In 34 (20.73%) cases of heroin overdoses, syringes and powdery substances were found next to the body during the investigation. Among all these causes, heroin, opium alkaloids (noscapine, papaverine, codeine) were found, and even paracetamol in five cases. No other toxic substance was found in other submitted samples.

Deaths caused by mechanical injuries due to falls from a height are most frequent in July (13.6%) and the least frequent in December (5.6%). In 62.40% of cases, it was a fall from the victim's apartment, in 17.60% a fall from the roof or floor of a building where the victim did not live, 8.80% a fall from a hospital window during hospitalization, 8.80% a fall from a bridge, and in 2.40% of cases, it was a fall from the workplace window. In 61 (49.19%) out of 124 cases of falls from a height for which toxicological analyses of blood and urine samples were performed, the isolated or combined presence of alcohol, drugs, or illegal substances was found. In 20 (16.13%) cases, the presence of various drugs was found, and the presence of only alcohol was found in 15 (12.10%) cases (in 14 cases, the presence of methanol was found in combination with ethanol). The presence of alcohol in combination with various drugs was found in 21 (16.93%) cases. Among the drugs found, the most frequent were benzodiazepines in 17 (11.33%) cases, painkillers and antipyretics in 10 (6.66%) cases, and antipsychotics in 6 (4.00%) cases. Antidepressants and antiepileptics have a somewhat lower degree of representation. The illegal substances were found in 5 (4.03%) cases (heroin and heroin metabolites in combination with alcohol and drugs in 2 cases, cocaine in 1 case, and MDMA in 2 cases).

## Discussion

Violent deaths in our study were far more frequent among men, which coincides with the research of other authors [4–6]. The authors from Finland claim that from the second decade of life, violent deaths are three to five times more frequent among men than among women [7]. In our study, all cases of violent deaths caused by mechanical blunt force trauma at the workplace, train collisions involving pedestrians, and physical injuries from electric shock and frostbite

occurred in male victims. Women dominate only in cases of corrosive agent poisoning and drug poisoning, as also claimed by other authors [8].

Violent deaths are the most frequent among people of the most productive age, i.e., from 21 to 40 years of age. Among most other authors, the age distribution is also dominant during this period of life, or somewhat outside this window [4, 6, 9]. In our study, victims of heroin overdose were the youngest, while corrosive agent poisoning victims were the oldest.

Mechanical injuries were the most frequent cause of death in our study. The results of other studies also show the predominance of mechanical blunt force trauma [4, 10]. Blunt force injuries were the result of traffic accidents in more than 60% of cases [11]. Traffic accidents led to a fatal outcome in 58.51% of forensic autopsies [6]. A study conducted in our region, in Northern Macedonia, has identified road traffic accidents as the leading cause of death [12]. The report on the state of road traffic safety in Serbia states that, from 2010 to 2019, the average number of fatalities in road traffic accidents in Serbia was 613 [13]. A smaller share of road traffic accident victims in our study is explained by the different jurisdictions of the prosecutor's offices that submit the bodies for autopsy, since most traffic fatalities are referred to other institutions for forensic autopsy.

In our study, the most common type of violent death from the group of mechanical injuries was blunt force trauma caused by a fall from a height. Other authors state that in the 30–39 age group, deaths most often result from gunshot wounds, falls from a height, road traffic accidents, and hanging [6]. In Slovakia, suicide by jumping from a height is, after hanging, the second most chosen method of ending life [14]. In contrast, results from a study conducted in Tunisia differ significantly, showing that deaths due to falls from a height were predominantly accidental and suicidal in only 13.5% of cases, with the majority of victims not having confirmed psychiatric diseases [15]. Another study, however, reported that 63% of deaths from falls from a height were suicides, and 32% of these victims had been treated for psychiatric disorders [16].

In our study, gunshot injuries ranked fourth in frequency, while in countries with a freer firearms market, such as the United States of America (USA), the percentage of gunshot injuries is 11.4% higher than in other highly developed countries [17]. A study of homicide cases also indicates the predominance of gunshot wounds autopsied in South Carolina, where in only 18% of cases the injuries were mechanical blunt force traumas or injuries inflicted by blade or asphyxiation [18]. Injuries to the head are more frequent in suicides caused by firearms, while injuries to the thorax are more frequent in homicide cases [19].

Among the victims of homicides in our study caused by mechanical injuries inflicted by a spike or a blade, both men and women are equally represented, while a retrospective study by the authors from Tunisia showed that even in cases of homicides with a blade or a spike, the victims are dominated by men, with thoracic injuries being the most common [20].

Deaths caused by chemical injuries account for 30.99% of violent deaths in our study. Such a high prevalence of chemical injuries is influenced by the fact that the National Poison Control Center is located within the MMA, so the patients from Serbia with suspected poisoning are hospitalized at the MMA. After death, they are autopsied at the PFMI of MMA based on the order of the competent prosecutor's office. Heroin, as a means of poisoning among all types of illegal substances, is the most represented in our study, and the victims of heroin poisoning have the lowest average age. Research by authors from Norway shows an increase in the age of victims of opioid poisoning from 33 to 43 years of age, a decrease in the number of heroin poisonings, and an increase in the number of poisonings by different prescription drugs [9]. Other authors point out the constant number of deaths due to heroin overdose and an increase in the number of prescription opioid overdoses [21]. A study conducted in Türkiye showed that the majority of suicides (86.4%) were committed by drug poisoning [22]. In cases of heroin poisoning, the authors state that, in addition to heroin, other substances were also found (3.23%); in cases without heroin, combinations of four to five substances were found, and in our study, in cases of drug poisoning, one to thirteen substances were found [23]. The analyses of the contents of the supplied syringes and substances found next to the bodies of the autopsied victims during the investigation did not prove the presence of toxic adulterants, while other authors report the presence of xylazine in 2% of cases [24].

The type of substances used for poisoning depends on local ecological and economic factors, so the methods of poisoning vary across different countries. Cases of pesticide poisoning in our study were rare, and other authors have also emphasized a decline in the number of pesticide poisonings in the past 20 years [25]. In contrast, the authors from India reported the highest number of pesticide poisoning cases at 44%, while among the drugs that were used less frequently, benzodiazepines were the most common [26]. The study conducted in Nepal reported 49.12% of unknown substance poisoning cases, followed by 38.10% of organophosphate and 12.70% of rodenticide poisoning cases [27].

In our study, injuries caused by asphyxiation were predominantly due to hanging. Other authors report that the total percentage of deaths by asphyxiation is 15.7%. Of that number, 41.8% are cases of hanging, most frequently among men, while homicide by manual strangulation or use of a noose makes up a smaller percentage of all deaths by asphyxiation, which is 2.3% [28]. Based on a retrospective study of autopsies performed in Poland, the authors found that one in six autopsies was due to asphyxiation injuries, with hanging being the most common cause [29]. Research on suicides among young people aged 15–19 years in Serbia, as well as research by authors from Slovakia, showed that the most common method of committing suicide was by hanging [14, 30]. Similarly, hanging has been reported as the most common cause of death among the survivors of the attack on the World Trade Center, but also among the homeless people in the USA [31, 32]. Research by authors from Greece on the violent deaths of people over 65 years of age showed that the

most common cause of death was asphyxiation due to drowning. When it comes to suicides, the leading cause of death was hanging, while in cases of homicide, the leading cause of death was suffocation [33]. The most common method of committing suicide in Brazil among men was by hanging at their own home, which coincides with our results [34].

Research in Poland showed that after hanging, the most common methods of suicide were falling from a height and poisoning, with male predominance, where all suicides were more common in urban areas [35].

The use of alcohol, drugs, and illegal substances is considered a risk factor for both perpetrating and experiencing violence. According to authors who analyzed numerous studies of substance abuse among patients whose injuries were the result of violence, alcohol was detected in 13–66% of cases, while illegal substances were found in 37% of hospitalized patients [36]. In our study on violent deaths, toxicological analyses showed that benzodiazepines were the most frequently detected drugs. Other authors also report the most frequent presence of benzodiazepines in cases of opioid overdose in 48% of cases, hanging in cases of suicide in 13% of cases, and suicide using a firearm in 17% of cases [37]. In the autopsied cases of violent deaths in the Republic of South Africa, the presence of alcohol was found in 41% of cases, illegal substances in 61%, and more than one substance in 49% of cases [38]. A retrospective analysis of urine screening in hospitalized trauma patients in rural parts of Virginia found substances in 58% of cases, most commonly opiates, alcohol, benzodiazepines, and cannabis [39]. The toxicological analysis of the suicides in Berlin found the tricyclic antidepressants in 48.1% and alcohol in 37.2% of suicide cases [40]. A study on the presence of alcohol in body fluids taken during forensic autopsies in the Canary Islands showed that 31.8% of cases were positive for ethanol [41]. Suicides with a positive toxicological result in a study conducted in Spain, dominated by alcohol, cocaine, and benzodiazepines, were found mostly in cases of hanging [42]. In Washington, the toxicological analyses performed on suicidal violent death victims were dominated by ethanol, antidepressants, opioids, and benzodiazepines [43]. The authors point out that 27.6% of blood samples of violent death victims in Brazil were positive for ethanol [5]. Research on suicides by hanging in Poland showed the presence of alcohol in more than half of the samples, which shows that alcohol is a significant suicidal factor [44]. Research in Norway showed that 35.7% of patients who were treated for various injuries had the presence of psychoactive substances, mostly alcohol, in 23% of cases [45]. Blood alcohol concentration was found in 55% of the autopsied victims of violent deaths in Lithuania and in 57.1% of cases of violent deaths in the USA [46, 47]. The authors report that more than a quarter of gun violence victims had consumed alcohol prior to death. For prevention, they recommend enforcing penalties for carrying firearms while intoxicated and prohibiting firearm possession for individuals convicted of driving under the influence [48].

## Conclusion

Violent deaths in the Pathology and Forensic Medicine Institute of the Military Medical Academy in Belgrade, Serbia, are most common among people aged 21–40 years. The most frequent causes of violent deaths were falls from a height among mechanical injuries, hanging among asphyxial injuries, and heroin poisoning among chemical injuries. In more than half of violent deaths, toxicological analyses revealed the presence of alcohol, drugs, and/or illegal substances, which may be a contributing factor in the occurrence of violent death. The number of violent deaths can be reduced by stricter control and punishment of non-compliance with the rules for dispensing psychotropic drugs, strict control and punishment of driving under the influence of alcohol and psychostimulants, as well as broader access to timely psychological and psychiatric support.

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