IMPACT OF INJURY LOCATION AND TYPE OF TRAFFIC PARTICIPANTS ON THE OUTCOME OF TRAFFIC ACCIDENTS IN MONTENEGRO

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SUMMARY

Objectives: The aim of this study was to examine the frequency of fatalities in injuries in traffic accidents in Montenegro, identify contributing risk factors, and determine the most vulnerable participants in these accidents.

Methods: The research was designed as a retrospective descriptive study. Participants were people admitted to the Urgent Centre of Clinical Centre of Montenegro due to injuries in traffic accidents that resulted in serious bodily injury or death in the period from 2011–2020. We presented data using descriptive statistics. The square test was used to examine the association between the outcome of traffic injury with sex, age, category of injury, type of traffic participant, and injury localisation. Additionally, we used logistic regression to estimate the best predictor value of these variables for outcome.

Results: It was found that 44.7% of injured people died, the most frequent fatal outcome was registered in patients with central nervous system injuries (73.2%), then in patients with asphyxia (47.0%), and patients with bleeding (40.5%), $\chi^2 = 27.530$, $p < 0.001$. The most frequently injured traffic participants were drivers, but the highest number of deceased were among cyclists. Also, logistic regression showed that the category of injury was the most predictive impact on outcome in traffic-injured correspondents ($p < 0.001$).

Conclusion: Among the injured, the highest number are drivers, and the fatal outcome mostly depends on the injury category. Nearly half of those injured in traffic accidents die, especially those with central nervous system injuries and cyclists. Therefore, special attention should be given during public health campaigns related to traffic accident prevention, focusing on this injury and this category of traffic participants.

Key words: traffic accidents, head injuries, chest injuries, bleeding

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INTRODUCTION

Traffic trauma represents a serious public health problem in modern society, leaving significant consequences in terms of lost years of life, high levels of preventable injuries and disabilities, as well as high costs for individuals, families, and society (1, 2). Those injured in traffic accidents predominantly suffer from severe multiple and combined injuries (polytrauma), often leading to permanent disability (3). Traffic accidents also bear a significant socioeconomic burden for the victims and their families, both through the costs of treating injuries sustained in traffic accidents and through the loss of productivity of those killed or disabled (4). In a broader sense, traffic accidents have a serious impact on national economies, costing countries around 3% of their annual gross domestic product. Injuries caused by traffic accidents present a serious and complex public health problem, especially in countries with low and middle incomes, where they are one of the leading causes of premature death. It is estimated that 1.35 million deaths occur annually worldwide due to traffic accidents, with 50 million people injured as a result of this problem (2). Globally, injuries sustained in traffic accidents rank eighth among all causes of death and currently represent the leading cause of death among children and young people aged 5 to 29 years (4, 5). It is estimated that by 2030, traffic injuries will be the fifth leading cause of death, with 2.4 million fatalities annually, and the third leading cause of disability worldwide, with an increasing physical, psychological and economic impact on society (4). Approximately 50% of fatal injuries in traffic trauma cause immediate death, 30% cause death within 48 hours of the injury, and the remaining 20% result in death from complications in the following weeks (6). Late deaths occur within a few days or weeks of the initial injury and are usually secondary due to multi-organ failure or sepsis (7).

The aim of this study was to examine the frequency of fatalities in injuries in traffic accidents in Montenegro, identify contributing risk factors, and determine the most vulnerable participants in these accidents.

MATERIALS AND METHODS

The research was designed as a retrospective descriptive study. The population were all participants in traffic accidents in Montenegro who experienced severe physical injuries or fatal outcomes due to injuries or resulting complications during the period from 2011 to 2020. The units of observation included all participants in traffic accidents with severe physical injuries: pedestrians, drivers, passengers of motor vehicles, cyclists, motorcyclists, passengers of motorcycles, as well as drivers of agricultural machinery. As prescribed by law, all fatal forms of accidental trauma are subject to autopsy. The research was approved by the Ethics Committee of the Clinical Centre of Montenegro. There was no conflict of interest on the part of the principal investigator regarding the research conducted with full ethical and professional responsibility. Ethical principles regarding patient rights and confidentiality were respected. The data were used solely for the purpose of research and for the preparation of a doctoral dissertation at the Faculty of Medical Sciences, University of Kragujevac. The study included 330 participants in traffic accidents in Montenegro during the period from 2011 to 2020, who experienced severe physical injuries or fatal outcomes due to injuries or resulting complications. Descriptive statistics methods were used to describe the data: absolute and relative frequencies for categorical variables, mean value and standard deviation for numerical variables. The Shapiro-Wilk test was used to test the normality of the distribution. The Chi-square test or Fisher test of exact probability was used to assess the association between traffic accident outcomes and the examined variables: gender, injury category, type of traffic participant, and injury localization. Additionally, logistic regression for binary outcomes was applied to determine the predictive values of the examined variables. Statistical significance was tested for a p-value less than 0.005. All tests were performed using Statistical Software for Social Science for Windows 26 (SPSS 26). For tabular and graphical presentation of data, Excel for Windows was used.

RESULTS

The study included 300 participants with an average age of 42.7 ± 18.3 years, with a predominance of males (78.3%). Among those injured in traffic accidents, the highest number were drivers (39.7%), followed by passengers (25.0%) and pedestrians (24.0%), with fewer cyclists (9%) and motorcyclists (2.3%) (Fig. 1).

The highest number of participants had injuries to the central nervous system (CNS) (41%), followed by bleeding injuries (37%), and asphyxia (22%) (Fig. 2). More than half of the traffic

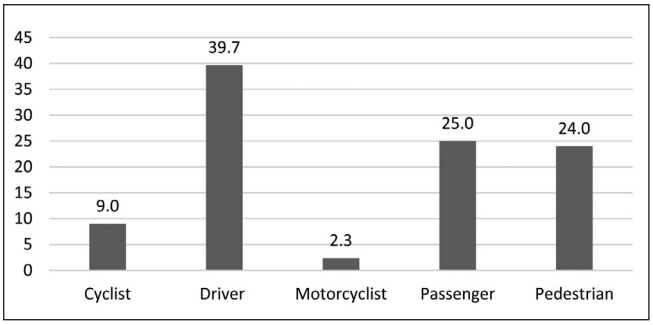

Fig. 1. *Distribution of traffic-injured in Montenegro by type of traffic participant.*

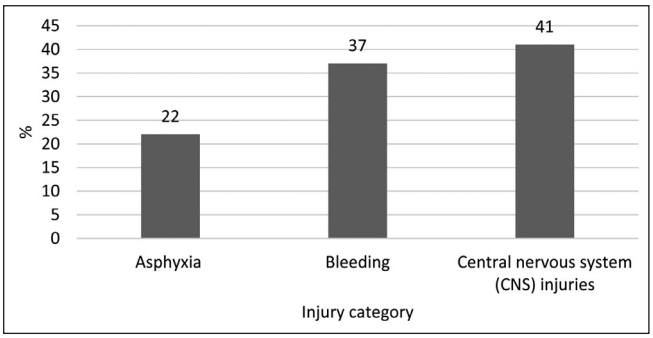

Fig. 2. *Distribution of participants injured in traffic by injury category.*

Table 1. *Result of examining association between outcome of traffic-injured participants and sex, injury category and type of traffic participants*

Variables		Outcome		Total	χ^2	p-value
		Deceased n (%)	Survival n (%)			
Sex	Male	131 (55.7)	104 (44.3)	235	0.074	0.785
	Female	35 (53.8)	30 (46.2)	65		
Injury category	Bleeding	45 (40.5)	66 (59.5)	111	27.530	< 0.001
	Asphyxia	31 (47.0)	35 (53.0)	66		
	CNS injury	90 (73.2)	33 (26.8)	123		
Type of traffic participants	Pedestrian	40 (55.6)	32 (44.4)	72	3.293	0.510
	Driver	61 (51.3)	58 (48.7)	119		
	Passenger	42 (56.0)	33 (44.0)	75		
	Motorcyclist	4 (57.1)	3 (42.9)	7		
	Cyclist	19 (70.4)	8 (29.6)	27		
Total		166 (55.3)	134 (44.7)	300		

injuries resulted in fatalities (55.3%). Injuries sustained in traffic accidents were most commonly located in the following areas: brain (35.3%), chest (24.3%), and abdomen (13.7%), with a notable frequency of facial injuries (10.3%) (Fig. 3).

Figure 4 shows that the incidence of CNS injuries is highest among cyclists and lowest among motorcyclists, likely because motorcyclists mostly wear helmets. However, head injuries are also encountered to a significant extent among passengers (46.7%), drivers (41.2%), and pedestrians (31.9%).

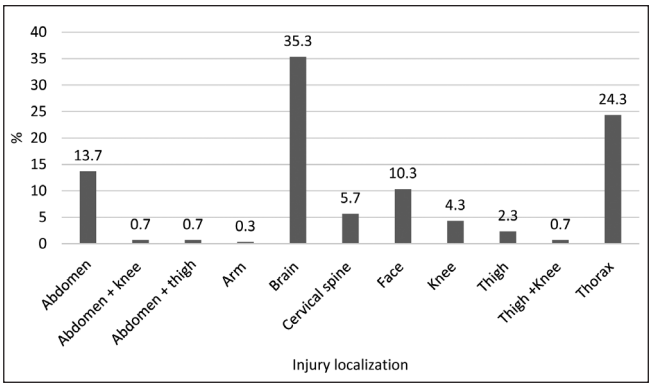

Fig. 3. *Distribution of participants injured in traffic in Montenegro by injury localizations.*

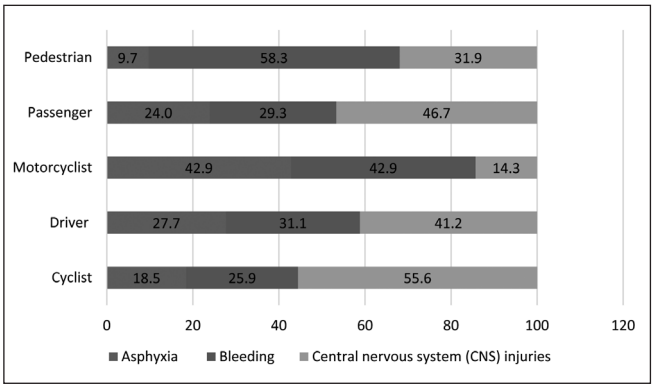

Fig. 4. *Distribution of traffic-injured type of participants in Montenegro by injury category.*

Table 2. *Presentation of differences in frequencies of outcome of traffic-injured participants related to injury localization and sex*

Injury localization	Sex	Outcome			p-value
		Deceased n (%)	Survival n (%)	All n	
Abdomen	Male	14 (41.2)	20 (58.8)	34	0.934
	Female	3 (42.9)	4 (57.1)	7	
Abdomen and knee	Male	2 (100.0)	0 (0.0)	2	–
	Female	0 (0.0)	0 (0.0)	0	
Abdomen and thigh	Male	1 (100.0)	0 (0.0)	1	–
	Female	0 (0.0)	1 (100.0)	1	
Abdomen and thorax	Male	4 (100.0)	0 (0.0)	4	1.000
	Female	1 (100.0)	0 (0.0)	1	
Arm	Male	0 (0.0)	1 (100.0)	1	–
	Female	0 (0.0)	0 (0.0)	0	
Brain	Male	63 (75.9)	20 (24.1)	83	0.537
	Female	16 (69.6)	7 (30.4)	23	
Cervical spine	Male	7 (70.0)	3 (30.0)	10	0.104
	Female	4 (57.1)	3 (42.9)	7	
Face	Male	3 (13.0)	20 (87.0)	23	1.000
	Female	1 (12.5)	7 (87.5)	8	
Knee	Male	3 (25.0)	9 (75.0)	12	1.000
	Female	0 (0.0)	1 100.0)	1	
Thigh	Male	2 (33.3)	4 (66.7)	6	1.000
	Female	0 (0.0)	1 (100.0)	1	
Thigh and knee	Male	1 (50.0)	1 (50.0)	2	–
	Female	0 (0.0)	0 (0.0)	0	
Thorax	Male	31 (54.4)	26 (45.6)	57	0.776
	Female	10 (62.5)	6 (37.5)	16	
Total	Male	131 (55.7)	104 (44.3)	235	0.785
	Female	35 (53.8)	30 (46.2)	65	
	All	166 (109.6)	134 (90.41)	300	

Table 3. *Result of univariate binary logistic regression with injury as a dependent variable*

		OR	95% CI for EXP(B)		p-value
			Lower	Upper	
Sex	Male/female	1.080	0.622	1.874	0.785
Age		1.001	0.988	1.013	0.936
Injury category	Bleeding (reference)				
	ICNS Injury	4.000	2.307	6.934	<0.001
	Asphyxia	3.079	1.645	5.763	<0.001
Type of traffic participants	Pedestrian (reference)				
	Driver	1.900	0.736	4.902	0.184
	Passenger	2.258	0.917	5.559	0.076
	Motorcyclist	1.866	0.726	4.794	0.195
	Cyclist	1.781	0.322	9.846	0.508
Injury localization	Thigh	4.583	0.673	31.198	0.120
	Thorax	1.431	0.478	4.285	0.522
	Face	12.375	2.913	52.567	0.652
	Brain	0.627	0.211	1.857	0.399
	Knee	6.111	1.198	31.164	0.294
	Thigh and knee	1.833	1.833	34.849	0.687
	Arm	2.961	0.000		1.000
	Abdomen	2.588	0.801	8.363	0.112
	Abdomen and thigh	1.833	0.096	34.849	0.687
	Abdomen and thigh	0.000	0.000		0.999
	Abdomen and knee	0.000	0.000		0.999
	Cervical spine	0.545			0.232

The frequency of fatal outcomes in relation to sex (55.7% of males and 53.8% of females deceased) did not show a statistically significant difference: $\chi^2=0.074$, $p=0.785$. Related to injury category, the highest frequency was found among patients with CNS injuries (73.2%), followed by those with asphyxia (47.0%) and bleeding (40.5%), $\chi^2=27.530$, $p<0.001$. Although the results showed the highest number of deceased patients among cyclists (70.4%), there were no statistically significant differences in outcomes related to the type of traffic participants, $\chi^2=3.293$, $p=0.510$ (Table 1). Additionally, there was no difference in outcome based on sex for separate injury locations ($p=0.785$) (Table 2).

Binary logistic regression showed that the highest predictive value for traffic-injured outcomes was the injury category. Individuals with CNS traffic injuries had a four times higher probability of a worse outcome compared to the bleeding category (OR=4.0, 95% CI: 2.3–6.9, $p<0.001$) (Table 3).

DISCUSSION

Increased motorization, coupled with poor road infrastructure and the spread of unsafe transportation modes (e.g., motorcycles), as well as risky behaviours (e.g., driving under the influence of alcohol and speeding), are the main determinants of increased numbers of traffic accident-related fatalities and/or disabilities (1). The literature suggests that of all traumas that occur, the most common are those sustained in traffic accidents. In a study by Majdan et al., which included 1,818 patients from Austria, Macedonia, Croatia, Bosnia, and Slovakia, road injuries were the dominant site of injury in all of the countries included in the study, while the workplace was the least likely site of injury (8). Studies from developing countries suggest that mortality from traffic trauma is attributed, among other factors, to speeding, vehicle overcrowding, poor-quality and aging passenger vehicles with fewer safety performance and features, increased traffic density due to population migration to larger cities, the growing presence of motorcycles in traffic, and inadequate and timely availability of health care due to poor organization of the healthcare system and a lack of adequate medical staff in certain specialties (4, 9). Studies indicate that the risk of death from traffic accidents may be influenced by factors such as age and gender (10, 11). Literature data show that trauma-related death in younger age groups accounts for more than 10% of global mortality, correlating with a high percentage of disability and economic costs globally, with as much as 90% of the costs going to low- and middle-income countries, including our own (12–14). For traffic accidents involving motorcycle drivers, three-wheeled motor vehicles, cars, heavy transport vehicles, and other nonspecific traffic accidents, the highest out-of-hospital mortality was found among adolescents. For accidents involving pedestrians and cyclists, the highest mortality was recorded among older adults (15). Studies have described the highest mortality rates among traffic participants

over 19 years old, consistent with many other studies (16). Most studies emphasize that older adults, especially those very old (75 years and older), should be identified as a distinct cohort due to their greater vulnerability to unfavourable outcomes following injury. The population of older people is expected to continue growing worldwide in the future, and the prevention of traffic accidents in this age group is an urgent issue. In underdeveloped and poorly developed countries, mortality from traffic trauma tends to increase, especially among individuals aged 40 to 49, with a slightly higher increase in the population over 60. Studies show that this is contrary to the trend in developed countries, where there is a decline in mortality among younger populations, and individuals over 60 have a more significant participation in traffic (17, 18). The results of our study showed that men were significantly more likely to be involved in traffic accidents, with a gender ratio of approximately 3:1, consistent with studies conducted worldwide that indicate gender inequality, namely significantly higher mortality rates among men (11). Risky driving behaviours among men are common from an early age and are observed throughout the life cycle. Men are more likely to drive after consuming alcohol, use mobile phones while driving, often violate traffic laws and regulations, and do not use safety devices (helmets, seat belts), which can lead to fatal injuries (15, 19). A study by Ladeira et al. conducted in Brazil from 1990 to 2015 showed that mortality rates from traffic accidents were four times higher in men. This risk is higher for all traffic participants, with the risk for males being 7.5 times higher for motorcyclists and 3.4 times higher for motor vehicle drivers. Additionally, the study, through the analysis of age-specific mortality rates, identified a higher risk for individuals aged 70 and older for pedestrians, cyclists, and car passengers. On the other hand, for motorcyclists, the highest risk of death was recorded in the 15–49 age group. In this age range, the risk is also high for car passengers (20). Our study also found that the mortality rate was higher among drivers and then among pedestrians for men and among passengers for women. The highest number of fatalities was among car passengers. Calosevic and Lovric, in a study conducted in Croatia, showed that pedestrians are the most exposed to injuries and therefore the most vulnerable group of traffic participants, with a higher mortality rate from trauma compared to drivers (21). A study conducted in Iran by Modarres et al. showed that the majority of those injured in traffic accidents were drivers (69%), while motorcyclists and pedestrians accounted for 16% of the injured, with a higher mortality rate recorded among motorcyclists and pedestrians (22). Hatamabadi et al. examined 433 injured traffic participants, of whom 345 were hospitalized, and 33 died before or after hospitalization at the nearest healthcare facility. Of the total number of injured individuals, 69% were in passenger cars, while pedestrians accounted for 49% of the fatalities. Among all traffic injuries upon admission to the hospital, the most common causes of injuries were head injuries, followed by chest injuries, and finally injuries to the upper and lower extremities. The gender and age structure of traumatized patients did not have a significant impact on mortality. An analysis based on the type of traffic participant indicates that mortality was significantly higher among pedestrians (23). Uncontrolled bleeding is the most common consequence of severe trauma, potentially leading to exsanguination (24). Acute and uncontrolled bleeding caused by trauma remains one of the leading preventable causes of death. Delayed response in providing first aid to the injured increases morbidity and mortality in these patients (25). Studies show that delayed bleeding episodes can lead to acute hemodynamic instability, significantly increasing morbidity, mortality, and the risk of multiple organ dysfunction (26). Uncontrolled bleeding is the leading cause of death in trauma and polytrauma patients of all ages, accounting for nearly 64% of preventable deaths (27). In the literature, it is described that around 40% of all trauma-related deaths are associated with severe coagulopathy (28). Studies indicate that chest injuries are relatively common in trauma patients, with pneumothorax being the predominant complication. One in four trauma patients dies from chest injuries or their complications. This data highlights the importance of chest trauma among all traumas, especially those acquired in traffic accidents (29). Brekke et al. state that traumatic mechanisms for blunt chest injuries are most common in traffic accidents, followed by falls. At the Norwegian regional trauma centre, haemothorax was diagnosed in 7% of patients admitted after chest trauma. Diaphragm injury was reported in less than 1% of cases after blunt chest trauma and is associated with severe intrathoracic or intraabdominal injuries (30). The study by Peličić et al. suggests that individuals with brain injuries must be transported to a hospital specialized in this type of injury, while patients with chest injuries and bleeding can be transported to the nearest hospital (31). Head trauma is the leading cause of morbidity and mortality in traffic accidents, so the results of these studies correlate with our results (32–34). The time of providing first aid when a traffic accident occurs, up to the transportation of the injured person to the nearest health facility, is a significant predictor of a better outcome for the injured person, which is described in the literature as the "golden hour" (35). The patient needs to be provided with adequate pre-hospital first aid and care within an hour of the injury, because the prognosis will be better. Education of the lay population on providing first aid to traffic-injured people can positively affect patient survival and reduce the mortality rate. For this type of care of the lay population, it is important to develop guidelines that would be implemented through legal regulations, because in such situations it is important to assess what a person who is not a healthcare professional can do for the injured person without causing them harm. The formation of a trauma registry in Montenegro would clearly define this possibility, through the education of the population, police and firefighters (31).

Timely and efficient trauma care should be a priority in all healthcare systems. Considering the high frequency of fatality outcome of traffic-injured people, it is important to consider all factors that affect the outcome of treating the injured. Establishing an accessible network of trauma centres and implementing a trauma registry can significantly improve the survival rate of severely injured patients in traffic accidents.

CONCLUSION

Among the traffic-injured in Montenegro, the drivers are the most frequent, and the fatal outcome mostly depends on the type of injury. Nearly half of those injured in traffic accidents die, especially those with central nervous system injuries and cyclists. Therefore, special attention should be given during public health

campaigns related to traffic accident prevention, focusing on this injury and this category of traffic participants.

Conflicts of Interest

None declared

Adherence to Ethical Standards

This manuscript is part of Dr. Damir Peličić's doctoral dissertation. The research was approved by the Ethics Committee of the Clinical Centre of Montenegro. The author expresses gratitude to the mentors during the doctoral studies at the Faculty of Medical Sciences in Kragujevac: Professor Branko Ristić, MD, PhD, Department of Surgery; and Professor Svetlana Radević, MD, PhD, Department of Social Medicine.

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