



# Influence of Spatial and Temporal Distance of the Hospital on Survival of Patients with Dangerous Injuries Sustained in Traffic Accidents

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## Abstract

**Background:** Effective care of any trauma is a priority in all health care systems. If a patient gets adequate treatment within "golden hour" from the injury the prognosis is better, but not as the only factor. The objective was focused on the influence of time and spacial distance of the hospital from the accident as determinant factors of survival, all in the aim Public Health System of Montenegro reorganisation for better accessibility for traumatized persons from 2011-2020.

**Methods:** Among 334 subjects, three groups were defined according to the type of injury: bleeding, asphyxiations, and cranio-cerebral injuries. In every group lethal and non-lethal subjects were analyzed.

**Results:** Cut-off values are given by ROC curves following proximity and transportation time to hospital specific for injury sustained, as well as for nearest hospital, showed significant differences for proximity of any hospital for bleeding and asphyxiation injuries, and for proximity of any hospital and transportation time to the hospital specific for the sustained cranio-cerebral injury.

**Conclusion:** Most of the seriously injured patients with bleeding or asphyxiation could be taken care of in any hospital while for cranio-cerebral injuries the specific hospital is crucial. How it is very often about, different organ systems are usually injured in single patient, so the forming of easily available trauma centers net is the best solution for Montenegro, which is necessary for better survival rates.

**Keywords:** Trauma center; Golden hour; Injuries; Emergency; Traffic accidents; Health care system

## Introduction

Traffic trauma is a serious public and healthy problem of modern society that leaves

consequences in the form of lost yr of life and high mortality rates (1,2). The WHO estimates



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that 1.35 million people die and more than 50 million are injured in road accidents worldwide each year (3). Factors such as the availability of adequate health care, emergency response, experience and organization of the trauma team, hospital distance, hospital equipment and professional skills for adequate care of severely injured—directly affect the quality and outcome of treatment and increase chances of survival (4,5).

Emergency pre-hospital care of the injured is necessary for the final outcome of treatment because there are a number of time-sensitive activities required to achieve full effectiveness of care for the injured (3,6-11).

“Golden Hour” is a term present in the trauma-related literature and includes the maximum time of patient care and transportation for a better outcome. If the patient receives adequate treatment within one hour of the injury, the prognosis is better, which is approximately time as a significant factor in the treatment of the injured (8,7).

Montenegro is a small country with a complex geography, and even in addition to a large road network, it has a weak infrastructure in terms of a modern understanding of fast road transport. Therefore, the possibility of providing adequate and timely care guaranteed to citizens by the Constitution and the Health Act is questionable, especially to those living in remote places away from health centers where the emergency parameter could be very important for survival (12, 13).

Death from traffic trauma affects not only victims but also their families and community at the national level with physical, psychological and economic consequences that affect the quality of life after survival (13-22).

We aimed to determine the general demographic characteristics of traffic accidents in Montenegro with a special goal on the impact of temporal and spatial distance of the hospital from the place where the accident occurred as a determinant of survival. The research will try to determine the need for reorganization of the health care system of Montenegro in order to make health care more accessible to severely traumatized persons.

## Materials and Methods

This research was designed as observational case-control study. Ethical Committee of the Faculty of Medical Science, University of Kragujevac approved the study. The population from which the respondents were sampled were all participants in traffic accidents in Montenegro with serious body injuries or death due to injuries or complications caused by them from 2011-2020. All participants in traffic accidents with serious body injuries were taken as observational cases: pedestrians, drivers and passengers of motor vehicles, bikers, motorcyclists, motorcycle passengers, as well as drivers of agricultural and other machineries.

From the population under study, we defined three groups of respondents according to the type of body injuries:

- First group: injuries related to bleeding (injuries of the big blood vessels including traumatic amputations and injuries of internal organs that lead to external or internal bleeding),
- Second group: injuries related to respiratory disorders (different forms of asphyxias, drowning, chest and abdominal compression, haemo/-pneumothorax, etc).
- Third group: cranio-cerebral injuries (but only these medically treated as different kinds of intracranial hemorrhages and certain forms of cerebral contusions).

In every group we differentiated lethal and non-lethal subjects. Group "cases" presented the ones with fatal injuries leading to death; group "controls" was formed from the cases who survived the immediate period after the injury (transported to the hospital alive where they were cured, healed or died from some other causes which were not directly related to the injury). Research included 334 subjects autopsied at the Center for Forensic Medicine in Podgorica or they were treated in the hospitals in Montenegro.

Using *t*-test with accepted values of probability of the error of the first type  $\alpha = 0.05$ , the strengths of the study 0.95, the size of the sample in whole was estimated to 100 of examined ones for every of three groups (sorted according to the injury types).

## Results

During the period from 2011-2020 average age of respondents observed at the level of the entire study population was  $43.01 \pm 18.13$  yr (the youngest respondent was 13 and the oldest 82). Concerning to the gender, there were 257 males (76.9%) and 77 females (23.01%). The gender ratio was approximately 3:1.

Observed in relation to the outcome of injuries to participants in traffic, there were 183 (54.8%) examined ones with fatal outcome (cases group) and 151 participant (45.2%) who survived (control group). Average age of the participants with the fatal outcome was  $42.69 \pm 18.66$  (min 13, max 82) and in the group of the survived ones  $43.41 \pm 17.52$  (min 15, max 78). There is no significant difference in the average age between the groups (Mann Whitney U-test,  $P=0.652$ ). Between respondents with fatal outcome were 139 males (54.1% of the whole male population) and

44 females (57.1% of the whole female population) and among control respondents were 118 (45.9%) males and 33 (42.9%) females. There was not found any significant gender difference among respondents according to the injuries outcome ( $\chi^2=0.117$ ;  $P=0.732$ ).

Among 334 examined participants in the traffic accidents, 110 died during transport to the hospital or on the day of admission (32.9%), 73 participants survived injuries for some period of time (21.9%) and 151 participant survived the traffic accident (45.2%).

We distinguished the hospitals specific for a therapy regarding the every certain injured patient and the nearest hospital which in some cases was not a proper one for the treatment of that patient. Average distance from the place of accident to the hospital specific for a therapy was  $37.10 \pm 45.08$  km (min 1 km, max 170 km). Average time of a transport of the injured to the hospital specific for a therapy was  $1.53 \pm 0.86$  h (min within 1 h, max 5 h). Observed according to the nearest hospital the average distance was  $13.41 \pm 14.50$  km (min within 1 h, max 2 h). Space distance between the nearest hospital and the hospital specific for a therapy as the time of a transport have significant influence on outcome of injuring in the traffic accidents (Table 1).

**Table 1:** Influence of time and spatial distance on the outcome of the traffic accidents

Variable	Exp (B)	95% CI	P
Proximity of the hospital specific for the sustained injury (km)	1.043	1.03–1.06	< 0.001
Transportation time to the hospital specific for the sustained injury (h)	4.389	2.79–6.89	< 0.001
Proximity of the nearest hospital (km)	1.041	1.02–1.06	< 0.001
Transportation time to the nearest hospital (h)	5.966	0.73–49.04	0.097

### Bleeding

Among 111 respondents diagnosed with severe bleeding, 65 (58.6%) died and 46 survived (41.4%). According to a gender distribution there were 89 male persons (80.2%) and 22 female persons (19.8%). When it is about survival among participants with bleeding diagnosed 17 (15.3%) died during transport or on the admission day, 29

(26.1%) lived for some time, and 65 (58.6%) survived. This difference is statistically significant ( $\chi^2 = 111.000$ ;  $P < 0.001$ ). There is statistically important influence of spatial distance from the nearest hospital ( $r=0.002$ ), hospitals specific because of the type of the therapy ( $r=0.001$ ) on the outcome of injuring in traffic accidents (Table 2).

**Table 2:** Influence of time and spatial distance on the outcome of bleeding accidents

<i>Time and spatial distance</i>	<i>Outcome</i>	<i>N<sup>o</sup></i>	<i>ȳ</i>	<i>SD</i>	<i>P</i>
Proximity of the hospital specific for the sustained injury (km)	Lethal	46	21.48	18.3	0.001
	Survived	65	11.20	12.4	
Transportation time to the hospital specific for the sustained injury (h)	Lethal	46	1.13	0.4	0.302
	Survived	65	1.06	0.2	
Proximity of the nearest hospital (km)	Lethal	46	20.29	16.4	0.002
	Survived	65	11.20	12.4	
Transportation time to the nearest hospital (h)	Lethal	46	1.02	0.15	0.806
	Survived	65	1.02	0.12	

According to a dominant injury at the persons with a bleeding it was noticed statistically significant impact to an outcome of traffic accidents ( $\chi^2 = 52.968$ ;  $P=0.001$ ). The highest percentage of died ones in category of bleeding had thoracic aortic injury (30.4%), followed by participants with multiple injuries of abdominal and pelvis injuries (13.1%), and on the third position according to a fatal outcome are participants with single abdominal organ injury (10.9%). In relation to the dominant injury in persons with bleeding it was noticed statistically important impact to an outcome of traffic accidents ( $\chi^2 = 52.968$ ;  $P=0.001$ ).

### *Asphyxiation*

Among 100 respondents with asphyxia diagnosed, 45 of them (45.0%) died and 55 survived (55.0%). According to gender distribution there were 75 persons male (75.0%) and 25 female (25.0%). When it comes to survival from the total number with asphyxiation diagnosed 24 (24.0%) died during transport or on admission day, 21 survived for some time (21.0%) and 55 (55.0%) survived. There is statistically significant impact of the spatial distance and time of transport to an outcome of injuries in traffic accidents (Table 3).

**Table 3:** Influence of spatial distance and time of transport to an outcome of traffic accidents with asphyxiation

<i>Time and spatial distance</i>	<i>Outcome</i>	<i>N<sup>o</sup></i>	<i>ȳ</i>	<i>SD</i>	<i>P</i>
Proximity of the hospital specific for the sustained injury (km)	Lethal	45	21.36	22.4	0.002
	Survived	55	9.56	10	
Transportation time to the hospital specific for the sustained injury (h)	Lethal	45	1.22	0.42	0.003
	Survived	55	1.02	0.14	
Proximity of the nearest hospital (km)	Lethal	45	18.67	20.1	0.007
	Survived	55	9.56	10	
Transportation time to the nearest hospital (h)	Lethal	45	1.11	0.32	0.024
	Survived	55	1	0	

According to a dominant injury to persons with asphyxiation there was no significant influence to the outcome of traffic accidents ( $\chi^2 = 14.081$ ;  $P=0.296$ ). The highest percentage of died ones in a category of asphyxiation had hematopneumothorax (48.9%), followed by participants with skull and face bones fractures

(13.4%), and on a third position according to a fatal outcome were participants with pneumothorax (11.3%).

### *Cranio-cerebral injuries*

Among 122 respondents with head injuries diagnosed, 91 of them died (74.6%) and 31

survived (25.4%). According to a gender distribution there were 90 male persons (75.4%) and 30 female persons (24.6%). An indirect death cause was mostly injury of brain's tissue, isolated cerebral contusion in 20 cases (13.3%), combined with subarachnoid haemorrhage 23 (18.7%), combined with subdural haemorrhage 16 (13%), isolated epidural haemorrhage 12 (9.8%), and isolated subdural haemorrhage 7 (5.7%).

When it is about survival for some time, from a number of injured ones in total with a diagnosed brain injury 24 (24.0%) died during transport or during admission day, 21 (21.0%) lived for some time and 55 (55.0%) survived.

There is significant difference between examined groups in the spatial distance of the nearest hospital and the hospital specific for a type of therapy from the place where an accident occurred ( $P < 0.001$ ) such as distance of the nearest hospital ( $P < 0.001$ ) (Table 4).

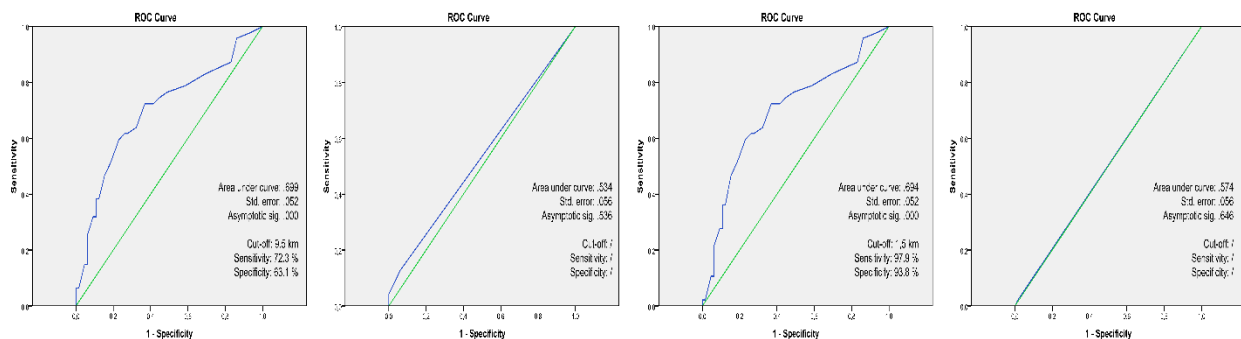
**Table 4:** Influence of spatial distance and time of a transport to an outcome of traffic accidents with head injuries

<i>Time and spatial distance</i>	<i>Outcome</i>	<i>N<sup>o</sup></i>	<i>ȳ</i>	<i>SD</i>	<i>P</i>
Proximity of the hospital specific for the sustained injury (km)	Lethal	31	27.77	20.241	0.000
	Survived	92	89.74	51.055	
Transportation time to the hospital specific for the sustained injury (h)	Lethal	31	1.52	0.626	0.000
	Survived	92	2.51	0.947	
Proximity of the nearest hospital (km)	Lethal	31	6.29	5.826	0.000
	Survived	92	13.53	13.992	
Transportation time to the nearest hospital (h)	Lethal	31	1	0	0.241
	Survived	92	1.01	0.105	

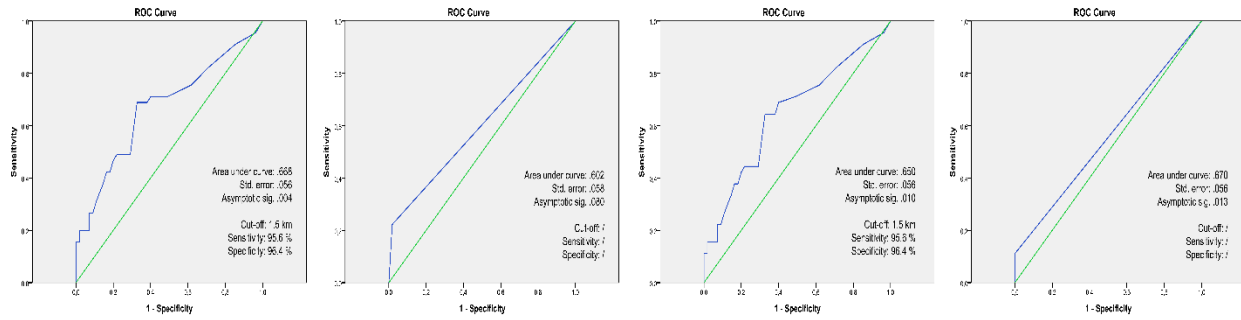
**ROC curves**

Cut-off values are given by ROC curves following bleeding (Fig. 1), asphyxiation (Fig. 2), and cranio-cerebral injury (Fig. 3), for Proximity of the hospital specific for the sustained injury (km), Transportation time to the hospital specific for the sustained injury (h), Proximity of the

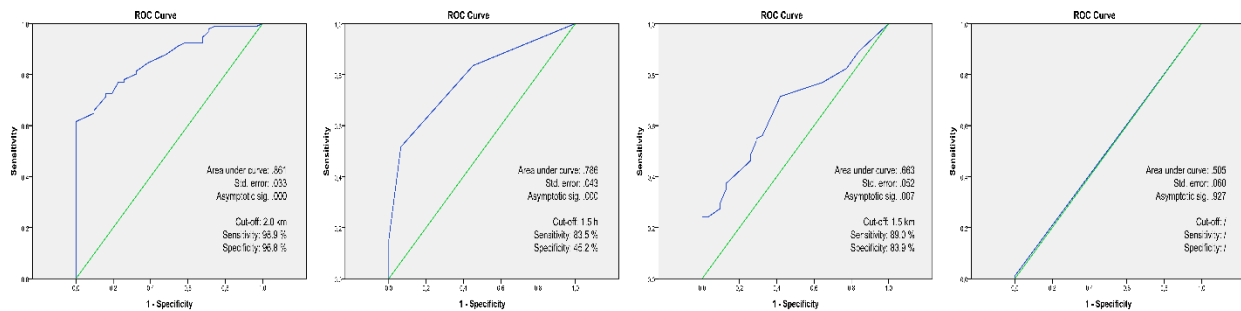
nearest hospital (km), and Transportation time to the nearest hospital (h), consequently for all figures. Significant differences are shown for proximity of any hospital for bleeding and asphyxiation injuries, and for proximity of any hospital and transportation time to the hospital specific for the sustained cranio-cerebral injury.



**Fig. 1:** ROC curves following bleeding: (1) Proximity of the hospital specific for the sustained injury (km), (2) Transportation time to the hospital specific for the sustained injury (h), (3) Proximity of the nearest hospital (km), and (4) Transportation time to the nearest hospital (h)



**Fig. 2:** ROC curves following asphyxiation: (1) Proximity of the hospital specific for the sustained injury (km), (2) Transportation time to the hospital specific for the sustained injury (h), (3) Proximity of the nearest hospital (km), and (4) Transportation time to the nearest hospital (h)



**Fig. 3:** ROC curves following cranio-cerebral injuries: (1) Proximity of the hospital specific for the sustained injury (km), (2) Transportation time to the hospital specific for the sustained injury (h), (3) Proximity of the nearest hospital (km), and (4) Transportation time to the nearest hospital (h)

## Discussion

The study under review belongs to a group of those one which determine dominant factors of decrease of mortality to traumatized patients (23-25).

Beside independent variables, those which cannot be changed by health institutions reorganization and they are type and severity of the injury, usage of security systems and similar- there are prehospital and hospital factors which are also important for survival. Adequate spatial and temporal distance of the hospitals specific for a therapy is an important factor in surviving, so the rates of survival are high if the distance between specific hospitals and place of the accident is 45 min (26). Beside that, decrease of prehospital interval for only 10 min from average 25 min to 15 min necessary for transport to the a hospital leads to significant decrease of the risk from fatal outcome to one third of injured in traffic

accidents (6). Some other studies didn't improve speed as a significant factor for survival (13,14), specially if it is about head injuries but the level of success of functional recovery is bigger in the case when the patient arrives into trauma center for time period of 60 min (17). For sure, depending from characteristics and type of the injury which endangered life, adequate prehospital help decreases mortality even when the time of transport to trauma center (16) is longer what depends from obstructive injuries of respiratory system, some types of bleeding and etc.

Montenegro is a small European and Mediterranean country with surface of 13.812 km<sup>2</sup> with 621.718 inhabitants and higher number of small towns which are, because of the inaccessible terrain, scattered not spatially but temporally from the nearest hospitals and hospitals specific for type of injury what influences outcome of survival because of the different accessibility. Our study showed that if even the average distance of the specific hospitals

were 37 km the average time of transport to the hospitals was 01:30 h while the nearest hospital was 13 km away from the accident place even an hour timely. This speaks in favor of slow reaction of emergency services and rescue teams (27).

Prehospital triasis, checking of the patient and adequate estimation of the injury type is an important factor in bringing decision about should the patient be transported into the nearest hospital or specific hospital (18, 28).

If we take into consideration actual organisation of the hospitals around Montenegro, adequate evaluation of the Emergency Medical Service on the terrain about patient care in the general hospitals or trauma center (Clinical Center or Special hospital for ortopedics and neurosurgery) could be essential for saving the time what was represented also in another study (9). Therefore, when it is estimated that the patient could survive transport to the institution for complete care (trauma center) than it is better to decide immediately for that transport because the patient will have better chances to survive (15). However, there are injuries which requires immediate treatment at the place of accident and it should not wait on transport to trauma center (29). Importance of triasis on the place of the accident is big but study (30) and our research showed that offered help on the place of accident does not have to necessarily decrease mortality and morbidity, already mortality was higher between the patients with Glasgow Coma Score lower than 9.

Our study showed that spatial and temporal distance are statistically important factor for survival of severe brain injuries but the cut-off values of spatial and temporal distance are very low, so we come to the conclusion that survival depends not only from type of injury but also to the type transport of injured. Because of the continuous monitoring of traffic but also other forms of traumatism it's necessary to possess appropriate registers for planning purposes of developing system such it was represented in study (31).

In the system such as ours where the results of research showed that even beside relatively good

average spatial distance of the nearest hospitals, the time of transport is bad so the type of transport could influence on survival – private or by emergency medical service.

## **Conclusion**

Most of the seriously injured patients with bleeding or asphyxia could be taken care of in any of the local hospitals while for brain injuries the specific hospital is crucial. How it is very often about half traumatised patients or the patients with serious injuries of the different systems, forming of the net of the easily and fast available specific centres is the best solution for choosing prehospital factors that are necessary for survival.

## **Journalism Ethics considerations**

Ethical issues (Including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, redundancy, etc.) have been completely observed by the authors.

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## **Conflict of interest**

This research process under full professional responsibility does not include any conflict of interests.

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