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Original Article

How Vulnerable Are the Elderly in Road Traffic-Autopsy Study?

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Abstract

Background: The aim of this study was to analyze characteristic and pattern of road traffic injuries in this special aging group, as well to examine the relevance of certain injuries or risk factors to outliving the injuries.

Methods: This epidemiological, analytical, retrospective, autopsy study investigated the road traffic deaths for period between 2001 and 2022. The subjects were divided into two age groups, elderly (65 years and older) and middle aged (16-64 years old).

Results: We included 213 (32%) elderly participants out of all 665 RTA subjects who died from sustained injuries or complications of the injuries. The majority of elderly subjects (61%) were pedestrians, and elderly participants in RTA were more likely to survive the injuries. The most common injuries among the elderly in all group of participants were chest injuries 81% (and among them, rib fractures were present in 76%). Craniocerebral injury is the most common cause of death in RTA subjects, singular (45%) or in combination with other causes. In the group of elderly RTA subjects complication of injury is represented in 36 subjects (17%), while as cause of death is represented in 22 subjects (10%). Elderly are less likely to have positive BAC, and even in cases when BAC was increased, the levels were on the lower scale.

Conclusion: More effort should be made to enhance road safety for elderly pedestrians, especially considering the expected rapid growth in the elderly population.

Keywords: Elderly; Road traffic accidents; Autopsy; Cause of death

Introduction

Road traffic injuries are a serious public health problem worldwide. It is estimated that in 2030 it might be the fifth leading cause of death in the world, with 2.4 million deceased per year (1). Globaly, more than 1.2 million people die every year and 50 million others are injured in road traffic accidents (RTA) each year. The WHO estimated that between 2000 and 2050, the per-

centage of the world's elderly population would double from about 11% to 22% (2). The absolute number of people of over 60 years at age and is expected to increase from 605 million to 2 billion over the same period. The proportion of elderly people in the population is increasing in many low- and middle- income countries (3,4). RTA is becoming an important health problem among the elderly because of the increase in the number of elderly populations and due to the growing industry and motorization of the population.

With the increase in the number of aged people, the age-related problems also increase. A significant proportion of the elderly suffer from impaired weakened vision, hear-loss, musculoskeletal problems, a decline in cognitive function and making them prone to traffic accident (5). Locomotor abilities of a person reach the culminate around the age of thirty, in the 50is year a person has around 70% of maximum physical abilities, and in the 70is with only 55% (6). A hallmark of elderly subjects is decline in speed of processing and responding, as well as the ability to switch rapidly attention in critical situations. On the other hand, due to chronic diseases like osteoporosis the rate of bone fracture and hospitalization increases which itself augments the mortality risk among elderly people (7,8).

The progressive ageing of the populations and the increasing importance of RTA in our society thus renders the relationship between elderly people and road traffic an increasingly important problem.

Accordingly, we aimed to analyze the most vulnerable road participants, the frequency and type of injuries among different subjects, as well as to examine the relevance of certain specific injuries and risk factors in outliving the injuries of the elderly, to apply appropriate measures for the prevention of RTA in the elderly.

Materials and Methods

This epidemiological, analytical, retrospective, autopsy study was conducted at the University Clinical Centre of Kragujevac, Department of Forensic Medicine and Toxicology, between the 2001 and 2022. For this twenty-two year period there 1,808 autopsies were performed, from which 665 were RTA subjects who died from sustained injuries or complications of those injuries. The subjects were included in the study according to the police reports and requests for forensic autopsy, and data on the injuries sustained were obtained by analyzing the autopsy records, as well as the available medical documentation. The study excluded children under the 14 years of age and subjects with a height less than 150 cm.

The subjects were divided into two age groups, elderly (65 years and older) and middle aged (16-64 years old). Both age's groups were analyzed in terms of gender, year, month and the day of the week when the accident occurred and type of traffic participants. According to their type of involvement in RTAs, all subjects were classified into the following groups: pedestrians, motor vehicle drivers, front-seat passengers, rear-seat passengers, bicyclists, motorcyclists and farm tractor drivers. When considering the time of death, the subjects were divided into two categories: subjects who died at the scene of the accident and those who survived their injuries for a certain period. Injuries were classified by the body region into the following groups: head injuries, chest injuries, abdomen injuries and combination of it.

Statistical Package for Social Sciences – SPSS for Windows, Version 22 (IBM Corp., Armonk, NY, USA) was used for processing the data. All numerical variables were tested with the Kolmogorov-Smirnov and Shapiro-Wilks tests for normal distribution as criteria for further implementation of parametric methods. According to the distribution of data, appropriate descriptive statistics were used (mean values with standard deviation or median with interquartile range – IQR). To estimate the differences between variables that exhibited parametric distribution, the Student's t-test was used. In variables that showed a nonparametric distribution, the Pearson's chi-square test (with Yates correction) and Kruskal-Wallis test were applied. The *P* value under 0.05 has been considered significant. Blood samples obtained

from the femoral vein during the autopsy were analyzed for blood alcohol concentration (BAC). BAC was determined by gas chromatograph with headspace and flame ionization detector (GC-2010 plus Shimadzu). The limit of ethanol detection was set at 0.001 g/l.

This study was conducted with the approval of the Ethical Committee of the Clinical Centre of Kragujevac (18/10/2016, No 01/13221).

Results

Demographic characteristics of the study group

At the Department of Forensic Medicine and Toxicology, University Clinical Centre of Kragujevac 1,808 medico legal autopsies were performed. The study included 213 (32%) elderly participants out of all 665 RTA subjects who died from sustained injuries or complications of the injuries. The mean age of the study population was 73.6±6.1 years.

There were 146 (74.9%) men, aged 73.7±6.2 years (ranging from 65 to 92 years) and 67 (25.1%) women, aged 73.3±5.9 years (ranging from 65 to 84 years). The ratio of male and female subjects was approximately 2.2:1 ($\chi2=29.793$; df=1; $P<0.01$).

August (27 i.e., 12.7%), September (27 i.e., 12.7%), and October (25 i.e., 11.7%), had the highest number of fatal accidents, while January, February, and March, were months with the least amount of accidents with elderly ($\chi2=26.552$; df=11; $P<0.01$), which is presented in Fig. 1.

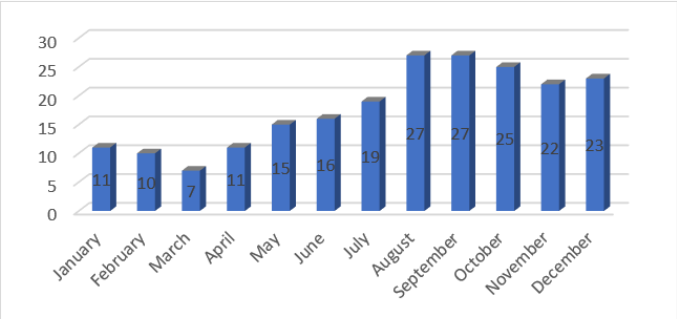

Fig. 1: RTA of elderly distribution by month

Depending on the days of the week, the highest number of RTA happened on Wednesday (42, i.e., 19.7%), while Saturday (20, i.e., 9.4%) was the day with the smallest number of accidents ($\chi2=17.977$; df=6; $P<0.01$) which is presented in Fig. 2.

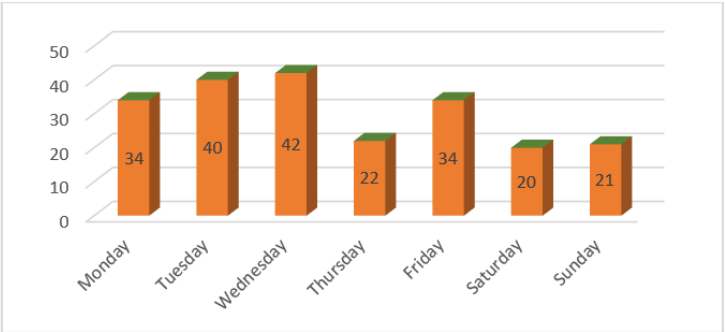

Fig. 2: RTA of elderly distribution by day of the week

RTA participation and surviving period

The majority of elderly subjects (129 out of 213 i.e. 61%) were pedestrians, while in the group of middle-aged subjects only 30% (135 out of 452), which proved to be statistically significant ($\chi2=307.632$; df=6; $P<0.01$). There was a significant difference in the number of motorcyclists and motor vehicle drivers who are more numerous in the group of middle age subjects compared to the group of elderly participants ($\chi2=64.384$; df=6; $P<0.01$). The distribution two age groups of subjects according to RTA participation is provided in Table 1.

Table 1: Survival after RTA according to the participations and age group

RTA subjects	***RTA subjects <65 years old***			***RTA subjects ≥65 years old***		
	Died at the scene	Survived the injuries	Total	Died at the scene	Survived the injuries	Total
Pedestrians (%)	72 (53.3)	63 (46.7)	135 (100)	60 (46.5)	69 (53.5)	129 (100)
Motor vehicle drivers (%)	79 (74.5)	27 (25.5)	106 (100)	14 (63.6)	8 (36.4)	22 (100)
Front seat passengers (%)	50 (69.4)	22 (30.6)	72 (100)	7 (38.)	11 (61.1)	18 (100)
Back seat passengers (%)	18 (58.1)	13 (41.9)	31 (100)	4 (57.1)	3 (42.9)	7 (100)
Bicyclists (%)	12 (36.4)	21 (63.6)	33 (100)	7 (36.8)	12 (63.2)	19 (100)
Motorcyclists (%)	37 (67.3)	18 (32.7)	55 (100)	1 (33.3)	2 (66.7)	3 (100)
Farm tractor drivers (%)	16 (80.0)	4 (20.0)	20 (100)	11 (73.3)	4 (26.7)	15 (100)
Total (%)	284 (62.8)	168 (37.2)	452 (100)	104 (48.8)	109 (51.2)	213 (100)

Elderly participants in RTA were more likely to survive the injuries (51.2%), than die at the scene of accident (48.8%). In the group of middle-aged subjects (452 subjects), 62.8% subjects died at the scene of the accident or on their way to the hospital, while 37.2% subjects survived the injuries for a certain period. The detail overview of survival after RTA according to the participations and age group are presented in Table 1.

The detailed distribution of survival period of elderly and middle ages RTA subjects is provided in Table 2. Trimodal distribution of deaths is observed including a high mortality rate at the scene, at first 6 hours as well as seven days after RTA.

Table 2: Surviving period of elderly and middle-ages RTA subjects

Variable	***Subject who died at the scene***	***Subjects who survived the injuries***							
		6 hours	24 hours	72 hours	7 days	14 days	30 days	Longer than 30 days	Total
<65 yr (n=452)	284	55	19	15	31	22	23	3	168
≥65 yr (n=213)	104	26	13	12	30	18	8	2	109
Total (n=665)	388	81	32	27	61	40	31	5	277

Distributions of injuries and cause of death

The most common injuries among the elderly in all group of participants were chest injuries, with statistically significant difference ($\chi2=32.372$; df=6; $P<0.01$). In second place in terms of the frequency of injuries among the elderly were head injuries which also showed statistical significance ($\chi2=19.292$; df=6; $P<0.01$). Abdominal injuries were the least prevalent among the elderly and showed no statistical significance ($\chi2=13.641$; df=6; $P>0.01$). The injury characteristics of two age groups of RTA subjects according to the participation are presented in Table 3.

Table 3: The distribution of injury of the elderly and middle aged subjects according to participation in RTA

RTA subjects <65 years old	*Head injury (%)*	*Chest injury (%)*	*Abdomen injury (%)*
Pedestrians (n=135)	96 (71.1)	102 (75.6)	55 (40.7)
Motor vehicle drivers (n=106)	63 (59.4)	87 (82.1)	53 (50.0)
Front seat passengers (n=72)	44 (61.1)	59 (81.9)	39 (54.2)
Back seat passengers (n=31)	18 (58.1)	21 (67.7)	12 (38.7)
Bicyclists (n=33)	26 (78.8)	22 (66.7)	7 (21.2)
Motorcyclists (n=55)	42 (76.4)	41 (74.5)	26 (47.3)
Farm tractor drivers (n=20)	4 (45.0)	16 (80.0)	8 (40.0)
Total (n=452)	298 (65.9)	348 (77.0)	200 (44.2)
RTA subjects ≥65 years old			
Pedestrians (n=129)	85 (65.9)	108 (83.7)	45 (34.9)
Motor vehicle drivers (n=22)	12 (54.5)	19 (86.4)	8 (36.4)
Front seat passengers (n=18)	7 (38.9)	13 (72.2)	7 (38.9)
Back seat passengers (n=7)	5 (71.4)	6 (85.7)	2 (28.6)
Bicyclists (n=19)	16 (84.2)	13 (68.4)	3 (15.8)
Motorcyclists (n=3)	3 (100)	1 (33.3)	1 (33.3)
Farm tractor drivers (n=15)	3 (20.0)	12 (80.0)	5 (33.3)
Total (n=213)	131 (61.5)	172 (80.8)	71 (33.3)

A detailed distribution of injuries of fatal RTA participants, depending on age group is shown in Table 4. The most common chest injury among elderly RTA participants was a rib fracture, with statistical significance ($\chi 2=1.107$; df=1; $P<0.01$).

Table 4: The detailed distribution of injury of the elderly and middle aged fatal RTA participants

Injuries	*RTA subjects <65 years old*		*RTA subjects ≥65 years old*		*Chi square test*	*P value*
	No	Yes	No	Yes		
Heart injuries	376	76	178	35	0.902	0.015
Aortic injuries	350	102	181	32	5.119	0.024
Lung injuries	209	243	107	106	0.927	0.336
Pneumothorax	362	90	183	30	3.324	0.068
Fractures of ribs	119	333	48	165	1.107	0.009
Skull bone fractures	192	260	101	112	1.433	0.231
Brain contusions	186	266	108	105	2.318	0.128
Kidney injuries	417	35	208	5	7.456	0.006
Liver injuries	310	142	174	39	12.553	0.004
Spleen injuries	346	106	187	26	11.506	0.001
Bladder injuries	427	25	196	17	1.469	0.226
Intestines injuries	362	90	176	37	0.605	0.437
Complications	399	53	174	39	5.265	0.004
Brain stem injuries	344	108	178	35	5.375	0.068

Cranio-cerebral injury was the most common cause of death in RTA subjects, either singular (296 or 44.5%) or in combination with other causes, such as exsanguination (30 or 4.5%) and respiratory distress (33 or 5%). A detailed distribution of all causes of death is provided in Table 5. Cranio-cerebral injury is the leading cause of death of elderly and middle ages RTA subjects. At the second place is exsanguination and at third place is complication of injury as cause of death

in RTA subjects. It is important to mention that not all complications that developed during hospitalization were the cause of death. In the group of middle-aged RTA subjects complication of injury is represented in 54 subjects (12.0%), while as cause of death is represented in 31 subjects (6.9%). In the group of elderly RTA subjects complication of injury is represented in 36 subjects (16.9%), while as cause of death is represented in 22 subjects (10.3%). The most common complications were pneumonia, sepsis and thrombotic embolism.

Table 5: Causes of death of RTA subjects

Cause of death	*RTA subjects <65 years old*	*RTA subjects ≥65 years old*	*Total (%)*
Cranio-cerebral injury	207 (45.8)	89 (41.8)	296 (44.5)
Cranio-cerebral injury + respiratory distress	24 (5.3)	9 (4.2)	33 (5.0)
Cranio-cerebral injury + exsanguination	26 (5.8)	4 (1.9)	30 (4.5)
Exsanguination	79 (17.5)	40 (18.8)	119 (17.9)
Breathing disorders	29 (6.4)	19 (8.9)	48 (7.2)
Breathing disorders+ exsanguination	18 (4.0)	12 (5.6)	30 (4.5)
Complication of injury	31 (6.9)	22 (10.3)	53 (8.0)
Vital organs destructions	18 (4.0)	6 (2.8)	24 (3.6)
Myocardial infarction	6 (1.3)	9 (4.2)	15 (2.3)
Neck injuries+ bleeding out	14 (3.1)	3 (1.4)	17 (3.4)
Total	452 (100)	213 (100)	665 (100)

BAC of RTA participants

The distribution of RTA participants with positive blood alcohol concentration (BAC) was different between the age group, with significance statistical difference (χ^2=15.74; df=2; P<0.01). In the group of middle-aged subjects 110 i.e. 31.3% was with positive BAC, while in the elderly group only 14 i.e. 8.04% had positive BAC. BAC values in deceased elderly participants ranged from 0.23 ‰ to 3.15 ‰, with mean value being 1.04±0.94‰, while in group of middle-aged subjects ranged from 0.30 ‰ to 3.81 ‰, with mean value being 1.64±0.86‰.

Discussion

The proportion of the elderly in the population is increasing in many countries and RTA involving elderly people has become an important problem that requires further investigation. According to our results, of the total number of RTAs, approximately 33% were accidents involving elderly, with mean age of the study population 73.6±6.1 years. In other published studies, the average age of the elderly is similar, as well as the percentage of the elderly in the RTA (8-10).

Epidemiological data demonstrate male prevalence to the total number of the elderly deceased RTA subjects, which is consistent with previous literature (11,12). Gender differences can be ascribed to the increased vulnerability and exposure of men because of social, specific occupational and cultural properties.

The majority of accidents were occurred in summer and autumn months, which can be explained by the increased activity of the population during these seasons. In the winter months, the elderly population is mostly stationed in houses and come out much less often. Seasonal differences are in accordance with the results from other studies (12-14).

There was a difference in the type of participation in traffic accidents depending on the age group and these differences are because the elderly are more likely to use other types of road transport than middle-aged subjects are. The

most vulnerable subjects in the elderly population were pedestrians. A high number of pedestrians in the elderly group in our study (60% versus 33% in the middle aged subjects group) could be explained by the fact that the elderly are most often in the role of pedestrians in traffic for several reasons, such as lack of driver's license or the presence of diseases that makes it difficult for them to drive. In addition, elderly have difficulties in noticing possible dangers; inadequate reaction, they commonly have dementia, hearing impairments or visions issue. Sadeghi-Bazargani et al. (3) point out that the elderly subjects were seven times more likely to die as a pedestrian compared to other age group, which correlates to the results of the our study. In contrast to the middle age group, a significantly lower number of elderly was observed in groups of motorcyclists (1% versus 11%) and motor vehicle drivers (9% versus 23%). The large number of motorcyclists and motor vehicle drivers in the middle-aged group can be explained by the fact that this is the most able-bodied population, working population, which is active on every day, so they are therefore at greater risk for RTA. Furthermore, elderly participants are less likely to be in the role of motor vehicle driver or motorcyclists because perceptual and cognitive abilities decline with age, making aspects of the driving task more challenging for elderly compared to middle age motor vehicle drivers or motorcyclists.

According to our results, elderly participants in RTA were more likely to survive the injuries, than die at the scene of accident. In a research (15), survival time after accidents is different in different age groups, and explained by the fact that elderly fatalities show lower Injury Severity Scores compared to the middle-ages RTA subjects. This can also be explained by the fact that the largest number of those who survived injuries are in the group of pedestrians, which is characterized by limb injuries that are not vital but they affect the time spent in the hospital during surviving period and the number of complications. In addition, during surviving period of elderly a high mortality rate seven days after RTA is observed. Already after seven days, complications develop, which in the group of the elderly were the direct cause of death in a higher percentage than in the middle-ages subjects. The elderly deaths are twice as likely to happen at the hospital compared to fatalities in other age groups. Recent studies demonstrated that elderly subjects were at high risk for longer hospitalizations during surviving period and develop complications, especially in cases where there were fractures of ribs (16,17). Increased mortality was also observed at the scene and first 6 hours after RTA, which is explained by the trimodal distribution of death.

In the present study, the elderly group had the highest rate of chest injuries compared to head and abdominal injuries, and the most common chest injuries were fracture of the ribs. High prevalence of chest injuries in elderly group can be explained by the mechanism of injury in RTA as well as the special characteristics of the elderly population. The types of injuries in RTA have some characteristics, which can be explained by the presence of a huge action force that occurs because of multiplying the mass and acceleration that the body absorbs during the accident. The injury occurs due to the absorption of an external force during impact, acceleration or deceleration, whereby the body tends to maintain its original position and speed (18). By the term special characteristics of the elderly population we mean the physiological changes that accompany the elderly population (hearing and vision impairment, musculoskeletal problems), as well as the presence of certain diseases (dementia, osteoporosis, osteoarthritis). Approximately 50 % of individuals aged 65 years and above have osteoarthritis that leads to a significant reduction of mobility and strength (19). All together leads to the point that in elderly participants in RTA, much less force is required for the bone fractures and following complications, and since the chest is the most prominent part of the body, the most common fractures is the fractures of the ribs. Fracture of the ribs are the cause of considerable morbidity and mortality, and Stawicki et al. (16) point out that the elderly population with fracture of the ribs had nearly twice the mortality rate as middle-ages

RTA subjects. The higher prevalence of abdominal injuries among younger participants can be explained by the fact that in the group of younger participants, there are more motorcyclists, motor vehicle drivers and front seat passengers compared to the group of the elderly, where abdominal injuries are much less common. The most common cause of death in RTA subjects is cranio-cerebral injury either singular or in combination with other causes, such as exsanguination and respiratory distress. Similar results were presented in other studies, where head injuries were the cause of death in about 50% of cases (15,20) and with study of Ryan et al. (21) in which head injuries and internal thorax injuries were identified as the leading causes in deaths due to traffic collisions. Head injuries are almost equally represented in the group of the elderly and the middle-aged subjects, but a significant difference was observed in the number of those where cause of death was a complication of the injury. Among elderly subjects who had some complication of the injury, it was the cause of death in one in five. Many studies have confirmed that the occurrence of complications in trauma patients is associated with a significant increase in mortality and that the percentage of deaths for those who had at least one complication was higher than for patients without complications (22,23). The most common hospital complications in trauma patients include pneumonia, sepsis, acute respiratory distress syndrome and deep vein thrombosis, which correlates with the results of our study (24).

In comparison to other age groups, elderly are less likely to have positive BAC, and even in cases when BAC was increased, the levels were on the lower scale.

Conclusion

The characteristics of injuries in elderly subjects is different from middle-aged RTA subjects. More effort should be made to enhance road safety for elderly pedestrians, especially considering the expected rapid growth in the elderly population.

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

The authors declare that there is no conflict of interests.

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