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Risk factors in urban road traffic accidents

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Abstract

Introduction: The urban road traffic accident (RTA) risks for the city of Zagreb, Croatia, from 1999 through 2000 were analyzed with the aim of reducing the increasing injury incidence. *Method*: Simple and bivariate analysis using χ^2, odds ratio, and confidence interval of 95% was used to determine risks in three outcome groups: killed, severely, and mildly injured. *Results*: There were 528 RTA victims consisting of 260 severely, 213 mildly injured, and 55 killed at the scene of an accident and during transportation. More fatal accidents occurred during night hours (OR = 3.78; 95% CI, 2.08 – 6.85), on urban road links (OR = 2.33; 95% CI, 1.30 – 4.19), and at exceeding speed limit (OR = 2.56; 95% CI, 1.43 – 4.61). More people were injured than killed on urban junctions (OR = 5.27; 95% CI, 2.21 – 12.57). The highest combined risk of dying or being severely injured was found in males, driving at excessive speed, on urban links, and during bad visibility (OR = 16.15; 95% CI, 3.901 – 66.881). *Conclusion:* These results will influence the urban traffic police enforcement measures, which will change inappropriate behavior of drivers and protect the least experienced road users.

Keywords: Urban road traffic accidents; linked hospital and traffic police data; risks for fatal, severe and mild injuries; urban road links and junctions

1. Introduction

Motor-vehicle accidents are complex events resulting primarily from human, technical, and environmental contributing factors. Design of streets with traffic signals and stop-signs as well as overall organization of road traffic control by traffic police, are major factors that influence the frequency and severity of motor-vehicle collisions in urban area. Traffic police have the responsibility of collecting and analyzing crashes, and a review of motor-vehicle collisions can be compiled from their reports (Retting, Weinstein, Williams, & Preusser, 2001). Al-Ghamdi (2002) analyzed pedestrian–vehicle crashes in Riyadh, Saudi Arabia using data from traffic police reports. In addition, data on the type of injury, injury severity, costs, and length of hospital stay were collected from hospital records. Identification of the most probable factors that affect accident severity is the basis for effective road traffic accident prevention. The most complete information about causalties in road traffic crashes can be obtained from linked police, hospital, and death records (Rosman, 2001).

The data from Ministry of Interior's Road Traffic Accident (RTA) Surveillance for the Republic of Croatia shows that there were 701 killed (mortality 15.8/100,000) and 26,182 injured people (injury incidence 590.0/100,000) in RTA in Croatia in 2003. The number killed has been decreasing since 1990 (1,366) and the number of injured has been increasing since 1990 (19,791) – the highest was in 2003. There were 53 killed (mortality 6.8/100,000) and 3,270 injured persons in RTA (injury incidence 419.7/100,000) in Zagreb, the capital of Croatia, in 2003 (Fig. 1); 17.6% of the Croatian population were living in the city of Zagreb. The traffic density in Zagreb is increasing compared to other large Croatian cities. Although the percentage of killed in RTA in Zagreb is not high (7.5%), the percentage of injured is high (12.5%), and is still increasing. Therefore, it is important to investigate factors that most influence urban RTA mortality and morbidity.

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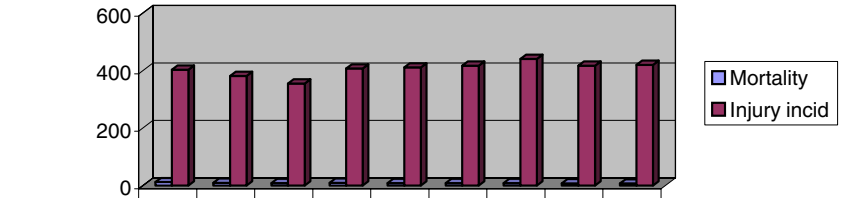

	1995	1996	1997	1998	1999	2000	2001	2002	2003
Mortality	11,4	9,5	8,5	9,5	8,5	7,8	8,1	7,4	6,8
Injury incid	403	381	355	407	411	417	441	417	420

Fig. 1. Mortality and injury incidence per 100 000 of RTA in the city of Zagreb in period 1995-2003.

The study used linked traffic police and hospital records in determining human and environmental risk factors, as well as calculating hospital cost and length of stay in hospital of RTA patients in the city of Zagreb during the 2-year period 1999–2000.

Three RTA outcome groups were included: (a) persons dead at the scene of the accident or who died during transportation; (b) severely injured (included deaths within 30 days); and (c) mildly injured persons (see definitions in the next section).

The aim of this paper is to determine circumstances and human and road traffic variables that most influence fatally, severely, and mildly injured urban road traffic users.

2. Material and method

A sample of 1,882 injured and killed persons in RTA in the city of Zagreb were hospitalized in three Zagreb hospitals: (a) Dubrava Clinic; (b) Clinic of Traumatology; and (c) Nun Clinic during the period January 1, 1999–December 31, 2000. These three hospitals receive about 75% of victims injured in RTA in the city of Zagreb.

A special form for those injured in RTA, as determined from hospital admission and discharge records (with length of stay data and costs of hospitalization) and death records (for those who died within 30 days of accident), was created. The data from these forms were linked with the corresponding data of traffic police reports. The study sample was 528 persons with their linked data. In this way, data were collected for each patient from the place of accident until the end of hospitalization.

According to traffic police reports, the following personal characteristics and road traffic variables were investigated: (a) age; (b) gender; (c) road user type (drivers, passengers and pedestrians); (d) the time of accident; (e) month; (f) day of week; (g) the time of day; (h) bad visibility condition (night, sunset, sunrise); (i) light(ing); (j) type of road (junctions, links); (k) road surface (wet, ice, uncleaned road); (l) bad weather condition (rain,fog,snow); (m) type of motor vehicle (car, vehicles on two wheels); (n) vehicle's year; and (o) driver's errors (driving with exceeding speed limit, not-using seat belts, and blood alcohol concentration found).

The three outcome groups have been compared:

1. persons who died at the scene of an accident or during transportation
2. severely injured persons
3. mildly injured persons.

The trauma experts suggest the determination of the two case groups: mildly and severely injured groups according the 10th revision of ICD (S00-T07). Mildly injured persons have: contusions, open wounds, sprains, strains and dislocations, and the combination of these types of injuries. Injured head with these types of injuries and without commotio cerebri is included. Severely injured persons have mild injuries plus: fractures, damage of nerves, blood vessels, muscles and tendons, crushing injury, traumatic amputation, and commotio cerebri. Both groups of injured were analyzed as the hospitalized RTA injured group. The mildly injured went home after hospitalization; and some of them went into rehabilitation. Severely injured people were sent to rehabilitation and/or died within 30 days.

The classification of the three outcome groups (dead, severely injured, and mildly injured persons) were evaluated according to the length of stay in the hospital and according to the respective hospital costs (Tables 1 and 2):

- Injury severity is significantly correlated with length of stay in hospital ($\chi^2=58.703$, df=2, $P<0.0001$) (Table 1).
- Injury severity is significantly correlated to the hospitalization costs ($\chi^2=74.806$, df=2, $P<0.0001$) (Table 2).

Table 1
Length of stay in hospital and injury severity

Injury severity/hospital days	1–7 days		8–28 days		29 and more days		Total	
Severely injured	88	36.8%	113	47.3%	38	15.9%	239	100%
Mildly injured	150	73.2%	40	19.5%	15	7.3%	205	100%

Table 2
Injury severity and hospitalization costs

Injury severity/ cost	<500 €		500–1500 €		>1500 €		Total	
Severely injured	42	18.7%	89	39.5%	94	41.8%	225	100.0%
Mildly injured	116	58.3%	52	26.1%	31	15.6%	199	100.0%

Statistically significant correlation of injury severity and stay in hospital, as well as hospital costs, has confirmed the appropriate classifications of severe and mild cases for those injured in road traffic.

The statistical analysis included simple and bivariate analysis using χ^2 Odds Ratio (OR) and Confidence Interval (CI) of 95% for potential risks. A chi-square (χ^2) test was calculated to find out the association of risks with the three outcome groups. The OR for fatal outcome compared with severely or mildly injured and related CI of 95% was calculated for all the statistically significant associations. The same was performed to show risks for those killed at the scene of the accident or during transportation, and for those severely injured versus mildly injured in road traffic accidents. The ORs and related CIs of 95% were calculated for a combination of several risks as well.

3. Results

The study sample of 528 persons with linked hospital and traffic police data consists of 260 severely injured and 213 mildly injured persons in RTA in the city of Zagreb during 1999–2000. There were also 55 persons killed at the scene of the accident or during transportation. The analyzed sample consists of 372 men and 156 women.

The only risk-variables presented in Table 3 show significant differences ($P<0.05$) between proportions of fatal and injured outcomes: 85.5% of those who died at the scene of the accident or during transportation were male; the risk involvement in fatal rather than injured outcomes was higher among males than among females (odds ratio OR=2.69; 95% confidence interval (95%CI) 1.24–5.84). The risk of death was higher for those injured in accidents that occurred between midnight and 6 a.m. than in other times of the day (OR=3.78; 95%CI, 2.08–6.85). More deaths than injuries occurred over the weekend (OR=1.89; 95%CI, 1.06–3.34). Significantly more mildly and severely injured than killed were found on urban junctions (OR=5.27; 95% CI, 2.21–12.57). On the contrary, more fatal than non-fatal accidents occured on urban road links (OR=2.33; 95% CI, 1.30–4.19) where 65.5% of road users died. More fatal than other injury outcomes were

Table 3
Fatal versus injured (severely and mildly) road traffic urban risks

Atributes	Risk-variables	Outcomes	Number (%)	Total no (missing data)	P-value	OR	(95% CI)
Gender	Male	Died	**47 (85.5)**	55	**<0.0095**	**2.69**	**(1.24–5.84)**
		Injured	323 (68.3)	473			
		Severely	183 (70.4)	260			
		Mildly	140 (66.4)	211 (2)			
Time of day	0–6 hours	Died	**22 (40.0)**	55	**<0.0001**	**3.78**	**(2.08–6.85)**
		Injured	71 (15.0)	473			
		Severely	36 (13.9)	260			
		Mildly	35 (16.4)	213			
Weekdays	Weekend (Friday, Saturday Sunday)	Died	**33 (60.0)**	55	**<0.0278**	**1.89**	**(1.06–3.34)**
		Injured	195 (46.4)	420			
		Severely	107 (43.7)	245 (15)			
		Mildly	88 (45.1)	195 (18)			
Type of Road	Junctions «T»,»Y» »+»	Died	6 (10.9)	55	**<0.000037**	**5.27**	**(2.21–12.57)**
		Injured	**173 (39.2)**	441			
		Severely	**89 (36.3)**	245 (15)			
		Mildly	**84 (42.9)**	196 (17)			
Type of Road	Road links	Died	**36 (65.5)**	55	**0.0037**	**2.33**	**(1.30–4.19)**
		Injured	212 (44.8)	473			
		Severely	125 (48.1)	260			
		Mildly	87 (40.8)	213			
Bad visibility	Night, sunset sunrise	Died	**33 (61.1)**	54 (1)	**0.0040**	**2.29**	**(1.28–4.08)**
		Injured	178 (40.7)	437			
		Severely	95 (39.1)	243 (17)			
		Mildly	83 (42.8)	194 (19)			
Speed	Speed over upper limit	Died	**36 (65.5)**	55	**0.0012**	**2.56**	**(1.43–4.61)**
		Injured	187 (42.4)	441			
		Severely	110 (44.9)	245 (15)			
		Mildly	77 (39.3)	196 (17)			
Seat belt	Not used	Died	**42 (76.4)**	55	**0.0090**	**2.33**	**(1.22–4.45)**
		Injured	275 (58.1)	473			
		Severely	164 (63.1)	260			
		Mildly	111 (52.1)	213			

Table 4
Risks of killed and severely injured versus mildly injured people

Attributes	Risks	Outcomes	Number (%)	Total no. (missing)	P - value	OR	95% CI
Age	<30 yrs	Died	16 (29.1)	55	**0.0014**	**1.78**	**1.245–2.539**
		Severely	90 (34.6)	260			
		Died+Sever	106 (33.7)	315			
		Mildly inj.	**101 (47.4)**	213			
Age	>64 yrs.	Died	9 (16.4)	55	**0.0024**	**2.49**	**1.359–4.564**
		Severely	41 (15.8)	260			
		Died+Sever	**50 (15.9)**	315			
		Mildly inj.	15 (7.0)	213			
Road users	Drivers	Died	28 (50.9)	55	**0.0058**	**1.87**	**1.305–2.664**
		Severely	114 (45.2)	252 (8)			
		Died+Sever	142 (46.3)	307			
		Mildly inj.	**130 (61.6)**	211 (2)			
Road users	Pedestrians	Died	16 (29.1)	55	**0.0081**	**2.00**	**1.328–3.016**
		Severely	88 (34.9)	252 (8)			
		Died+Sever	**104 (33.9)**	307			
		Mildly inj.	43 (20.4)	211 (2)			
Type of road	Road links	Died	36 (65.5)	55	**0.0204**	**1.51**	**1.066–2.152**
		Severely	125 (48.1)	260			
		Died+Sever	**161 (51.1)**	315			
		Mildly inj.	87 (40.8)	213			
Type of road	Junctions	Died	6 (10.9)	55	**0.011**	**1.62**	**1.114–2.35**
		Severely	88 (36.3)	245 (15)			
		Died+Sever	94 (31.1)	300			
		Mildly inj.	**84 (42.9)**	196 (17)			
Speed	Speed over upper limit	Died	36 (65.5)	55	**0.0400**	**1.47**	**1.020–2.110**
		Severely	110 (44.9)	245 (15)			
		Died+Sever	**146 (48.7)**	300			
		Mildly inj.	77 (39.3)	196 (17)			
Seat belts	Seat belt not used	Died	42 (76.4)	55	**0.0022**	**1.74**	**1.217–2.477**
		Severely	164 (63.1)	260			
		Died+Sever	**206 (65.4)**	315			
		Mildly inj.	111 (52.1)	213			

found when visibility was decreased (night, sunset, and sunrise; OR=2.29; 95% CI, 1.28–4.08). Fatal outcomes occured more frequently than non-fatal when speed exceeds upper limit (OR=2.56; 95% CI, 1.43–4.61). When their speed exceeded the upper limit, 65.5% of all road users died. The majority (76.4%) of the people who died at the scene of an accident or during transportation had not used their seat belts and therefore the risk of fatal accident was high (OR=2.33; 95% CI, 1.22–4.45).

Table 4 presents only those risk variables that show statistically significant differences ($P<0.05$) between fatally or severely versus mildly injured people.

Higher risk was found in the mildly injured group than in the fatally or severely injured group in younger urban road users (<30 years) (OR=1.78; 95% CI, 1.25–2.54). Elderly (≥65 years) had significantly higher risk for fatal or severe injuries than for mild injuries (OR=2.49; 95% CI, 1.36–4.56). In drivers, risk for mild injuries was higher than for fatal or severe injuries (OR=1.87; 95% CI, 1.31–2.66). In pedestrians significantly higher risk was for fatally or severely injured than for mildly injured (OR=2.00; 95% CI, 1.33–3.02). On urban links there were more fatally or severely injured than mildly injured (OR=1.51; 95% CI, 1.07–2.15) and more mildly injured than fatally or severely

Table 5
Risk combinations for male road users: fatal versus injured

Risk combinations	Outcomes	Numbers (%)	Total number	P-values	OR	95 % CI
male + hours (0–6)	Dead vs. Injured	20 (42.5)	47	0.000057	3.56	1.865–6.788
		56 (17.2)	325			
male + high speed	Dead vs. Injured	33 (70.2)	47	0.000842	2.99	1.538–5.814
		134 (44.1)	304			
male + no using seat belt	Dead vs. Injured	34 (73.9)	46	0.000016	4.34	2.142–8.771
		100 (39.5)	53*			
male + high speed + no using seat belt	Dead vs. Injured	25 (75.7)	33	0.000156	5.08	2.089–12.344
		40 (38.1)	105*			

* Pedestrians excluded.

injured on urban junctions (OR=1.62; 95% CI, 1.11–2.35). Driving at a speed exceeding the upper limit resulted in more fatal or severe injuries than mild injuries (OR=1.47; 95% CI, 1.02–2.11). Car occupants who were not using seat belts had more fatal and severe injuries than mild injuries (OR=1.74; 95% CI, 1.22–2.48).

Males have a 2.69 times higher risk of dying in urban RTA than females and therefore a combination of males with traffic variables and the odds ratio for dying is shown in Table 5. Statistically significant differences ($p<0.001$) show the following risk combinations: males driving during night hours (midnight–6 a.m.) have a higher risk of dying (OR=3.56; 95% CI, 1.865–6.788), as well as driving at excessive speed (OR=2.99; CI, 1.538–5.814). Males who do not use seat belts have a higher risk for dying (OR=4.34; 95%, CI, 2.142–8.771). There is a high dying risk for males driving at excessive speed and not using seat belts (OR=5.08; 95% CI, 2.089–12.344).

The combined risk for dying or being severely injured versus mildly injured for males who were driving at excessive speed on links and with decreased visibility was significantly high (OR=16.15; 95% CI, 3.901–66.881).

4. Discussion

Information about road traffic crashes would be biased if the analyses were based solely on traffic police report data. They are less biased if they are derived from the hospital admissions linked database (Cryer et al., 2001). A high proportion of traffic police underreporting was found in this study, as in some other investigations, by trying to link hospital with police records. Aptel et al. (1999) found that only 37.3% of non-fatally traffic-injured hospital patients were recorded by the police. In a 1-year survey by telephone about traffic injuries, 1 in 34 of the Dutch had some type of injury in a road accident. Police recorded only about 25% of these causalities during the same year (Harris, 1990). There have been several reasons for traffic police underreporting:

(a) in single crashes (especially bicyclists) people usually call only an ambulance; (b) when children were injured, adults immediately called an ambulance and went with their children to the hospital without calling traffic police; (c) car occupants under the influence of alcohol or drugs did not want to call traffic police; (d) traffic police were not called if someone had an apparently mild injury; (e) traffic police reports didn't include car occupants who at onset had an apparent mild injury and later had complications requiring them to be admitted to the hospital without their police records; (f) some hospitalized persons in three Zagreb hospitals had RTA outside of the territory of Zagreb.

The total number killed in the city of Zagreb was 66 in 1999 and 61 in 2000, but regarding the investigation of fatal risk factors, only those who died at the scene of the accident and during transportation (55 killed persons in both years) were analyzed; 29 were included in the severe injured group because they were at first hospitalized; others were not included in this analysis because the death records were taken only from those traffic police units that cover the city area where three hospitals under investigation are located.

By calculating OR for the group of killed or severely injured versus mildly injured, the OR's had lower values (between 1-2) because of smaller differences in frequencies between two injured groups. Exceptions were elderly people (>65 years) who died or were severely injured 2.5 times more frequently than other mildly injured road users. The total number of road users with risk combinations is lower (or decreasing), with an increasing number of risk combinations.

No statistically significant association was found for all other road traffic variables and the three outcome groups: (a) the state of road surface, (b) public light(ing), (c) bad weather condition, (d) type of motor vehicle, (e) vehicle's years, and (f) summer and winter months. There were only 29 (5.5%) RTA victims with blood alcohol concentration (BAC) over 0.5%; other car occupants with a high BAC did not call traffic police and therefore they do not have their linked data. Although alcoholic drivers are underreported, they present an important problem in our urban road traffic at the moment.

Only 13 (24.5%) of 53 motorcycle drivers were wearing a helmet. Only seven (1.3%) drivers reported using a cellular phone before the accident.

In other international studies, the problem of road traffic accidents in urban areas was shown. Hijar, Arredondo, Carrillo, and Solorzano (2004) emphasized the economic impact of road traffic accidents in an urban area in Mexico. Valent et al. (2002) showed a wide number of fatal risks in Udine, Italy; fatal risks were significantly higher on roads outside the city than in the urban center. In our study, significantly higher fatal risk was found on urban links and more injured were found on urban junctions. A meta-analysis of 33 studies presents an evaluation of effects on road safety of area-wide urban traffic calming schemes; they are implemented in residential areas in order to reduce safety problems caused by road traffic (e.g., street closures, streets with one-way direction, speed reducing devices, street improvements). In a Swedish city, an experiment with small roundabouts as speed reducing measures was carried out. The speed was considerably reduced at the junctions and on links between roundabouts. Pedestrian and bicycle risk was significantly reduced (Hyden & Varhelyi, 2000).

5. Summary

On the basis of linked road traffic accident data of hospital records and traffic police reports, the study of urban RTA victims was performed. Sixteen personal characteristics and traffic variables were analyzed and for those variables that show statistically significant differences ($P<0.05$) between proportions of fatal, severely, and mildly injured

RTA victims, OR and CI were calculated. High risks for fatal road traffic accidents were found on urban links, during night hours, and with bad visibility (night, sunset, sunrise), in male drivers who drove without using seat belts and at exceeding speeds. Higher risk for mild injuries then for severe and fatal was found in younger urban road users, as well as for all urban road users on urban junctions. Elderly people and pedestrians had higher risk of fatal or severe injuries. The highest combined risk for dying or being severely injured was found in male drivers driving at excesive speed, on urban links, and with bad visibility. Traffic police enforcement with the new traffic safety laws that were introduced in Croatia in August 2004 will hopefully change inappropriate behavior of male drivers and more effectively reduce road traffic injury incidence in the whole country, as well as in the cities. The results of our investigation of specific risks can help the police to make this enforcement more effective.

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