Risk factors in urban road traffic accidents

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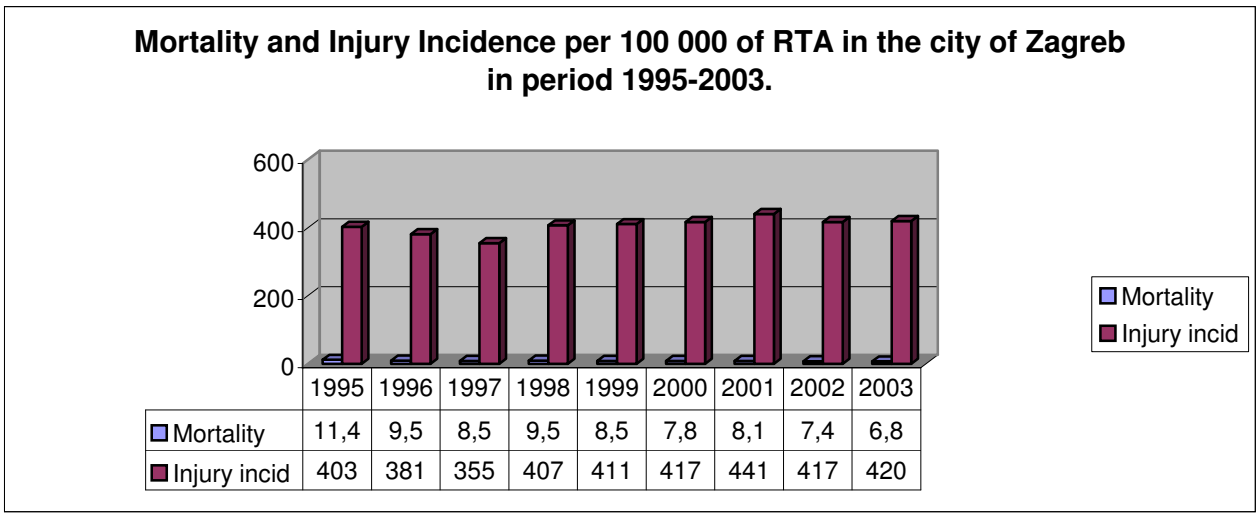
INVESTIGATION OF RISK FACTORS ON ROAD TRAFFIC ACCIDENTS IN THE CITY OF ZAGREB, CROATIA

1. Introduction

Motor vehicle accidents are complex events resulting primarily from human and environmental contributing factors. Design of streets with traffic signals and stop signs as well as overall organization of road traffic control doing by traffic police, are major factors which influence on the frequency and severity of motor vehicle collisions in urban area. Traffic police, beside that, have responsibility of collecting and analyzing crashes and from their reports a review of motor vehicle collisions can be obtained (Retting et al., 2001). Data about type of injury, injury severity, costs and length of stay can be investigated from hospital records. Identification of the most probable factors that affect accident severity is the basis for effective road traffic accident prevention (Al-Ghamdi, 2002). The most complete outcome information of 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 Republic of Croatia and the Zagreb County 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 of killed is decreasing since 1990 (1 366) and the number of injured is increasing since 1990 (19 791) – the highest is 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. 17.6 % of the Croatian population were living in the city of Zagreb. The traffic density in Zagreb is increasing and is the highest, regarding other larger croatian cities. Although the percentage of killed in RTA in Zagreb is not too high (7.5%), percentage of injured is high (12.5%) and still increasing. Therefore, it is important to investigate factors which mostly influence on urban RTA mortality and morbidity.

Figure 1



	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

This study was done with linked police and hospital records which were used in determining human and environmental risk factors, as well as hospital cost and length of stay of RTA in the city of Zagreb during the two-year period 1999 - 2000. Three outcome groups were determined: died persons at the place of accident or during transportation, severely injured (included deaths within 30 days) and mild injured persons.

The aim of this paper is to determine circumstances, human and road traffic variables mostly influencing fatal, severe and mild injured urban road users.

2. Material and method

A sample of 1882 injured and killed persons in RTA in the city of Zagreb, were hospitalized in three Zagreb hospitals: «Dubrava Clinic», «Clinic of Traumatology» and «Nun Clinic» during period January 1,1999 – December 31, 2000. These three hospitals receive about 75% of injured people in RTA in the city of Zagreb.
A special form for injured in RTA based on hospital admission and discharge records (with length of stay data and the costs of hospitalization) and death records (for those died within 30 days of accident) was created. These data were linked with the corresponding data of traffic police reports. The study sample was 528 persons with their linked data. Thus for each patient we had continuing data 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; 1. age, 2. gender, 3. road user type (drivers, passengers and pedestrians), the time of accident: 4. months, 5. days of week, and 6. the time of day; 7. bad visibility (night, sunset, sunrise), 8.light(ing), 9. type of road (junctions, links), 10. road surface (wet, ice, uncleaned road); 11. bad weather (rain,fog,snow), 12. type of motor vehicle (car, vehicles on two wheels), 13. vehicle's year; driver's error: 14. driving with exceeding speed limit, 15. not-using seat belts, 16. blood alcohol concentration found.
The three outcome groups will be compared:

1. persons died at the scene of accident or during transportation
2. severely injured persons
3. moderately-mild injured persons

The trauma experts suggests the determination of the two case groups: moderately-mild and seriously-severe injured groups according the 10th revision of ICD (S00-T07). Moderately-mild 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 (beside these types of injuries) have: fractures, damage of nerves, blood vessels, muscles and tendons, crushing injury, traumatic amputation and commotio cerebri. Both groups of injured were analized as hospitalized RTA injured group. Moderately -mild injured group went home after hospitalization and a part of them went to rehabilitation. Severely injured people went to rehabilitation and/or died within 30 days.

The classification of the three outcome groups: died, severely injured and mildly injured persons was evaluated according to the length of stay in hospital and according to the respective hospital costs (Table1) and (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 %
Mild injured	150 73.2%	40 19.5%	15 7.3%	205 100 %

Injury severity is significantly correlated with length of stay in hospital (χ^2= 58.703, df=2, P<0.0001)

Table 2. Injury severity and hospitalization costs

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

Injury severity is significantly correlated to the hospitalization costs (χ2=74.806, df=2, P<0.0001)

Statistically significant correlation of injury severity and staying in hospital as well as hospital costs has confirmed appropriate classification of road traffic injured as severe and mild ones.

The statistical analysis included simple and bivariate analysis using χ^2 odds ratio (OR) and confidence interval of 95% for potential risks. Chi-square (χ^2) test was calculated to find out the association of risks with the three outcome groups. The Odds Ratio (OR) for the fatal outcome compared with severe + mild injured and related confidence interval of 95% (CI 95%) was calculated for all the statistically significant associations. The same was performed to show risks for killed at the scene of accident or during transportation +severe injured versus mild injured in road traffic accidents. The Odds ratios and related confidence intervals of 95% were calculated for 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 accident or during transportation. The analyzed sample consists of 372 men and 156 women.

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

Atribu-tes	Risk - variables	Outcomes	Number (%)	Total no (missing data)	P – value	OR	(95% CI)
Gender	Male	Died Injured Severely Milde	**47 (85.5)** 323 (68.3) 183 (70.4) 140 (66.4)	55 473 260 211(2)	**<0.0095**	**2.69**	**(1.24-5.84)**
Time of day	0 – 6 hours	Died Injured Severely Milde	**22 (40.0)** 71(15.0) 36 (13.9) 35 (16.4)	55 473 260 213	**<0.0001**	**3.78**	**(2.08 – 6.85)**
Week-days	Weekend (Friday, Saturday Sunday)	Died Injured Severely Milde	**33 (60.0)** 195 (46.4) 107(43.7) 88 (45.1)	55 420 245(15) 195(18)	**<0.0278**	**1.89**	**(1.06-3.34)**
Type of road	Junctions : «T»,»Y» ,»+»	Died Injured Severely Mild	6 (10.9) **173 (39.2)** **89 (36.3)** **84 (42.9)**	55 441 245(15) 196(17)	**<0.0000 37**	**5.27 ***	**(2.21-12.57)**
Type of road	Road links	Died Injured Severely Mild	**36 (65.5)** 212 (44.8) 125 (48.1) 87 (40.8)	55 473 260 213	**0.0037**	**2.33**	**(1.30 – 4.19)**
Bad visibility	Night, sunset sunrise	Died Injured Severely Mild	**33 (61.1)** 178(40.7) 95(39.1) 83(42.8)	54 (1) 437 243(17) 194(19)	**0.0040**	**2.29**	**(1.28 – 4.08)**
Speed	Speed over upper limit	Died Injured Severely Mild	**36 (65.5)** 187(42.4) 110(44.9) 77 (39.3)	55 441 245(15) 196 (17)	**0.0012**	**2.56**	**(1.43-4.61)**
Seat belt	Not used	Died Injured Severely Mild	**42 (76.4)** 275(58.1) 164(63.1) 111(52.1)	55 473 260 213	**0.0090**	**2.33**	**(1.22 – 4.45)**

P=0.000037 OR=5.27 CI=2.2108-12.5710 severe and mild injuries are 5.27 times more frequent than fatal accidents in junctions in urban area
Bolded data have higher risk

There are only those risk-variables presented on Table 3, which show significant differences (P<0.05) between proportions of fatal and injured outcomes: 85.5% of those who died at the scene of 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 than for injured in accidents that occurred between 0:00-6:00 h as in other time of the day (OR= 3.78; 95%CI, 2.08-6.85). More deaths than injuries occurred during 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 injury outcomes were found when visibility was bad (night, sunset and sunrise) (OR = 2.29; 95%CI, 1.28-4.08). Fatal outcomes happened more frequently than non-fatal, when speed exceeds upper limit (OR = 2.56; 95% CI, 1.43-4.61) - in such way died 65.5% of road users. Majority (76.4 %) of people who died at the scene of accident or during transportation didn't use seat belts and therefore their risk for fatal accident was high (OR = 2.33; 95% CI, 1.22-4.45).

Table 4. Risks of killed and severely injured versus mildely injured people

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

* Bolded data have higher risk

In Table 4 there are only those risk-variables presented which show statistically significant differences (P<0.05) between fatal + severe versus mild injured people.

Higher risk was found in mild injured group than in fatal + severely injured group in younger urban road users (<30) (OR = 1.78; 95%CI, 1.25-2.54). Elderly (≥ 65) had significantly higher risk for fatal + severely 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 + severe injuries (OR = 1.87; 95% CI, 1.31-2.66). In pedestrians significantly higher risk was for fatal +severely injured than for mild injured (OR = 2.00; 95%CI, 1.33-3.02). On urban links there were more of fatal + severely injured than mild injured (OR = 1.51; (95% CI, 1.07-2.15) and more mild injured than fatal + severe injured on urban junctions (OR = 1.62 (95% CI, 1.11-2.35). Driving by a speed exceeding the upper limit results with more fatal + severe injuries than mild injuries (OR = 1.47; 95% CI, 1.02-2.11). Car occupants who haven't used seat belts had more fatal and severe injuries than mild injuries (OR=1.74; 95% CI, 1.22-2.48).

Table 5 Risk combinations with 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) 56(17.2)	47 325	0.000 057	3.56	1.865 – 6.788
male + high speed	Dead vs. Injured	33 (70.2) 134(44.1)	47 304	0.000 842	2.99	1.538 – 5.814
male + no using seat belt	Dead vs. Injured	34 (73.9) 100(39.5)	46 53*	0.000 016	4.34	2.142 – 8.771
male + high speed +no using seat belt	Dead vs. Injured	25 (75.7) 40(38.1)	33 105*	0.000 156	5.08	2.089 – 12.344

* pedestrians excluded

Males have 2.69 times higher risk to die in urban RTA than females and therefore a combination of males with traffic variables and OR for dying was shown in Table 5. Statistically significant differences (p<0.001) show the following risk combinations: male driving during night hours(0:00-6:00 h) have higher risk for 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). Male who do not use seat belts have higher risk for dying (OR=4.34; 95%, CI,2.142-8.771). It is high risk for dying 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 + being severely injured versus mild injured of males who were driving at excessive speed on links and by bad visibility was significantly high (OR= 16.15;95% CI, 3.901-66.881).

4.Discussion

Informations about road traffic crashes would be biased if the analizes were based solely on traffic police reports data, they are less biased if they derived from the hospital admissions linked database (Cryer et al., 2001). A high proportion of traffic police under-report was found in this study as in most of other investigations, by trying to link hospital with police records. There have been several reasons: 1. some hospitalized persons in three Zagreb hospitals had RTA outside of the territory of Zagreb, 2. traffic police was not called if someone had apparently mild injury, 3.

when children were injured, adults immediately call ambulance and went with their children to hospital without calling traffic police,
4.car occupants under alcohol or druggs do not want to call traffic police, 5. in single crashes (especially byciclists) people usually call only ambulance, 6.traffic police in their reports didn't include car ocupants with apparently mild injury and later complications appear and they have to be admitted to hospital without their police records. Maas, & Harris, 1984 in Netherland study shows rather high (83%) police data coverage.
The total number of killed in the city of Zagreb was 66 in 1999 and 61 in 2000, but regarding the investigation of fatal risk factors, there were analized only those died on the scene of accident and during transportation (55 killed persons in both years); other 29 were included into severe injured group, because they were at first hospitalized. Others were not included into this analysis, because the death records were taken only from those traffic police units which cover the city area where three hospitals under investigation are located.
By calculating OR for the group of killed+severely injured versus mild injured the OR-s had lower values (between 1-2) because of smaller differences in frequencees between two injured groups. Exceptions were elderly people (>65 yrs.) who died or were severely injured 2.5 times more frequently than other mild injured road users. The total number of road users with risk combinations is lower (or decreasing), with increasing number of risk.combinations.
No statisticaly significant association was found for all other road traffic variables and the three outcome groups: the state of road surface, public light(ing), bad weather, type of motor vehicle, vehicle's years, summer and winter months.
There were found only 29 (5.5%) RTA victims with blood alcohol concentracion over 0.5‰; other alcoholized car occupants have not called traffic police and therefore they do not have their linked data. Only 13 (24,5%) from 53 motorcycle drivers used helmet. There were reported only 7 (1.3 %) drivers who used cellular phone before accident.

In some other studies in the world, the problems of road traffic accidents in urban area was shown. Hijar M et al (2004) emphasised the economic impact of road traffic accident in an urban area in Mexico. Valent F. 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 urban centre and in our study significantly higher fatal risk was found on urban links and more injured were on urban junctions.

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. 16 personal characteristics and traffic variables were analized and for those variables which show statistically significant differences ($P<0.05$) between proportions of fatal, severely and mildly injured RTA victims OR and CI was calculated. High risks for fatal road traffic accidents were found on urban links, during night hours and by bad visibility (night, sunset, sunrise), in male drivers who draw without using seat belts and at exceeding speed limit. Higher risk for mild injuries was found on urban junctions. Elderly people and pedestrians have higher risks for 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 by bad visibility. Traffic police inforcement with the new low of traffic safety which was just introduced in Croatia, will hopefully change bad

behavior of our male drivers and more effectively reduce road traffic injury incidence in the whole country, as well as in our cities.

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Abstract

Introduction: The urban road traffic accident (RTA) risks for the city of Zagreb during period 1999-2000 were analyzed with the aim to reduce the increasing injury incidence. *Method*: Simple and bivariate analysis using χ^2 odds ratio (OR) and confidence interval of 95% was included to find out the association of risks with the three outcome groups: killed, severely injured, mild injured. *Results*: 528 RTA victims consists of 260 severely and 213 mildly injured and 55 killed at the scene of accident or during transportation. More fatal accidents were found 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 mild and severely injured than killed were found on urban junctions (OR = 5.27; 95% CI, 2.21-12.57). The highest combined risk for dying or beeing severely injured was found in males, driving at excessive speed, on urban links and by bad visibility (OR= 16.15;95% CI, 3.901-66.881). *Impact:* these results will influence to the new low of traffic safety in Croatia, with more penalty points and other severe penalties which will change bad behavior of our drivers and protect the weakest road users.

Author Keywords: Urban road traffic accidents; Linked hospital and traffic police data; Risks for fatal, severe and mild injuries; Urban road links and junctions.