Blood alcohol concentration in fatally injured drivers and the efficacy of alcohol policies of the new law on road traffic safety: A retrospective 10-year study in autonomous province of Vojvodina, Republic of Serbia

Stojan Petković, Kristina Palić, and Isidora Samojlik

Department of Forensic Medicine, Faculty of Medicine, University of Novi Sad, Faculty of Medicine, Novi Sad, Serbia;
Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia;
Department of Pharmacology, Toxicology and Clinical Pharmacology, Faculty of Medicine, University of Novi Sad, Novi Sad, Serbia

ABSTRACT

Objective: The aim of this study was primarily to evaluate inebriated fatally injured drivers (FIDs) according to blood alcohol concentration (BAC) in a 10-year period (2004–2013) in Autonomous Province (AP) of Vojvodina, Republic of Serbia, to analyze the efficacy of alcohol policies in the new law on road traffic safety through changes in the number of inebriated FIDs before and after implementation of the law, as well as to identify factors that influence the occurrence of FIDs with BACs above the legal limit.

Methods: All data for this retrospective study were obtained from the Centre of Forensic Medicine, Toxicology and Molecular Genetics of Clinical Centre of Vojvodina, Novi Sad. Autopsy records for each case included age, gender, BAC, type of vehicle, and date of accident (year, month, and recalculated day of the week). BAC was determined by gas chromatography with flame ionization detection. Statistical analysis was carried out by chi-square tests and Student’s t-test, with \( P < .05 \) as a statistical significance, and multiple binary logistic regression.

Results: Of the 354 inebriated FIDs (60% of all FIDs), the majority had BACs between 0.031 and 0.3 mg/ml (28%), followed by those with BAC > 2.01 mg/ml (23%). The average BAC of those driving under the influence of alcohol (DUIA) for the whole period was 1.235 ± 1.00 mg/ml and the average number of DUIA/year was 35. Among the total number of FIDs there were significantly more males (93.7%; \( P < .001 \)) than females (6.3%), though the distribution of intoxicated men and women was not different (\( P > .05 \)). There was a statistically significant difference in the distribution of sober and inebriated FIDs according to age (\( P < .001 \)) with the predominance of inebriated FIDs between 21 and 30 years. Although gender and age were found to be significant predictors of BAC above legal limit in FIDs, the area under the receiver operating characteristics (ROC) curve showed that the model had poor discrimination (ROC = 0.673). Of all observed FIDs, 65 cases per year were attributed to the first 5-year period (2004–2009) and 49 to the second 5-year (2010–2013) period, which indicates that there was no statistically significant decrease in the number of FIDs after implementation of the new law.

Conclusion: The highest number of intoxicated FIDs during the period in AP Vojvodina were mildly and completely inebriated. In the 4-year post-policy period (2010–2013), the number of FIDs and average BAC levels of inebriated FIDs did not significantly change. The abolition of a permissible BAC should be considered.

Introduction

Alcohol use is causally linked with many of diseases or trauma types and with numerous social or other problems in a population. Mortality from alcohol-related injuries, especially from traffic accidents, is highly present in European countries (Sauliune et al. 2012; Skog 2001).

High blood alcohol concentration (BAC) is a leading risk factor for traffic accidents that is well acknowledged. However, a study by Breitmeier et al. (2007) showed that low BAC, as low as 0.3 mg/ml, significantly impaired cognitive functions such as perception and processing of visual information, which are of great importance for more complex and urgent tasks, such as steering a vehicle.

Considering the permissible level of BAC in traffic, there is disagreement between different countries. For instance, BAC legal limit in 2007 in Sweden, Germany, and the UK were 0.2, 0.5, and 0.8 mg/ml, respectively (Albalate 2008). In the Republic of Serbia the allowed BAC is currently 0.3 mg/ml.

In the Republic of Serbia, in the period 1981–2012 there were 41,064 victims in traffic accidents (V. Ristić and Maljanović 2011), and in the period 2010–2014 there was a total of 3,265 fatalities in road accidents (Road Traffic Safety Agency 2015). Most of the men were killed as drivers of cars (31%). In Belgrade, the capital of Serbia, driving under the influence of alcohol (DUIA) has been considered as the leading cause of traffic accidents (Denić et al. 2013), and the Northern Bačka region
of Vojvodina (Severnobački okrug) has been noted as the most risky region in Europe, with a mortality rate of 6.91 fatalities/10,000 vehicles (V. Ristić and Maljanović 2011). In the last decade, there have been many activities aimed to establish more safety in traffic that resulted in a new, enhanced, and strengthened law on road traffic safety. This law came into force on December 2009, with some amendments in 2010 (The Law on Road Traffic Safety 2010).

The aim of our study was to evaluate the efficacy of alcohol policies in the new law on road traffic safety through changes in the number of inebriated fatally injured drivers (FID) before and after the law implementation, as well as to analyze these drivers according to BAC, gender, age category, type of vehicle driven, day of the week, and season of the traffic accident for a 10-year period in Autonomous Province (AP) of Vojvodina, Republic of Serbia.

**Methods**

This survey represents a retrospective study of fatally injured drivers over a 10-year period (2004–2013) in the AP of Vojvodina (northern part of the Republic of Serbia with approximately 2 million inhabitants). Data were obtained from the Centre of Forensic Medicine, Toxicology and Molecular Genetics of Clinical Centre of Vojvodina, Novi Sad, where all of the autopsies had been performed. Autopsy records for each case included all autopsies and blood sampling were performed 12–36 h after the victim’s death. Vials containing blood samples were warmed at 100°C for 7 min in an Agilent G1888 headspace sampler (Agilent Technologies, Santa Clara, CA). After incubation, the samples were injected into an Agilent 6850 series II gas chromatograph with a flame ionization detector. Separation was achieved utilizing an Agilent J&W DB-ALC1 capillary column (length 30 m, ID 0.53 mm, film 3.00 µm) at a constant temperature of 80°C, and the signals were processed by HP GC ChemStation with Windows REV A.09.01 (1206) system software. The carrier gas was laboratory nitrogen, GC purity, flowing at 10 ml/min. The GC parameter settings were for an injector temperature of 250°C and a detector temperature of 300°C. The retention times of analytes were as follows: 1.002 for ethanol and 1.254 for n-propanol.

**Blood alcohol concentration determination**

BAC was determined by gas chromatography (GC) after the calibrations were performed. Calibration solutions (standards) were prepared in a matrix of certified-negative human blood as dilutions of ethanol and n-propanol (Darmstadt, Merck, Germany; GC purity). The concentration of 6 standards ranged from 0.156 to 5 mg/ml for ethanol and 2 mg/ml for n-propanol. The coefficient of correlation for those values was \( r = 0.999 \). The estimated limit of detection was 0.01 mg/ml and the limit of quantification was 0.03 mg/ml.

Statistical analysis was carried out by chi-square test and Yates correction where needed, in order to estimate differences in nonparametric variable, and Student’s \( t \) test was used in the analysis of parametric variable. A \( P \) value of .05 was considered significant and the calculations were done by MS Office Excel 2010. Multiple binary logistic regression analysis, ROC curve, and the Hosmer-Lemeshow test were performed using SPSS software 20 for Windows (IBM, Armonk, NY).

**Results**

There were 587 FIDs during the observed 10-year period, with 233 (40%) sober (BAC up to 0.03 mg/ml) and 354 (60%) inebriated. The distribution of inebriated FIDs according to BAC categories showed a statistically significant difference (\( \chi^2 = 69.53, P < .001 \)), with mild (28%) and complete drunkenness (23%) predominant.

Among the total number of FIDs the male gender was significantly dominant (\( n = 550; \) 93.7%; \( \chi^2 = 448.33, P < .001 \)) vs. females (\( n = 37; \) 6.3%). Structurally, among females 51.35% (\( n = 19 \)) were sober and 48.65% (\( n = 18 \)) were inebriated, while among males 38.91% (\( n = 214 \)) were sober and 61.09% were inebriated (\( n = 336 \)). In inebriated female FIDs a BAC of 0.031–0.3 mg/ml was most frequent (50%; \( n = 9 \); \( P = 0.01 \)). In inebriated male FIDs there was statistically significant differences (\( P < .005 \)) between BAC categories, where the most frequent were mildly (27%; \( n = 91 \)) and completely inebriated (24%; \( n = 79 \)) FIDs. The distribution of intoxicated among men and women was not different (\( \chi^2 = 2.42, P > .05 \)).

There was statistically significant difference in the distribution of sober and inebriated FIDs according to age categories. Thus, the greatest percentage of sober FIDS (72%) was noted in the category over 70 years, whereas for inebriated FIDs the greatest percentage was among those 21–30 years (Table 1). The youngest victim was 17 years old and the oldest was 90 years old. In the youngest FIDs group (up to 20 years) there were no differences between BAC categories; in all other age categories these differences were present and are shown in Table 2. The sample
for age analyses included the total number of 543 FIDs instead of 587 (for all other analyses) due to lack of age data for 44 cases.

There were 75% car, 21% motorcycle, 3% truck and lorry, and 1% tractor FIDs during the observed period. The distribution of sober and inebriated FIDs is presented in Table 3. The BAC categories of inebriated FIDs are presented in Table 4. The distribution of sober and inebriated FIDs according to the type of vehicle used are presented in Table 4.

The distribution of sober and inebriated FIDs during the week was unequal ($\chi^2 = 15.84$, $P = .01$ and $\chi^2 = 38.28$, $P < .001$, respectively). The greatest number of sober as well as inebriated FIDs (especially those with BAC between 0.51 and 2.0 mg/ml) was recorded on weekend days. Moreover, the greatest number of inebriated ($\chi^2 = 26.705$, $P < .001$), especially mildly inebriated (BAC 0.031–0.3 mg/ml), was noted in summer months, though the distribution of sober FIDs throughout the seasons was equal ($\chi^2 = 4.90$, $P > .05$).

Comparing 2 periods—before and after implementation of the new law (2004–2009 vs. 2010–2013)—according to the average number of sober, inebriated (below and above the legal limit of BAC), and total FIDs per year, there was no statically significant differences (Table 5). Furthermore, no significant difference between average BAC levels of DUIA in these 2 periods (BAC $= 1.19 \pm 0.93$ mg/ml in 2004–2009 vs. BAC $= 1.33 \pm 1.13$ mg/ml in 2010–2013, $P = .204$) was obtained.

According to the multiple binary logistic regression, only 2 factors were found to be significant (Table A1, see online supplement): gender (coefficient $= 0.977$, $P = .016$, odds ratio [OR] = 2.655, 95% confidence interval [CI], 1.197–5.892) and age (coefficient $= -0.031$, $P < .001$, OR = 0.970, 95% CI, 0.957–0.982). Overall data fit the model (Hosmer-Lemeshow $\chi^2(8) = 7.652$, $P = .468$) but the area under the ROC curve showed that the model had poor discrimination/prediction (ROC = 0.673; Figure A1, see online supplement).

**Discussion**

The results of this study show that alcohol consumption leading to fatal injuries in drivers is widespread in our territory during the observed period. It is present in both males and females, though the predominant FIDs were males (93.7%). Men are 2.65 times more likely to have a BAC above the legal limit. Mild inebriation is a common characteristic in both genders, whereas in males there is also a dangerous appearance of hard alcohol consumption (24% completely inebriated). These findings confirm that excessive alcohol consumption explains the mortality differences between males and females in European countries cited by Sauliune et al. (2012). This leads to 2 possible patterns of alcohol consumption in drivers in our territory and their attitude toward the danger of DUIA: either drinking of small amount of alcohol because it is allowed by the law or a hard drinking.

In general, considering the whole sample of FIDs, we can say that mild inebriation prevails, along with the highest number of young inebriated FIDs. The noted frequency of young inebriated FIDs (age category 21–30) is disturbing and tells us 2 things: alcohol is widely available and younger people are ignorant of the dangers of alcohol. In addition, in our society, especially among young and middle aged persons, it is common for 1 or 2 alcoholic beverages to be consumed during normal social contacts. DUIA is least common in the eldest population (over 70 years). This is in accordance with the logistic regression analyses showing that with each 1-year increase in age there is a 3% lower chance of having a BAC over the legal limit.

However, we should keep in mind that gender and age as well as all of the other examined factors might be used as predictors of BAC above the legal limit with great caution because of the poor discrimination/prediction power described earlier by the calculation of area under the ROC curve.

DUIA was present in all types of vehicles, with more than 50% of inebriated in each type of vehicle group. According to the statistical significance in the distribution of BAC levels it is obvious that mild inebriation—below the legal limit—and complete inebriation were dominant in both car and motorcycle FIDs.

The most frequent presence of drunk FIDs during the weekend could be easily explained by the fact that alcohol consumption is almost mandatory in celebrations, parties, and social

---

**Table 1. Distribution of sober and inebriated FIDs according to age categories.**

| Age categories, n (%) | Total $\chi^2$ (df = 6) | $P$ |
|----------------------|--------------------------|-----|
|                      | $\leq 20$ | 21–30 | 31–40 | 41–50 | 51–60 | 61–70 | $>70$ |
| Sober                | 14 (37) | 46 (33) | 46 (37) | 35 (38) | 43 (47) | 22 (52) | 13 (72) | 219 | 41.67 | <.001 |
| Inebriated           | 24 (63) | 92 (67) | 77 (63) | 58 (62) | 48 (53) | 20 (48) | 5 (28) | 324 | 131 | <.001 |
| Total                | 38 (100) | 138 (100) | 123 (100) | 93 (100) | 91 (100) | 42 (100) | 18 (100) | 543 | 161.32 | <.001 |

---

**Table 2. Distribution of inebriated FIDs according to age and BAC categories.**

| BAC category (mg/ml) | $\leq 20$ | 21–30 | 31–40 | 41–50 | 51–60 | 61–70 | $>70$ |
|----------------------|-----------|-------|-------|-------|-------|-------|-------|
| 0.031–0.3            | 7 (29)    | 16 (17) | 19 (25) | 17 (29) | 20 (42) | 9 (45) | 3 (60) |
| 0.31–0.5             | 2 (8)     | 5 (5) | 1 (1) | 3 (5) | 2 (4) | 3 (15) | 1 (20) |
| 0.51–1.2             | 6 (25) | 13 (14) | 16 (21) | 3 (5) | 2 (4) | 2 (10) | 0 (0) |
| 1.21–1.6             | 4 (17) | 26 (28) | 10 (17) | 7 (12) | 9 (19) | 1 (15) | 1 (20) |
| 1.61–2.0             | 1 (4) | 15 (16) | 7 (11) | 9 (19) | 1 (15) | 1 (20) | 0 (0) |
| >2.01                | 4 (17) | 17 (18) | 20 (26) | 18 (31) | 14 (29) | 4 (20) | 0 (0) |
| Total of inebriated  | 24 (100) | 92 (100) | 77 (100) | 58 (100) | 48 (100) | 20 (100) | 5 (100) |
| $\chi^2$ (df = 5)    | 6.50 | 14.96 | 20.49 | 32.55 | 37.75 | 13.61 | 11.67 |
| $P$                  | .26 | <.001 | <.001 | <.001 | <.001 | .02 | .04 |
events, which most often take place on Saturday and Sunday. Furthermore, the highest number of inebriated FIDs in summer implies another habit of alcohol consumption in our region, beer intake. Beer is not even considered an alcoholic beverage because of its low alcohol content, slow absorption rate, and slow onset of drunkenness. The increasing popularity of beer drinking in Serbia as well as its popularity among adolescents and students has been recently documented by Vidal-Marques (2009) and Višnjić et al. (2015). This drinking pattern is opposite to cultures of northern Europe with traditions of irregular bouts of heavy drinking of spirits (Sauliune et al. 2012).

However, our results are well matched to the study of a geographically and socially close region performed by Sutl official et al. (2014).

The new law on road traffic safety of the Republic of Serbia included some issues regarding alcohol: stricter control of BAC by the police and lowering the legal BAC limit from 0.5 to 0.3 mg/ml (Road Traffic Safety Agency 2015). This study demonstrates that the implementation of new traffic safety measures concerning alcohol resulted in no change in the number of FIDs, both sober and inebriated, or on average BACs found in those DUIA. Similarly, Živković et al. (2013) explored the effect of the new law on road traffic safety in our country in a 2-year postimplementation period and concluded that there was no decrease in the ratio of drivers under the influence of alcohol vs. all drivers or in the number of drivers under the influence of alcohol. Missioni et al. (2012) concluded that the number of traffic accidents caused by DUIA had increased by 12% in the 2-year period after the New Road Traffic Safety Act was implemented in the Republic of Croatia and that alcohol use still remained a significant factor in road traffic accidents and was an important area for injury prevention efforts. On the other hand, the number of traffic accident deaths involving alcohol declined by more than 2 times in Lithuania during the period 2006–2009 as the result of the state’s alcohol policy in 2007–2008 (Sauliune et al. 2012).

The great number of mildly inebriated FIDs in our study showed the detrimental effect of low BAC on driving skills, which was confirmed by other authors (Phillips and Brewer 2011; Ristic et al. 2013). Taking into account all that was noticed regarding the habits of alcohol use in our region (e.g., consumption of alcohol beverages during any kind of social contact, ignorance of the harmful alcohol effects on driving abilities, lack of self-control during drinking, etc.), there is a need for a national strategy for the prevention of DUIA. Such a strategy could include the following measures: education about the effects of alcohol and the dangers of DUIA as mandatory training to obtain a driver’s license; prohibition of the sale of alcohol at petrol stations; time restriction for sale of alcohol beverages, especially on weekend days; the development and implementation of programs of social standards regarding DUIA, etc. Finally, there is the necessity to change the permissible BAC from 0.03 to 0.0 mg/ml. Similar policies regulating alcohol have been recently implemented in Montenegro (Ministry of Health of Montenegro 2012) and with success in Lithuania (Sauliune et al. 2012).

Table 3. Distribution of FIDs according to type of vehicle.

| Type of vehicle, n (%)       | Car       | Motorcycle | Truck and lorry | Tractor |
|-----------------------------|-----------|------------|-----------------|--------|
| Sober                       | 176 (40)  | 47 (38)    | 9 (47)          | 1 (33) |
| Inebriated                  | 266 (60)  | 76 (62)    | 10 (53)         | 2 (67) |
| Total                       | 442 (100) | 123 (100)  | 19 (100)        | 3 (100)|

Table 4. Distribution of inebriated FIDs according to BAC category and type of vehicle.

| BAC category (mg/ml) | Car       | Motorcycle | Truck and lorry | Tractor |
|----------------------|-----------|------------|-----------------|--------|
| 0.031–0.3            | 68 (26)   | 27 (36)    | 3 (30)          | 2 (100)|
| 0.31–0.5             | 13 (5)    | 3 (4)      | 2 (20)          | 0 (0)  |
| 0.51–1.2             | 40 (15)   | 8 (11)     | 2 (20)          | 0 (0)  |
| 1.21–1.6             | 41 (15)   | 14 (18)    | 1 (10)          | 0 (0)  |
| 1.61–2.0             | 38 (14)   | 9 (12)     | 1 (10)          | 0 (0)  |
| >2.01                | 66 (25)   | 15 (20)    | 1 (10)          | 0 (0)  |
| Total                 | 266 (100)| 76 (100)   | 10 (100)        | 2 (100)|

Table 5. Average number and percentage of sober, inebriated (below and above the legal BAC limit), and total FIDs before and after implementation of the new law at the end of 2009.

| Period           | 2004–2009 | 2010–2013 | χ² (df = 1) | P     |
|------------------|-----------|-----------|-------------|-------|
| Sober            | 26 (39.39)| 20 (40.30)| 0.78        | .38   |
| Inebriated < LL  | 13 (20.20)| 8 (16.84) | 1.12        | .29   |
| Inebriated > LL  | 26 (40.41)| 21 (42.86)| 0.61        | .43   |
| Total FIDs       | 65 (100)  | 49 (100)  | 2.32        | .128  |
The highest number of drunken FIDs during the observed period in AP Vojvodina was among those with a BAC of 0.03–0.3 mg/ml (mild drunkenness, below the legal limit) followed by those with a BAC over 2.01 mg/ml (complete inebriation). The average BAC of DUIA for whole period was \(1.235 \pm 1.00\) mg/ml and the average number of DUIA/year was 35. Although gender and age were found to be significant predictors of BAC above the legal limit in FIDs, the area under the ROC curve showed that the model had poor discrimination (ROC = 0.673).

As for law enforcement measures implemented, in the 4-year post-policy period (2010–2013), the number of FIDs (154 sober and 237 inebriated FIDs in 2004–2009 vs. 79 sober and 117 inebriated FIDs in 2010–2013) and average BAC levels of inebriated FIDs (1.19 ± 0.93 mg/ml vs. 1.33 ± 1.13 mg/ml, respectively) was not significantly changed. Abolition of a permissible BAC should be considered.

Acknowledgments
The authors thank Professor Zagorka Lozanov Crvenković for assistance, interpretation, and practical advice regarding multiple binary regression analyses.

Funding
This work was supported by the Ministry of Education and Science of the Republic of Serbia (Grant Number III41012).

References
Albalate D. Lowering blood alcohol content levels to save lives: the European experience. *J Policy Anal Manage.* 2008;27:20–39.
Breitmeier D, Seeland-Schulze I, Hecker H, Schneider U. The influence of blood alcohol concentrations of around 0.03% on neuropsychological functions—a double-blind, placebo-controlled investigation. *Addict Biol.* 2007;12:183–189.
Denić K, Rudić B, Dordević S, Kilibarda V. Alcohol intoxication as cause of traffic accidents in Belgrade during 2011 and 2012 year. *MD-Medical Data.* 2013;5:23–26.

The Law on Road Traffic Safety. *The Official Gazette of the Republic of Serbia* 53/10. 2010. Available at: [http://en.abs.gov.rs/regulations](http://en.abs.gov.rs/regulations). Accessed June , 2015.

Ministry of Health of Montenegro. National strategy to prevent harmful use of alcohol and alcohol-related disorders in Montenegro 2013–2020. 2012. Available at: [http://www.mzdravlja.gov.me/en/library/strategije?alphabet=lat](http://www.mzdravlja.gov.me/en/library/strategije?alphabet=lat). Accessed February , 2015.

Missoni E, Bozić B, Missoni I. Alcohol-related road traffic accidents before and after the passing of the Road Traffic Safety Act in Croatia. *Coll Antropol.* 2012;36:1483–1489.

Phillips DP, Brewer KM. The relationship between serious injury and blood alcohol concentration (BAC) in fatal motor vehicle accidents: BAC = 0.01% is associated with significantly more dangerous accidents than BAC = 0.00%. *Addiction.* 2011;106:1614–1622.

Ristic B, Rancic N, Maksimovic M, Ignjatovic-Ristic D. The influence of alcohol intoxication on the severity of injuries suffered by drivers in road traffic accidents. *Eur J Trauma Emerg Surg.* 2013;39:363–368.

Ristic V, Maljanovic M. Road traffic injuries of 21th century in Subotica. *Medicina Danas.* 2011;4–6:182–189.

Road Traffic Safety Agency. Structure of fatalities in road accidents in Serbia. 2015. Available at: [http://en.abs.gov.rs/news/article/20072015/structure-of-fatalities-in-road-accidents-in-serbia](http://en.abs.gov.rs/news/article/20072015/structure-of-fatalities-in-road-accidents-in-serbia). Accessed July , 2015.

Sauliune S, Petrauskiene J, Kalediene R. Alcohol-related injuries and alcohol control policy in Lithuania: effect of the year of sobriety, 2008. *Alcohol Alcohol.* 2012;47:458–463.

Skog OJ. Alcohol consumption and mortality rates from traffic accidents, accidental falls, and other accidents in 14 European countries. *Addiction.* 2001;96(Suppl 1):S49–S58.

Sultovic D, Scepanovic A, Bosnjak M, Versic-Bratincevic M, Deinsic-Gojanovic M. The role of alcohol in road traffic accidents with fatal outcome: 10-year period in Croatia Split–Dalmatia County. *Traffic Inj Prev.* 2014;15:222–227.

Vidal-Marques P. Trends in beer drinking in Europe. In: Preedy VR, ed. *Beer in Health and Disease Prevention.* London, UK: Academic Press; 2009:129–139.

Višnjić A, Jović S, Grbeša G. Alcohol consumption among students—a cross-sectional study at three largest universities in Serbia. *Srp Arh Celok Lek.* 2015;143:301–308.

Živković V, Nikolić S, Lukić V, Živadinović N, Babić D. The effects of a new traffic safety law in the Republic of Serbia on driving under the influence of alcohol. *Accid Anal Prev.* 2013;53:161–165.