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ORIGINAL RESEARCH

Comparative Analysis of Injury Severity Caused by Traffic Accidents Classified as Severe Injury in Police Database vs. MAIS 3+ Injury in Hospital Database -- First Pilot Research in Serbia

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Abstract

Objective: Conduct a comparative analysis of injury severity (IS) caused by traffic accidents (TA) and classified as severe injury (SI) in police database vs. MAIS 3+ injury in hospital database, and determine correction factor (CF). **Methods:** Data were collected prospectively on the injured in TA examined by Emergency medical services. Were identified the numbers of fatalities, the numbers of patients transported to hospitals, and those examined at the scene of TA who refused further medical treatment and transport. IS was asssessed in hospital according to ICD, AIS and MAIS for each patient. The data on SBI were compared vs. MAIS 3+ and CF was determined. **Results:** 134 respondents were included: 55 drivers, 37 passengers, 23 pedestrians, 17 motorcyclists and 2 cyclists. 12% out of 17% of MAIS 3+ patients were hospitalized. One patient with MAIS 5 died during the hospitalization. The comparative analysis of IS as assessed in the police vs hospital database showed the ratio SI : MAIS 3+ to be 1.2. Eighteen SIs belonged to MAIS 3+, one to MAIS 1 and one to MAIS 2. Four patients with MAIS 1 and 2 score sustained no injuries, according to the police report. Six moderate IS according to police data were classified as MAIS 3 in hospital registers. CF for MAIS 3+ was 0.316 and for minor IS was 0.016. **Conclusion:** The results confirm that there are discrepancies in assessments of IS between police and hospital records and that it is neccessary to form a common database.

Keywords

Traffic accident, Severe injury, MAIS

1. Introduction

According to the World Health Organization, 1.35 million people worldwide are killed in traffic accidents (TA) annually (1 person every 25 seconds), 20 to 50 million are injured, and the costs are measured in billions of dollars [1] Traditionally, the main source of information on TA and injuries sustained in them are police reports done upon investigation at the scene. They contain crucial data to create statistical analyses at national levels in Europe (Community Road Accident Database - CARE) [2]. Police reports usually contain detailed information on the circumstances of the occurrence, the date and place of the TA, the category of participants, and the characteristics of the driver and the passengers in the vehicle, especially in TAs with serious injuries or fatalities. However, the persons who perform investigations are not medical professionals and cannot assess the injuries severity (IS) adequately. Therefore, police registers classify IS as either fatal, severe (SIS) or minor injury (MIS) [3].

In recent years, hospital records are another source of data [4]. They generally provide very little information on the circumstances of the TA, but contain demographic data on the person involved (age, sex and address) and on the

TABLE 1. Accessing injury severity for each patient according to the ICD 10, AIS and MAIS.

No	ICD 10												AIS 1	AIS 2	AIS 3	MAIS	AIS 4	AIS 5	AIS 6
1	S06.0	R58	V99	S01	T07	S20.4	S36	S82.1	S51.0	S32.1	Z01.6	Z01.9	1202.5	8406.3	4106.2	5			
2	S13.4	Z01.9											3106.1			1			
3	S13.4	S40.0	V43	V72	T90	Z01.6							1206.1	3106.1	4104.1	1			
4	S13.4	S00	V49.4	Z01.6									3106.1			1			
5	S13.4	Z01.9											3106.1			1			
6	S13.4	S40.0	V72	V43	T90	Z01.6							3502.1	3106.1	1102.1	1			
7	S13.4	S00	S33.5	V49.4	Z01.6								6506.1	1106.1		1			
8	S81.0	Z01.9											8508.1			1			
9	S00.9	V99	Z01.9										1106.1			1			
10	T01.9												9150.1			1			
11	S00.4	S00	S20.0	S20.2	S42	S42.1	S82.6	V49	V99	T07	Z01.6		4104.2	7508.3	8508.2	3	1406.1	9150.1	3106.1
12	S30.4	W19	Z01.6	Z01.9									8504.2			2			
13	S13.4	S30.0	S70.0	S93.4	V23	V29.2	Z01.6	Z01.9					8504.2	8504.3	3106.1	3			
14	S00	S13.4	V49.4	Z01.6	Z01.9								3106.1	1106.1		1			
15	S13.4	V49.9	Z01.9										3106.1			1			
16	S00.0	S60.2	S61.0	S80.1	V49.4	Z01.6	Z01.9						1106.1	7508.2	8504.2	2			
17	S72.0	R58	V99	Z01.6	Z01.9								8508.3			3			
18	S003	V49.4	Z01.6	Z01.9									2106.1			1			
19	S13.4	V99	Z01.6	Z01.9									3106.1			1			
20	S90.3	V09	Z01.6	Z01.9									8104.1			1			
21	S50.0	R10.4	V09	Z01.6	Z01.9								7504.1	5150.1		1			
22	S13.4	S30.0	S80.0	V28.2	Z01.6	Z01.8	Z01.9						3106.1	8504.1		1			
23	S13.4	Z01.6	Z01.9										3106.1			1			
24	S13.4	V49.4	Z01.6	Z01.9	Z47.0								3106.1			1			
25	S50.0	S60.2											7504.1			1			
26	S80.0	S70.1											8504.1			1			
27	S01.0												1150.2			2			
28	S13.4	V49.4	Z01.6	Z01.9									3106.1			1			
29	S42.1	Z01.9											7508.2			2			
30	S01												1150.2			2			
31	S20.2	S00	S01.0	S61.0	V23	V99	Z01.6	Z01.9					1150.2	1504.2	4504.3	3			

TABLE 1. Continued.

No	ICD 10											AIS 1	AIS 2	AIS 3	MAIS	AIS 4	AIS 5	AIS 6
32	S10											3106.1	7504.1		1			
33	S00	S13.4	S50.0	Z01.6	Z01.9							1106.1			1			
34	M65.1	Z01.9										7204.1			1			
35	S13.4	S30.0	S80.0	V49.4	Z01.6	Z01.8	Z01.9					3106.1	8504.2	8504.1	2			
36	S01	S01.0	S13.4	V43.0	V49.4	Z01.6	Z01.9					1106.1	1150.2	3106.1	2			
37	S70.1	Z01.6	Z01.8	Z01.9								8504.1			1			
38	S13.4	S20	S30.0	V43	V49.4	Z01.6	Z01.9					3106.1	8504.2	4102.1	2			
39	S01.0	S02.2	S80.0	V18.2	Z01.6	Z01.8	Z01.9					1150.2	8504.1	2508.2	2			
40	S13.4.	Z01.6	Z01.9									3106.1			1			
41	S13.4	V49.4	Z01.6	Z01.9								3106.1			1			
42	S00.0	S13.4	S20.2	S30.0	S33.5	S50	S60.0	S80	I20	Z01.6	Z01.9	1150.2	4404.3	6504.2	3		8504.2	7504.1
43	S00	S01.0	S13.4	S23.5	S80.0	V49.4	Z01.6	Z01.9				1150.1	3106.1	4504.2	2	8504.1		
44	S00	V49.9	S32.1	Z01.6	Z01.9							1150.1			1			
45	S00	S82.3	V99	Z01.6	Z01.9							1104.1	8508.2		2			
46	S00	S00.0	S80.1									1150.2	1104.1	8504.1	2			
47	S00	S13.4	V69.0	V49.4	Z01.6	Z01.9						1104.1	3106.1		1			
48	S13.4	V69.0	Z01.6	Z01.9								3106.1			1			
49	S00.5	S00.9	S20.2	S22.4	V49.4	V99	I49.3	J93	Z01.6	Z01.9		4508.3	4202.5	4104.1	5		3106.1	2102.1
50	S00	S13.4	S23.3	V43	Z01.6	Z01.9						3106.1	4106.1	1104.1	1			
51	S13.4	Z01.9										3106.1			1			
52	S13.4	S20.4	V49.4	Z01.6	Z01.9							4502.1	3106.1		1			
53	S13.4	Z01.6	Z01.9									3106.1			1			
54	S20.2	S61	S80.0	S80.1	V72	Z01.6	Z01.9					4104.1	8504.1	7506.2	2	7504.1		
55	S00	S13.4	Z01.9									1504.1	3106.1		1			
56	S00	S13.4	S20.2	Z01.6	Z01.8	Z01.9						3106.1	4504.1		1			
57	S13.4	Z01.6	Z01.9									3106.1			1			
58	S13.4	V43	Z01.6	Z01.9								3106.1			1			
59	S00	S42.0	S82.1	V03	S82.1	Z01.6	Z01.9					8408.3	4504.2	1104.1	3			
60	S13.4	V49.9	Z01.6	Z01.8	Z01.9							3106.1			1			
61	S13.4	V49.9	Z01.6	Z01.8	Z01.9							3106.1			1			
62	S13.4	V49.9	Z01.6	Z01.9								3106.1			1			

TABLE 1. Continued.

No	ICD 10											AIS 1	AIS 2	AIS 3	MAIS	AIS 4	AIS 5	AIS 6
63	S70	S30	Z01.9									8502.1	5102.1		1			
64	S70.1	S81.0	Z01.9									8504.1	8504.1		1			
65	S30	Z01.9										3106.1			1			
66	S00.0	S13.4	V43	Z01.6	Z01.8	Z01.9						1150.1	3106.1		1			
67	S13.4	Z01.6	Z01.8	Z01.9								3106.1			1			
68	S00.8	Z01.6	Z01.9									1102.1			1			
69	S00.0	Z01.6	Z01.8	Z01.9								1150.1			1			
70	S13.4	V43	T90	Z01.6	Z01.8	Z01.9						1102.1	3106.1		1			
71	S51.0	S92.3	V03	Z01.6	Z01.9							7508.1	7508.1		1			
72	S13.4	V49.4	Z01.6	Z01.9								3106.1			1			
73	S13.4	V43	Z01.6	Z01.8	Z01.9							3106.1			1			
74	S01.0	S01.0	Z01.6	Z01.8	Z01.9							1150.1	3106.1		1			
75	S00.9	S13.4	Z01.9									1150.1	3106.1		1			
76	S00	S13.4	V49.4	Z01.6	Z01.8	Z01.9						1104.1	3106.1		1			
77	S00.0	S10.9	Z01.6	Z01.8								1102.1	3102.1		1			
78	S00	S00.0	S13.4	S30.0	Z01.6	Z01.8	Z01.9					1104.1	8504.1	3106.1	1			
79	S00	S00.0	S42.2	S82.8	V43	Z01.6	Z01.9					1104.1	1150.1	7508.2	2	8504.1		
80	S00.0	S01.0	S13.4	V43	Z01.6	Z01.9						1150.1	1102.1	3106.1	1			
81	S00.0	S13.4	V49.4									1150.1	3106.1	1104.1	1			
82	S00	S80.0	Z01.6	Z01.9								1104.1	8504.1		1			
83	S13.4	S20.2	V03	Z01.6	Z01.9							4504.1	3106.1		1			
84	S13.4	S20.2	S30.0	Z01.6	Z01.9							8504.1	4504.1	3106.1	1			
85	S00	S06.3	S13.4	S81.0	V23	Z01.6	Z01.9					1104.1	1604.3	8506.2	3	3106.1		
86	S00	S22.1	S22.4	S27.1	S42	V99	Z01.6	Z01.9				4508.2	6502.2	4206.4	4	4508.1		
87	S02.0	S02.6	S13.4	S20.2	S61	S80.0	S80.1	V72	Y04	Z01.6	Z01.9	1406.4	2508.2	3106.1	4	4104.1	7102.1	8104.1
88	S42.1	S81.0	V23	V49.9	V99	Z01.6	Z01.9					4504.2	8508.1		2			
89	S06.0	S30.0	Z01.6	Z01.9	W19							1610.3	8504.1		3			
90	S70.1	Z01.9										8504.1			1			
91	S01.9	S06.0	S41	V23	V99	Z01.6	Z01.9					1102.1	4102.2	1610.3	3			
92	S01.0	S91.1	S92	S92.3	S92.4	S92.5	V03.0	Z01.6	Z01.9			8508.2	8508.2	8508.3	3	8508.1	1104.1	8508.1
93	S10	V23	Z01.6	Z01.9								3102.1			1			

TABLE 1. Continued.

No	ICD 10								AIS 1	AIS 2	AIS 3	MAIS	AIS 4	AIS 5	AIS 6
94	S30	V29.8	V23	Z01.6					5102.1			1			
95	S41	S42.0	V23	S00	V29.8	Z01.6	Z01.9		1104.1	4108.2	4102.1	2			
96	S81	Z04.9							8102.1			1			
97	S00.0	S43							1102.1	7510.1		1			
98	S00	S00.0	S40.0	Z01.6	Z01.9				1102.1	1104.1	7504.1	1			
99	S00.0	S13.4	S40.0	S52.5	S62.0	V03	Z01.6	Z01.9	7508.1	7508.2	3106.1	2	7504.1	1104.1	
100	S00	S50.0	S60.2	S80.0	V03	V09	Z01.6	Z01.9	8504.1	7504.1	1104.2	2	7504.1		
101	S82.1								8508.1			1			
102	S50.9	Z47.9							7502.1			1			
103	S80	S80.0							8504.1	8102.1		1			
104	S80.1								8504.1			1			
105	S80.1								8504.1			1			
106	S13.4								3106.1			1			
107	S72.0	Z47.9							8508.2			1			
108	S13.4								3106.1			1			
109	S13.4								3106.1			1			
110	S13.4								3106.1			1			
111	S72.3								8508.2			1			
112	S13.4								3106.1			1			
113	S33.5								3106.1			1			
114	S13.4								3106.1			1			
115	S93.6								8508.1			1			
116	S00.0								1102.1			1			
117	S90.8								8102.1			1			
118	S82.3								8508.2			2			
119	S12.2	S20.2	S30.0	S40.0	S70.1				6502.2	4104.1	8401.3	3	7104.1	8508.1	
120	S00.0								1102.1			3			
121	S13.4								3106.1			1			
122	S16.0	M54.2							3102.1			1			
132	S20.2								4104.1			1			
124	S16.0	M54.2							3102.1			1			

TABLE 1. Continued.

No	ICD 10					AIS 1	AIS 2	AIS 3	MAIS	AIS 4	AIS 5	AIS 6
125	S00.1	S20.2				2104.1	4104.2		2			
126	S13.4	S13.6	S00.9			3106.1	3406.1	1102.1	1			
127	S00.9					1102.1			1			
128	S82.2					8508.1			1			
129	S00.9	S40.8	S50			1102.1	7102.1	7502.1	1			
130	S13.4	S30.0	S40.0			3106.1	8504.2	7102.1	2			
131	S13.4	Z04.9				3106.1			1			
132	S13.4					3106.1			1			
133	S01.3	S82.6	S82.8	S32.0	S32.5	8508.1	6506.2	8508.3	3	1102.1	8508.1	
134	S00.0	S16				1102.1	3102.1		1			

TABLE 2. Injury severity (IS) in participants of traffic accidents according to HR.

IS		Category of participants in TAs					
MAIS score		drivers	pedestrians	passengers	motorcyclists	cyclists	Total
	1	17	9	12	6	1	45
	2	32	3	24	5	1	65
MAIS 3+	3	6	10	1	5	0	22
	4	0	0	0	1	0	1
	5	0	1	0	0	0	1
Total		55	23	37	17	2	134

TABLE 3. Correction ratio of MAIS 3+ and SIS by category of participants.

IS	drivers	pedestrians	passengers	motorcyclists	cyclists	total
MAIS 3+	6	11	1	6	0	24
SIS	5	9	1	4	1	20
Correction ratio	1.2	1.2	No correction	1.5	-	1.2

hospitalization (dates of hospital admission and discharge, medical diagnosis with the code, mechanism or external cause of injury and medical interventions taken). To assess IS doctors use medical diagnoses, which are classified and encrypted by the International Statistical Classification of Diseases and Related Health Problems (ICD). Revisions 9 and 10 of ICD are currently in use [5], and injuries sustained in road traffic have separate codes in "the external causes" section, as well as codes for injury description.

A group of EU member states high representatives for traffic safety has realized that a universal definition of serious injury is necessary for the comparison and monitoring of IS. In January 2013, the definition of SIS in road traffic as non-lethal traffic injury was published with Maximum Abbreviated Injury Scale (MAIS) 3+ [6]. A year later, it was recommended that all EU countries collect SIS data according to this definition.

To determine MAIS 3+ variables must be selected from hospital data. MAIS 3+ represents the maximum value of Abbreviated Injury Scale (AIS) on a scale of 3 or more. The AIS – published by the Association for the Advancement of Automotive Medicine – is an internationally accepted tool used to describe the IS for each of nine regions of the body [7]. The AIS scale has two components: (1), a description of the injury (represents the unique numerical mark of each injury); and (2), grading of the IS in the range between1 (minimal injury) and 6 (injury incompatible with life). The AIS scale grades IS as: minor - 1; moderate - 2; serious - 3; severe - 4; critical - 5; unsurvivable – 6, unspecificied - 9. The AIS scale is estimated for each injury separately. AIS code can be determined directly or indirectly (derived from other encoding systems, e.g. ICD) [8]. Various tools are available to convert ICD codes to AIS codes, e.g. ICDmap90, ICDpic [9], ECIP and AAAM.

The study was conducted a comparative analysis of IS caused by traffic accidents (TA) in the inner-city area of Belgrade, classified as SI in the police registry (PR) vs. MAIS 3+ injuries as classified in hospital registry (HR), and determine the correction factor (CF).

2. Materials and Methods

2.1 Data collection

Data were collected prospectively (from 14 to 31 August 2017) on the injured in TA in Belgrade examined by Emergency medical services (EMS). The numbers of patients transported to hospitals were identified, as well as the number of fatalities at the scene, and of those examined at the scene of the TA and who refused further medical treatment and transport. IS was asssessed in hospital according to ICD, AIS and MAIS for each patient. Finally, a comparison of data on IS obtained from the PR and those from the HR were compared.

The research included: a. creating a unique database designed for this research, b. estimation of IS by determining AIS and MAIS score, c. a comparative analysis of IS recorded by hospital doctors (HD) and the police, and d. determination of CF.

2.2 Creating a unique database

The data were entered into a previously created database with pre-defined variables for each person injured in a TA. The following variables were monitored at the pre-hospital level: name and surname, gender, age, personal ID number, date and time of receiving the call at emergency number 194, locating the TA, wheter the police was already present at the scene when the EMS team arrived, the status of the participant in TA, the injured body regions, the hospital to which the patient was transported, the time when the patient was handed over to the hospital, and the diagnosis according to ICD-10 code. These data were collected from medical reports and electronic databases of EMS in Belgrade.

After the request was sent and the ethical approval to access the data from the HR was obtained, hospital data were collected in accordance with the Law on Personal Data Protection. Participants in TA brought in by EMS were identified in the HR by name, surname, unique personal identification number and location of TA. The following hospital variables were monitored: the date and time of the examination in the pre-admission clinic, the method of care (outpatient, observation, hospitalization), the outcome of the treatment (date and time of discharge or death), hospital diagnosis with codes according to ICD-10. Four out of six Belgrade hospitals that treat traumatized patients were included in the project. The remaining two did not participate in the research: one due to lengthy procedures for obtaining ethical approval, and the other one because there were no patients transported to that hospital during the monitoring period.

The frequency of the death of the injured at the scene of the accident (pre-hospital) was also observed, as well as the lethal outcome in the hospitalized patients within 30 days of hospital admission. The cause of death according to the severity of injuries by MAIS score was analysed for fatalities.

2.3 Estimation of IS by determining AIS and MAIS score

For each registered injury, respondents were diagnosed according to ICD 10 classification, which was then indirectly converted into the AIS scale by assessing the severity of individual injuries in different regions of the body (AIS 1-6), the 2008 revision. Finally, MAIS was determined by direct coding from AIS (AIS = MAIS). The subject of the observation were SI presented as AIS 3+ in AIS coding system. That resulted in MAIS 3+ as the equivalent of severe trauma.

2.4 Matching the data obtained and forming a single unique database

In the next study stage, data from hospital and police databases were matched. By this method, some missing

TABLE 4. Injury severity in participants in TA according to police records.

IS	drivers	pedestrians	passengers	motorcyclists	cyclists	Total
SIS	5	9	1	4	1	20
MIS	49	14	34	12	1	110
NO INJURIES	1	-	2	1	-	4
TOTAL	55	23	37	17	2	134

TABLE 5. Discrepancy between MAIS score and recorded severity of injury (severe – SIS and minor – MIS).

HR	PR			
MAIS	**SIS**	**MIS**	**No injuries**	**Total**
1	1	41	3	45
2	1	63	1	65
3	16	6	0	22
4	1	0	0	1
5	1	0	0	1
Total	20	110	4	134

data were entered and the incorrectly recorded external causes (E-codes) were corrected in the hospital registry. The process of data matching in our study was based on one or more variables recored in both databases. The key variable is unique personal identification number, which enables identification on a 1-to-1 connection and a relatively easy and direct deterministic connection. However, this variable was often unavailable in one or both databases due to the Personal Data Protection Act. In those cases, a probabilistic method of identification was applied, i.e. a process of remote connection, based on several other variables: date and time of TA (and/or date and time of hospital admission), the location of TA, the gender and the date of birth (or age) of the injured person, the mode of transport.

Finally, a common database was formed.

2.5 Determining correction factors

Applying the CF to the police data is used to validate the number of MAIS 3+. CF are mathematical settings or adjustments prepared to assess the real number of SIS in order to correct the deviation from the correct values based on sampling or data selection method. In order for police data to become part of an integrated state/national database, correction of the magnitude of reporting on the number of SIS persons in TAs is necessary, which can not be achieved without access to some reference/comparative data, such as hospital data.

3. RESULTS

During the monitoring period, EMS teams intervened for 186 patients injured in TAs. The study did not include a total of 52 patients, including: one deadly injured person, 24 transported to a hospital where the ethical approval was not obtained, 24 patients who were examined at the scene refused transport to the hospital, and for 3 patients it was impossible to find data in HR.

The study included 134 patients, the average age of 47 years (SD ± 4,2), predominantly male (78 - 58,2%). 55 drivers, 37 passengers, 23 pedestrians, 17 motorcycle riders and 2 cyclists were injured as participants in TAs. In 95 TAs the police intervened before the arrival of the EMS team. Most TAs (96 – 71,6%) occured between 08 and 20h.

The assessment of IS for each patient was initially done according to the ICD 10 classification of disease, then the AIS score was determined and finally MAIS was estimated (Table ??).

Table 2. presents the MAIS assessment by category of participants in TAs. 12% out of 17% of MAIS 3+ patients were hospitalized. One patient with MAIS 5 died on the second day of hospitalization.

Comparative analysis of IS as assessed by HD (MAIS score) or the police (SIS) showed the ratio between SIS : MAIS 3+ injuries to be 1.2 (Table 3). More precisely, out of 24 MAIS 3+ patients, the police classified 20 as SI. Of the total of 23 injured pedestrians, 11 had MAIS 3+ score, while according to the police 9 persons suffered SISs, which makes the SIS: MAIS 3+ ratio for pedestrians 1.2. Of the 55 injured drivers, 6 had MAIS 3+, and according to PR 5 drivers had SIS. One passenger and one cyclist sustained SIS according to the police; however, HD assessed that the passenger had a MAIS 3+ injury, while the cyclist did not sustain a MAIS 3+ injury (Table 4).

Comparative analysis of SIS and MAIS shows that 18 SI belong to MAIS 3+ injuries, while one SIS belongs to MAIS 1 and 2. Six injuries classified by the police as MIS belong to MAIS 3 on the scale of injuries (Table 5).

According to police records, 20 persons sustained SIS, while 110 had MIS. It is important to point out that, according to PR, 4 persons did not have any injuries, while HR show that those patients sustained injuries equivalent to those on MAIS 1 and 2 scale. The data confirm the differences in the SIS as assessed by HD and by the police. Even among TA participants with minor injuries (MAIS 1), in PR there is one person with SI. Table 6 shows in detail the differences in HD and PR by the severity of injuries (SIS vs. MAIS).

The largest number of unregistered bodily injuries in the PR referred to persons who suffered an injury equivalent to MAIS 1 and 2 scales (Table 7). There were no unidentified

TABLE 6. A comparison of police (PR) and hospital (HR) road injury data.

HR	PR	pedestrians	drivers	passengers	motorcyclists	cyclists	total
MAIS	SIS	0	1	0	0	0	1
1	MIS	9	15	11	5	1	41
	no injuries	0	1	1	1	0	3
	total	9	17	12	6	1	45
MAIS	SIS	0	0	0	0	1	1
2	MIS	3	32	23	5	0	63
	no injuries	0	0	1	0	0	1
	total	3	32	24	5	1	65
MAIS	SIS	8	4	1	3	0	16
3	MIS	2	2	0	2	0	6
	total	10	6	1	5	0	22
MAIS	SIS	0	0	0	1	0	1
4	total	0	0	0	1	0	1
MAIS	SIS	1	0	0	0	0	1
5	total	23	55	37	17	2	134

TABLE 7. Unaccounted patients (number and percentage) with severe (SIS) and minor (MIS) injury in PR compared to MAIS score.

MAIS	SIS	MIS	Unaccounted (n - %)
1	1	41	3-7
2	1	63	1-2
3	16	6	0 - 0
4	1	0	0 - 0
5	1	0	0 - 0
Unknown	0	2	1 - 33
Total	20	112	5-4

injuries in MAIS 3+ group.

The methodology for calculating the total number of MAIS 3+ is based on PR. It takes into account the severity of injuries estimated by HD and the police, the injured not registered by the police (while registered by HD) and the total number of injured persons according to PR, on which basis the total number of the injured is calculated (Table 8).

The SIS and MAIS correction factor represents the ratio of the total number of MAIS 3+ injuries and the sum of SIS as recorded in both databases and the total number of SIS as recorded only by the police. The CF for SIS in our study was: CFSI= (16 + 1 + 1) : (20 + 37); CFSI= 0.316. The CF for MIS compared to MAIS 3+ injuries was: = CF 6 : (110 + 255); CF= 0.016. The number of MAIS 3+ is determined by multiplying the number of SISs recorded in PR with Sf 0.20 and the number of MIS with Sf 0.01. In other words, on the basis of the conducted survey, the total number of MAIS 3+ injuries in Belgrade is obtained by multiplying the number of SIS recorded in police reports with Sf 0.316 and the number of MIS number with Sf 0.016 (N = 0.316 SI + 0.016 MSI).

4. Limitations

In the Republic of Serbia (RS) IS is established on the basis of a medical examination and a specialist doctor's opinion.

Both EMS and traffic police databases, which can be considered as the most complete records of injuries in TA participants, have certain shortcomings. Errors on the identity of the patient (name, surname, personal identification number) are not uncommon.

Police reports on TA often contain errors and the significance of those errors increases with further data processing. There are errors either in the recording of the type of TA or due to classification being too general, or the causes being unclear. Especially susceptible to errors are data related to IS due to different classification made by police and doctors.

When talking about EMS records, the first shortcoming is that, for justified reasons, a significant number of patients are treated as NNs (e.g. the injured person being unconscious, personal IDs being unavailable, etc.). For the injured persons without an established identity, electronic monitoring of health status is difficult as well as subsequently more comprehensive identification of IS through matching with data records kept in other health care institutions (HI). It should also be kept in mind that these are urgent cases in which the EMS team is focused on taking the necessary urgent procedures, so it is not able to "investigate" the data to be recorded.

Another shortcoming of pre-hospital records is the relatively short contact and monitoring of patients, and the objective inability to reliably determine IS, including MAIS 3+ injuries.

Third, the EMS records do not contain data on the in-

TABLE 8. The values for calculating the correction factor for MAIS 3+ injuries.

	Recorded in both databases		Not recorded in the PR	Total number of the injured according to PR		Estimated total number of the injured	
MAIS	SI	MI		SI	MI	SI	MI
1 and 2	2	104	4	37	255	39.1	363
3	16	6	0	0	0	16	6
4	1	0	0	0	0	1	0
5	1	0	0	0	0	1	0
total	20	110	4	37	255	57.1	369

TABLE 9. Comparative analysis of correction factors in EU countries and Belgrade.

	Correction factor	
	SBI	MBI
France	0.68	0.06
Hungary	0.48	0.04
Greece	0.46	0.12
The Netherlands	0.39	0.006
Belgrade	0.32	0.016
Spain	0.26	0.02
The Czech Republic	0.21	0.002
Scotland	0.2	0.01

jured in TAs that were transported to hospitals in vehicles other than ambulances, or those who were treated in public healthcare centers.

Fourth, although the injured in TAs on the territory of RS are mostly treated in state HI, they can also be partially or completely treated in private HI in RS or in HI abroad.

5. Discussion

By adopting MAIS3+ as the definition of SIS in TAs, most European countries have conducted a joint analysis of PR and HR in road transport for the first time [10, 11]. The pioneering steps in the implementation of the MAIS3 scale of injury were carried out by the Forum of European Road Safety Research Institutes (FERSI) in cooperation with the European Commission in the period 2014-2016 [12]. The current status of introducing MAIS 3+ scale of injury shows that 17 European countries have the capability to assess SIS as MAIS 3+. In the remaining 14 countries, the process of introducing MAIS 3+ is still at an early stage or has not started. Our study is a pioneering step for the introduction of MAIS 3+ in Serbia.

The European Commission has identified three main methods of MAIS 3+ assessment [11]: 1. applying the correction factor to police data; 2. using only hospital data and 3. using matched / paired police and hospital data. We have chosen method number 3.

The reliability and comparability of MAIS 3+ is dependent on the method of data collection both in the methodological sense and in the sense of presenting the acquired data sets from the related hospital. In some countries [2] IS is estimated directly using the AIS scale (France), others (Spain, the Netherlands) use software programs (eg. ICDmap90, ICDpic, ECIP and AAAM) to directly convert versions nine or ten of the ICD into AIS score, while the third group of countries (Great Britain, the Czech Republic) use indirect transformation of hospital data from other encoding systems, such as ICD, like we did in our study.

For the purposes of our study, the literature on direct encoding from AIS scores, or AIS scores by ICD conversion, was searched and analyzed using conversion tools that are applied in Europe. SCOPUS, ISI Web of Science and Pubmed databases were searched. Very limited literature was found.

De Bartolomeo et al. [13] and Greene et al. [14] compared injury severity levels determined by ICDpic with the levels of IS based on direct AIS coding. De Bartolomeo carried out a comparison of ICDPIC-ISS score (determined indirectly from Injury Score Severity – ISS) with d(direct)AIS-ISS score. On a small sample (289 cases), he concluded that despite the high potential, ICPIC-ISS proved to be a weaker predictor of IS than direct AIS encoding. In Greene's study [14] on a sample of over 40,000 patients, ICDPIC-derived AIS score for each region of the body was compared with trauma registry AIS scores. It was concluded that the performance of ICDpic tools vary by region of the body; IS is well classified for thoracic and abdominal injuries, moderately for head and neck injuries, and it is most adequate for injuries to the face and extremities. ICDpic proved to be a reliable way of codifying injury according to degree.

We performed some additional analyses. In the German In-Depth Accident Study (GIDAS) database [15], during several years of monitoring, a direct MAIS coding for 16,695 injured persons in TAs from AIS 1998 and AIS 2008 was conducted. The application of AIS 1998 resulted in a 12% higher number of MAIS 3+ than the application of AIS 2008 [16]. The reason for this is the more detailed specification of injuries in AIS 2008 and more adequate trauma care. Therefore, AIS 2008 which was also applied in our study is considered a gold standard for IS assessment [17]. Table 9. [18] presents the method for 1 of the AIS scores for each region of the body. Japan and the Czech Republic are two exceptions where IS is assigned

exclusively by a doctor in hospital on the basis of available documentation (2). As recommended by Broughton et al. [19], IRTAD [20] and High Level Group on Road Safety [21], MAIS 3+ score was adopted to define IS in road traffic. In our study, the following categorization of MAIS injuries was made: MAIS 1 code 88, MAIS 2 - 20, MAIS 3 - 12, MAIS 4 - 2 and MAIS 5 - 2 patients. Sixteen patients in total were hospitalized. It is important to point out that in the MAIS scale of injury it is not necessary to have a linear relationship with the likelihood of death [21]. Thus, in our study, one patient with MAIS 5 died but another one with the same MAIS score was hospitalized and discharged after 17 days. In Dutch connectivity studies, police data are linked to hospital records and compared to the ICD-derived MAIS scale [2]. The estimated real number of IS is now based on MAIS, and not on IS assessed by the police. Currently, only in Austria, Hungary, the Netherlands, Sweden and Slovakia, the medical database of injured persons in TAs is linked to the national database [2].

Calculating CF requires access to HR, which are considered more reliable than PR. Nowadays, HR are better for assessing the number of severely injured persons in TAs. Therefore, as in our study, hospital data are accessed in order to use CF to correct police data. The reference used in France for the development of CF represents matched police and hospital information in French Rhone county [22]. The results of our pilot study show that CF is 0.32 for SIS and 0.016 for MIS in Belgrade, which is lower than CF in France, Hungary, Greece and the Netherlands, but higher than CF in Spain, the Czech Republic and Sweden (Table 9) [2]. The values of CF in our study are the most similar to the values of coefficients in Spain.

The results obtained in this pilot study should be taken with reserve because they are based on a small number of injured persons in TAs and a short monitoring period (15 days). In order to obtain more reliable data, it is necessary to conduct research in a number of HIs throughout Serbia and for a longer period of time. The future perspective requires setting up an integrated database consisting of PR and HR.

Before future research, it is necessary to educate healthcare professionals on how to record MAIS 3+ injuries (by direct encoding using specialized software or indirectly through prior registration into the AIS scale) as well as on how to accurately enter data into the national database common for HI and police.

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CONFLICT OF INTEREST

The authors have declared that no competing interests exist.

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