CHARACTERISTICS OF SOME ACCIDENT CIRCUMSTANCES ON ROAD BLACKSPOT SECTIONS

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1 Introduction

Accidents are a consequence of various aspects of road, vehicle and road user. They are scarce over time and space. Sometimes there is no initial indicaton why accidents cluster at certain locations and what particular circumstances accompany accidents at these locations. Any inferences drawn from systematical statistical analysis of accident data can be of great importance in accident investigation, leading to the provision of suitable remedial countermeasures to improve road safety.

In order to identify hazardous sections of a road the Bayesian approach has been utilized in the paper. The total numbers of: fatalities, injuries and vehicles involved in accidents along a road section are considered as they represent accident severity. The probabilities of the occurences of these accident quantitative features with respect to the fact that parameters of the respective distributions are random variables have been defined. On the basis of these probabilities as well as on the basis of the length of the road section a weight is given to the section. The weight is a measure of the level of accident risk of the section. The measure greater than a certain threshold value identifies the section as a blackspot one.

Accident details are included in road police reports. The majority of the details are qualitative features. Some of them have been chosen to find out possible accident problems characteristic to blackspot sections. Algorithms of qualitative analysis are applied to systematize the information, to identify typical characteristics of a specified accident feature and to find out associations between the features and between their classification categories.

2 The method of blackspot sections identification

To perform the road safety analysis, road sections characterized by grouping of accidents are determined first. This is done by applying one of methods of clustering analysis. To identify a blackspot section among accident cluster sections, which are the result of clustering analysis, an accident-proness model has been elaborated [Tracz and Nowakowska; 1996]. The model describes distributions of some quantitative accident variables. As the model is based on the Bayesian approach [Benjamin and Cornell; 1977] the method of blackspot sections identification is called a Bayesian one. The model is based on two sources of information. The first one $h(x)$ is a prior distribution of the accident variable X over accident cluster sections:

$$h(x)=\begin{cases}(s/(1+s))^k & \text{for } x=0\\ h(x-1)\cdot(x-1+k)/(x\cdot(1+s)) & \text{for } x\geq 1\end{cases} \tag{1}$$

The second source $\tilde{h}(x|z,i)$ is a posterior distribution of X variable which can occur at those sections, where the variable value of z over i time units has been recorded:

$$\tilde{h}(x|z,i)=\begin{cases}((i+s)/(i+1+s))^{z+k} & \text{for } x=0\\ \tilde{h}(x-1|z,i)\cdot(x-1+z+k)/(x\cdot(i+1+s)) & \text{for } x\geq 1\end{cases} \tag{2}$$

In the above distributions $s>0$ is a scale parameter and $k>0$ is a shape parameter.

The safety of a road section is characterised by the following set of weights:

$$S=\{W(X_1),\ W(X_2),\ W(X_3),\ LW(l)\} \tag{3}$$

The variable X_i identifies the number of i-th accident variable as follows: X_1 is the number of injured people, X_2 is the number of people killed, X_3 is the number of vehicles involved in accidents. The weight $W(X)$ is defined by the expression (4):

$$W(X)=\sum_{m+1}^{\infty}\tilde{h}(x|z,i)dx \qquad \text{where: } \sum_{0}^{m}h(x)dx\approx\sum_{m}^{\infty}h(x)dx\approx 0.5 \tag{4}$$

The element $LW(l)$ of the set S is the weight of a section length:

$$LW(l)=\begin{cases}-0.5\cdot l^2+1 & \text{for } l\in<0,1>\\ 0.5\cdot(l-l_{max})^2/(l_{max}-1)^2 & \text{for } l\in<1,l_{max}>\end{cases} \tag{5}$$

A section classification value SW has been defined to proceed the identification:

$$SW=\sqrt{\sum_j W(X_j)^2+LW(l)^2} \tag{6}$$

A blackspot criterion is determined by a critical set S^* of the elements equal to 0.5, 0.4, 0.6 and 0.75. These values reflect the rank of respective elements of the set S. An accident cluster section is indicated as a hazardous one, i.e. a blackspot section, if its classification value SW is greater than the value (6) for the critical set S^*.

3 Qualitative analysis

Accident details are included in road police reports called Road Accident Cards. This information is collected and stored in computer database files. The majority of fields of such files are of descriptive character like driver's behaviour for example. Qualitative analysis was applied to systematize the descriptive information and to characterize accident qualitative features and their combinatons. The analysis is based on cross-classification (contingency) tables.

Describing the set of qualitative features can be processed on the basis of some statistical measures [Góralski; 1979]. Modal category M is the feature value to which the majority of the set observations belongs. It characterises the most typical property of the set and is defined as follows:

$$M = max\{n_i, \quad i = 1,2,\ldots,k\} \tag{7}$$

Dispersion of classification coefficient enables to evaluate the degree of homogenity of the set. The range of the dispersion coefficient is the interval <0, 1>. The value h=0 confirms full homogeneity of the set. The value h=1 presents the evidence of full heterogeneity of data. The dispersion coefficient is a measure of the form:

$$h = 2\left(\sum_{i=2}^{k}(i-1)\cdot c_i\right)/(k-1) \qquad c_{i-1} \geq c_i \tag{8}$$

In the formulas (7) and (8): i is the number of the i-th feature category, n_i is the number of observations that belong to the i-th category, k is the number of categories of a considered feature, c_i defines sequence of frequencies of feature categories ordered in a not ascending way: $c_i = n_i / N$, N is a sample size.

Associations in a cross-classification table is investigated by testing null hypotheses H_0 of no association [Agresti;1984]. A general association can be tested by the χ^2 Pearson's test with a test statistic of the following form:

$$\chi^2 = \sum_i \sum_j (n_{ij} - m_{ij})^2 / m_{ij} \tag{9}$$

where: n_{ij} is the number of observations of the i-th category of the first feature and the j-th category of the second feature and m_{ij} is the expected number of observations of the categories combination as above, provided that the H_0 is true. The statistic (9) is asymptotically (as $N \to \infty$) χ^2 distributed with degrees of freedom $DF = (r-1)(c-1)$.

The association between categories in a cross-classification table cell can be evaluated on the basis of the relevance of surpluses or deficiencies in the cell [Góralski; 1979]. To ascertain if the surplus or deficiency is relevant the value of ψ^+ or ψ^- statistic for the ij-th cell is calculated:

$$\psi^{sgn(n_{ij}-m_{ij})} = \left|n_{ij} - m_{ij}\right| / \left\{\sqrt{1 + \left(m(m-K-1)\right)/K^m} \cdot \sqrt{m_{ij}(1 - m_{ij}/N)}\right\} \tag{10}$$

where, the sgn function determines surplus (+) or deficiency (–) of the number of observations, $K = max\{k_1, k_2\}$, k_1, k_2 are the numbers of categories of the first and the second feature respectively and m is the number of considered features; in this paper m=2. The null hypothesis is rejected if the value (10) is greater than a ψ critical value, tabulated elsewhere [Góralski; 1966].

4 An experiment

Information about accidents, involving death or injury, recorded during the years 1991-1995 on roads of two neighbouring provinces of south-central Poland was the source of data for the experiment of searching for connections between accident features on road blackspot sections. Among 61 roads (rural and of non urban traffic character) four have been chosen as the subject of the experiment. Some characteristics of these roads and the results of the process of blackspot sections identification are presented in the table 4.1.

Only one blackspot section with fifteen observations was identyfied on the road No 728. Conclusions for that section have been given up. In addition, results obtained for the roads No 44 and No 74 are interpreted for small sample sizes.

Table 4.1. Some accident statistics of road blackspot sections.

Road number	Road category	The length of the road [km]	Number of accidents on the road	Blackspot sections information		
				Number of the sections	Total length [km]	Number of accidents
-1-	-2-	-3-	-4-	-5-	-6-	-7-
7	international	192.2	1318 (2.3)	31	39.0	716 (3.7)
44	interregional	84.5	376 (1.5)	6	14.6	145 (2.0)
74	interregional	82.1	393 (1.3)	3	8.7	103 (2.4)
728	regional	146.0	258 (0.6)	1	2.6	15 (1.2)

Average accident densities (number of accidents/km/year) are given in brackets.

Nine qualitative features that describe accident circumstances are included in the Road Accident Card. Some of them were chosen for closer investigation to identify possible accident problems characteristic to road blackspot sections: ACCIDENT TYPE that has 11 categories, PEDESTRIAN'S BEHAVIOUR with 20 categories and DRIVER'S BEHAVIOUR with 16 categories. The significance of presence of alcohol in road users' blood has also been examined.

The percentage of accidents with pedestrians in the considerded region of Poland was very high. It exceeded 30% and close to 20% of injured and over 38% of killed in accidents were pedestrians during the years 1991-1995. Subsets of data including only *Hitting pedestrian* accident type were created and further analysis where „pedestrian" features are involved concerns these subsets.

4.1 Statistical characteristics of some qualitative accident features

Some results of statistical analysis of descriptive accident features are presented in the table 4.2. On the basis of them it can be said that:

- Most frequent accident types are common for all analysed roads. Their distributions are just the same for both a chosen road and its blackspot sections (see table 4.2.A). The category *Hitting pedestrian* is a median one for all cases. It occured even in every third accident. The values of dispersion coefficient show the tendency to the differentiation of the set within the feature.

– Three groups of categories represent DRIVER'S BEHAVIOUR in the table 4.2.B. The order of these groups is in principle the same not only within a road and its sections but also within all cases (compare columns 2, 3, 4, 6, 7 of the table 4.2.B). The medians are different for blackspot sections of different roads. Values of dispersion coefficient evidence the concentration tendency of the feature, taking into acount that there are twenty possible driver's behaviour.

Table 4.2. Most frequent categories of three accident features.

The category of accident feature	Ratio of the number of accidents of a category to the total number of accidents[%]							
	road	sections	road	sections	road	sections	road	sections
- 1 -	-2-	-3-	- 4 -	- 5 -	- 6 -	- 7 -	- 8 -	- 9 -
	Roan No 7		Road No 44		Road No 74		Road No 728	
A. Most frequent accident types								
• Hitting pedestrian	26.6	28.8	23.7	24.7	30.3	40.8	29.8	20.0
• Head on collision	19.9	20.9	18.9	18.6	15.8	10.7	16.3	26.7
• Rear-end collision	18.1	16.6	20.5	20.7	15.3	15.5	17.1	40.0
• Side collision	12.8	13.1	13.3	13.8	10.9	11.7	14.0	13.3[1]
Total [%]	**77.4**	**79.4**	**76.4**	**74.5**	**72.3**	**78.6**	**77.2**	**100**
Dispersion [–]	**0.43**	**0.41**	**0.44**	**0.44**	**0.45**	**0.34**	**0.42**	**0.213**
B. Most frequent driver's behaviours								
• Nothing particular • Inattenation, distraction, imprudence • Tiredness, falling asleep	31.9	32.0	30.4	25.4	29.7	42.7	33.3	13.3
• Mismatching the speed to a traffic situation, • Exceeding speed limit	23.8	24.4	21.6	25.5	26.2	22.3	21.3	13.3
• Incorrect overtaking or passing round	10.8	10.5	14.1	12.4	14.2	6.8	14.7	33.3
Total [%]	**66.5**	**66.9**	**66.4**	**63.3**	**70.1**	**71.8**	**69.3**	**59.9**
Dispersion [–]	**0.38**	**0.37**	**0.37**	**0.37**	**0.35**	**0.33**	**0.33**	**0.24**
C. Most frequent pedestrian's behaviours								
• Enter a roadway before a moving vehicle	47.1	44.2	29.2	29.0	44.1	31.0	32.5	66.6
• Nothing particular	30.9	29.6	31.5	29.0	26.1	26.2	32.5	33.3
• Running across a roadway	8.3	12.1	9.0	8.5[2]	6.8	9.5	7.8[2]	33.3[2]
• Children up to seven running onto a rodway	2.6	3.9	12.4	16.1	5.9	14.3	6.5	0.0
Total [%]	**88.9**	**89.9**	**82.1**	**80.6**	**82.4**	**80.6**	**79.3**	**100**
Dispersion [–]	**0.16**	**0.17**	**0.24**	**0.24**	**0.22**	**0.25**	**0.24**	**–**
D. Presence of alcohol in driver's blood								
Yes	5.0	5.0	3.7	3.4	12.0	10.7	7.8	6.7
Dispersion [-]	**0.10**	**0.1**	**0.08**	**0.07**	**0.24**	**0.21**	**0.16**	**0.13**
E. Presence of alcohol in pedertrian's blood								
Yes	27.1	30.1	21.3	22.6	36.1	38.1	19.5	66.7
Dispersion [–]	**0.55**	**0.60**	**0.43**	**0.45**	**0.72**	**0.76**	**0.39**	**0.67**

The following categories instead of the categories referenced in relative rows are represented in the bold, dark framed cells of the table:

[1] Rolling over
[2] Walking along a wrong side of a roadway
[3] Standing or falling down on a roadway

- The accidents of the type *Hitting pedestrian* are concentrated on two categories of the PEDESTRIAN'S BEHAVIOUR feature: *Enter a roadway before a moving vehicle* and *Nothing particular*. The concentration is confirmed by the dispersion coefficient, which does not exceed the value of 0.25 in any case.
- Results for the feature PRESENCE OF ALCOHOL IN PEDERTRIAN'S BLOOD are significant. Irresponsible behaviour of pedestrians being under the influence of alcohol may be one of the most important reasons of road accidents.

4.2 Association between some qualitative accident features

Preparatory analyses of cross-classification resulted in contingency tables of very small cell frequences. In order to obtain tables having larger cell frequences some categories of the features were combined, which is commonly done by researches [Agresti; 1984]. New created categories and thier definitions are given in the table 4.3. Results of general association tests for combinations of two qualitative features are presented in the table 4.4. Some results of tests of associations between categories of analysed features are presented in the tables 4.5, 4.6 and 4.7. There are the following abbreviations for the features there: DB is DRIVER'S BEHAVIOUR, AT is ACCIDENT TYPE, PB is PEDESTRIAN'S BEHAVIOUR and AP is PRESENCE OF ALCOHOL IN PEDESTRIAN'S BLOOD.The interpretation is done at the common type I error rate α=0.05.

Table 4.3. New classifications of categories for three accident features.

Old values	New value	New classification category
- 1 -	- 2 -	- 3 -
A. ACCIDENT TYPE		
1	1	Head on collision
2	2	Side collision
3	3	Rear-end collision
4	4	Hitting pedestrian
5, 7, 8, 9	5	Hitting object on carriageway
6	6	Hitting fixed object
10	10	Rolling over
11	11	Others
B. DRIVER'S BAHAVIOUR		
0, 17, 18	0	Late driver's reaction
1, 2	1	Excessive speed
3,10	3	Disobeying priority
4,5,7	4	Incorrect manoeuvres of a driver
6	6	Incorrect crossing a pedestrian crosswalk
8	8	Incorrect vehicle stoppage or parking
9	9	Keeping the wrong side of a roadway
12, 13	12	Too close distance between vehicle
14, 15	14	Sudden changing of speed (external traffic situation)
16	16	Dazzling a driver by another vehicle
11, 19	19	Disobeying other traffic regulations
C. PEDESTRIAN'S BEHAVIOUR		
0, 15	0	Indefinable pedestrian's fault
1	1	Standing or falling down on a roadway
2	2	Walking along the wrong side of a roadway
3,4,5	3	Incorrect crossing a roadway
6, 7, 8, 9, 10	6	Incorrect enter a roadway
11, 12, 13	11	Children up to seven entering a roadway
14	14	Falling in/from vehicle

Table 4.4. Results of tests of general association between two features.

Road number	Sample size	χ^2		% of cells of expected counts < 5	DF
		Value	Prob.		
- 1 -	- 2 -	- 3 -	- 4 -	- 5 -	- 6 -
A. Driver's behaviour x Accident type					
7	716	898.05	0.001	60	70
44	145	223.79	0.001	90	56
74	103	127.97	0.001	93	56
B. Pedestrian's behavoiur x Driver's behaviour					
7	206	121.04	0.001	88	35
44	31	18.19	0.259	92	15
74	42	29.10	0.09	93	20
C. Presence of alcohol in pedestrian's blood x pedestrian's behaviour					
7	197	34.86	0.001	40	4
44	26	7.06	0.133	80	4
74	36	13.08	0.011	60	4
D. Presence of alcohol in pedestrian's blood x Presence of alcohol in driver's blood					
7	197	0.374	0.541	25	1
44	26	0.798	0.372	50	1
74	36	1.286	0.257	50	1

Table. 4.5. Significant relationships between some categories of the features: DRIVER'S BEHAVIOUR (DB) and ACCIDENT TYPE (AT).

		Road No 7 black sections			Road No 44 black sections			Road No 74 black sections		
DB	AT	n_{ij}	m_{ij}	ψ	n_{ij}	m_{ij}	ψ	n_{ij}	m_{ij}	ψ
- 1 -	- 2 -	- 3 -	- 4 -	- 5 -	- 6 -	- 7 -	- 8 -	- 9 -	- 10 -	- 11 -
Significant surpluses										
		ψ_α=1.63			ψ_α=1.60			ψ_α=1.58		
0	4	160	65.9	13.32	25	7.5	7.34	31	17.9	3.79
1	10	20	8.1	4.59	8	4.3	1.99	4	1.7	2.19
1	6	30	11.8	5.83	10	4.1	3.32	5	2.5	1.83
1	1	45	34.8	1.95						
3	2	59	9.5	17.76	11	2.1	6.98	6	0.7	7.10
4	3	31	15.5	4.37	9	4.6	2.36			
4	1	32	19.5	3.15						
6	4	8	2.3	4.12						
9	1	13	2.9	6.45						
12	3	42	11.1	10.20	6	2.3	2.78	4	1.1	3.13
12	2	15	8.8	2.30						
14	1	22	7.3	5.96	6	3.2	1.79			
Significant deficiences										
		ψ_α=1.66			ψ_α=1.70			ψ_α=1.71		
0	2	1	30.1	5.93	0	4.8	2.49	0	5.1	2.59
0	3	10	38.1	5.11	3	7.2	1.81	1	6.8	2.58
0	1	16	48.0	5.23						
0	10	6	11.2	1.71	1	4.1	1.74			
1	2	7	21.8	3.52	1	5.1	2.06	0	2.7	1.85
1	4	15	47.8	5.37	3	7.9	2.00			
3	4	0	20.7	5.06	0	3.2	2.02	0	2.4	1.76
3	3	0	12.0	3.82	0	3.1	1.99			
3	5	0	4.5	2.34						
3	6	1	5.1	2.00						
4	6	0	6.6	2.8	0	2.4	1.75			
4	4	12	26.8	3.18	1	4.7	1.94			
4	10	1	4.5	1.83						
12	4	0	19.3	4.87	0	2.4	1.73	0	2.9	1.91
12	1	5	14.0	2.67						
12	6	0	4.8	2.40						
14	4	2	10	2.80	0	3.7	2.16			
14	3	0	5.8	2.65						

Table. 4.6. Significant relationships between some categories of the features: PEDESTRIAN'S BEHAVIOUR (PB) and DRIVER'S BEHAVIOUR (DB) for *Hitting pedestrian* acident type.

		Road No 7 black sections			Road No 44 black sections			Road No 74 black sections		
PB	DB	n_{ij}	m_{ij}	ψ	n_{ij}	m_{ij}	ψ	n_{ij}	m_{ij}	ψ
- 1 -	- 2 -	- 3 -	- 4 -	- 5 -	- 6 -	- 7 -	- 8 -	- 9 -	- 10 -	- 11 -
Significant surpluses										
		ψ_α=1.62			ψ_α=1.44			ψ_α=1.48		
0	1	15	4.6	5.56	3	0.87	2.72			
0	4	10	3.7	3.77	1	0.29	1.56	4	1.2	2.96
0	6	8	2.4	4.04						
0	19	6	2.1	3.00						
3	0	93	73	3.29						
Significant deficiences										
		ψ_α=1.68			ψ_α=1.82			ψ_α=1.80		
0	0	20	48.9	5.36				4	9.6	2.42
3	1	0	6.8	3.01						
3	4	0	5.5	2.68						

Table. 4.7. Significant relationships between some categories of the features: PRESENCE OF ALCOHOL IN PEDESTRIAN'S BLOOD (AP) and PEDESTRIAN'S BEHAVIOUR (PB) for *Hitting pedestrian* acident type.

		Road No 7 black sections			Road No 44 black sections			Road No 74 black sections		
AP	PB	n_{ij}	m_{ij}	ψ	n_{ij}	m_{ij}	ψ	n_{ij}	m_{ij}	ψ
- 1 -	- 2 -	- 3 -	- 4 -	- 5 -	- 6 -	- 7 -	- 8 -	- 9 -	- 10 -	- 11 -
Significant surpluses										
		ψ_α=1.62			ψ_α=1.41			ψ_α=1.46		
0	0	60	43.3	3.38				12	7.2	2.41
1	3	44	29.4	3.42						
1	1	4	1.9	1.83						
1	6							4	2.2	1.49
Significant deficiences										
		ψ_α=1.68			ψ_α=1.83			ψ_α=1.81		
0	3	50	64.6	2.60						
1	0	3	19.7	4.67	0	2.4	1.98	1	5.8	2.60

General association – table 4.4. The significance level for testing independence of the combination of the features DRIVER'S BEHAVIOUR and ACCIDENT TYPE is less than 0.05 for all cases. Hence there is some evidence of an association. Looking at the numbers in the parts B and C of the table 4.4 one can say of the association between the respective features for blackspot sections of the road No 7 and the lack of association for blackspot sections of the road No 44. Very slight associations can be considered for the sections of the road No 74 – P-values are equal to 0.09 and 0.011 for the features combinations in the parts B and C of the table 4.4. As can be seen in the table 4.4.D the fact that both a driver and a pedestrian were under the influence of alcohol when an accident occured is a coincidence as there is no evedence to reject H_0.

Tests of associations between categories of qualitative features – tables 4.5, 4.6, 4.7. Test statistics ψ calculated from data are given in the columns 5, 8 and 11 of the tables. Those combinations of categories are put in the tables for which the n_{ij} numbers for significant surpluses were not less than 5 and the m_{ij} numbers for significant deficiencies were not less than 5. Hovever, there are some exceptions given for comparison. They are marked gray in the tables. There are surpluses between five combinations of DRIVER'S BEHAVIOUR and ACCIDENT TYPE that are significant for blackspot sections of the three roads.

Particular drivers' behaviours can cause accidents of certain types independently of the category and the function of a road (table 4.5). These are:

- *Hitting pedestrian* (AT=4) coincided meaningly with a driver's behaviour about which is hardly to say it is admittedly in fault (DB=0),
- *Excessive speed* (DB=1) usually results in *Rolling over* or *Hitting fixed object* (AT=10 and AT=6 respectively),
- *Disobeying priority* (DB=3) ends in *Side collision* (AT=2) more often than one could expected,
- *Rear-end collisions* (AT=3) caused by *Too close distance between vehicles* (DB=12) confirms common expectations about this kind of association.

Significant surpluses were also found out between other combinations of categories but not for blackspot sections of all roads:

- *Head on collision* category (AT=1), which is considered the most dangerous accident type, can be a consequence of the following behaviours of a driver:
  a) *Sudden changing of speed* (DB=14); sections of the roads No 7 and No 44,
  b) *Excessive speed* (DB=1), *Incorrect manoeuvres of a driver* (DB=4), *Keeping the wrong side of a roadway* (DB=9); sections of the road No 7.
- In the case of the roads No 7 and No 44 there is dependency between *Incorrect manoeuvres of a driver* (DB=4) and *Rear-end collision* accident type (AT=3).
- *Too close distance between vehicles* (DB=12) caused not only *Rear-end collisions* (AT=3) but also *Side collisions* (AT=2) on blackspot sections of the road No 7.

Some types of accidents usually cannot be connected with certain driver's behaviour on considered road blackspot sections – this is confirmed by significant deficiences obtained for the combinations of categories that are referenced to in the columns 1 and 2 of the table 4.5.

Particular attention should be focused to *Hitting pedestrian* accidents. Numbers in the table 4.5 show that it could be hardly say about evident driver's fault (DB=0) in that type of accidents for blackspot sections of all roads. However, tests of associations can give a bit different results for conditional probabilities [Agresti; 1984]. So looking at the contens of the table 4.6 it can be stated that:

- *Incorrect crossing a roadway* (PB=3) coincides significantly with mentioned earlier driver's behaviour (DB=0) for blackspot sections of the road No 7,
- a pedestrian could become a victim (PB=0) of the following behaviours of a driver for some of the blackspot sections: *Excessive speed* (DB=1), *Incorrect manoeuvres of a driver* (DB=4), *Incorrect crossing a pedestrian crosswalk* (DB=6) and *Disobeying other traffic regulations* (DB=19).

Presence of alcohol in pedestrian's blood infulences significantly particular pedestrian's behaviour such as (see table 4.7): *Incorrect crossing a roadway* or *Incorrect enter a roadway* (PB=3 and PB=6 respectively) or *Standing or falling down on a roadway* (PB=2). In accidents with pedestrian if a pedestrian was under the influence of alcohol usually the guilt was on his side – see significant deficiences for the combination AP=1 and PB=0.

5 Final remarks and conclusions

The analysis of some circumstances which accompanied acccidents that had occured along blackspot sections on some roads in Poland has been presented in the paper. The blackspot sections were identified on the basis of Bayesian approach, that enables to take into account randomness of accident occurence in time and space. In order to identify typical characteristics of certain descriptive accident features qualitative analysis has been used. Some conclusions that concern the analysis are presented below.

- Not long time interval of collecting accident data should be taken to the process of blackspot sections identification in order to keep the information up-to-date. On the other hand statistical characteristics and searching for associations between qualitative features involve quite a big sample size and consequently a longer time interval of data registration.
- There are too many categories defined for some features in Road Accident Card. What is more they are not separate and not independent one of another within a feature. As a consequence a policeman can have doubts while evaluating a feature category. In addition cross-classification of such data could be difficult. In order to obtain more coherent classification some suggestions of new categories have been put forward for three qualitative features: ACCIDENT TYPE, DRIVER'S BEHAVIOUR and PEDESTRIAN'S BEHAVIOUR.
- Results of tests of associtations for cross-classification of qualitative features depend on a road, its category and function.
- Tests of associations have confirmed a crucial role of excessive speed not only in head on collisions but also in other accident types such as: rolling over, hitting fixed object and hitting pedestrian.
- Extremally high number of accidents relates to accidents with pedestrians. This is connected with too easy access to a road from a neighbour and with the lack of separation of local both pedestrian and vahicular traffic with transit traffic.

References

1. Agresti A. (1984). Analysis of Ordinal Categorical Data. John Wiley & Sons, Inc., New York.
2. Benjamin J. and A. Cornell (1977). Rachunek prawdopodobieństwa, statystyka matematyczna i teoria decyzji dla inżynierów. WNT, Warszawa.
3. Góralski A. (1966). Kryterium ψ oceny istotności nadwyżki i niedoboru liczebności w elementarnej kostce wielodzielczej m-wymiarowej tablicy. Zeszyty Naukowe Politechniki Warszawskiej, Warszawa.
4. Góralski A. (1979). Algorytmy i programy statystyki kwalitatywnej. Wydawnictwa Naukowo-Techniczne, Warszawa.
5. Tracz M. and M. Nowakowska (1996). Bayesian Theory and Cluster Analysis in the Identification of Road accident Blackspots. 13-th International Symposium on Transportation and Traffic Theory, Lyon, 24-26 July.

Appendix

TABLE A. Classification categories of some qualitative accident features in Road Accident Card.

Classification category	Numerical value of the classification category
- 1 -	- 2 -
ACCIDENT TYPE	
Head on collision	1
Side collision	2
Rear-end collision	3
Hitting pedestrian	4
Hitting a standing (immobilized) vehicle	5
Hitting fixed object	6
Hitting railway barrier	7
Hitting road device	8
Hitting animal	9
Rolling over	10
Others	11
DRIVER'S BEHAVIOUR	
Nothing particular	0
Exceeding speed limit	1
Mismatching the speed to a traffic situation	2
Disobeying right of way regulations	3
Incorrect overtaking or passing round	4
Incorrect passing	5
Incorrect crossing a pedestrian crosswalk	6
Incorrect turning	7
Incorrect vehicle stoppage or parking	8
Keeping the wrong side of a roadway	9
Entering red signal	10
Disobeying other road signals and signs	11
Following too closely	12
Barring one's way	13
Skidding	14
Sudden braking	15
Dazzling a driver by another vehicle	16
Inattenation, distraction, imprudence	17
Tiredness, falling asleep	18
Others	19
PEDESTRIAN'S BEHAVIOUR	
Nothing particular	0
Standing or falling down on a roadway	1
Walking along a wrong side of a roadway	2
Enter a roadway at a red signal	3
Imprudent enter a roadway:	
– before a moving vehicle	4
– from behing a vehicle or an obstacle	5
Incorrect crossing a roadway:	
– at unseen places	6
– slowing down or stopping	7
– running across	8
– walking in subgrade (line)	9
– at prohibited places	10
Children up to seven years old:	
– playing in a roadway	11
– running onto a roadway	12
– cycling and so on	13
Falling in/from a vehicle	14
Others	15