EVALUATION ACCIDENT RISK ON INTERURBAN RURAL HIGHWAYS, SIVAS SAMPLING

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1. Introduction

Safety and efficiency are the two primary goals of transportation enginering. The effort that public agencies put into reducing traffic accidents is highly justifiable. Traffic accidents place a huge financial burden on society. Two major factors usually play an important role in traffic accident occurrence. The first related to the driver, and the second related to the roadway design. (Miaou and Lum, 1993). Miaou (1994) studied the relationship between highway geometric and accidents using Negative Binomial regression. In this study, Miaou evaluated the performance of the Poisson regression, zero-inflated Poisson regression, and Negative Binomial regression. Ivan and O'Mara (1997) applied Poisson regression for the prediction of traffic accidents using the Connecticut Department of Transportation's accident data. Results of the model suggest that the posted speed limit, the annual average daily traffic of the highway are critical accident prediction variables leading to the conclusion that the Poisson regression model is preferred than the linear regression model. Shankar et al. (1995) used both the Poisson and Negative Binomial distributions (Poisson when the data was not significantly over dispersed and negative binomial when it was) to evaluate the effects of roadway geometrics and environmental factors on rural accident frequency in Washington State. Agent and Deen (1975) attempted to identify high-accident locations with respect to the functional type and geometry of the highway, using accident and volume data from rural highways in Kentucky collected from 1970 through 1972. Milton and Mannering (1996) found that narrow shoulder width, sharp horizontal curve, reduced lane width and high volume of traffic all have a potential effect on increasing accident frequency. Knuiman et al. (1993) studied the effect of median width on accident rates using a Negative Binomial regression model. For a median without barrier, they found that the accident rate declines rapidly when median width exceeded about 7.6m. (25ft). Decreasing trend seemed to become level at median widths of approximately 18.9–24.4 m (60–80 ft). (McGee et al., 1995). (Ivan et al., 1999) specifically that single vehicle and multi-vehicle highway crashes occur under markedly different circumstances with respect to traffic volume, light and roadway conditions. Persaud and Mucsi (1995) found that the effect of daylight conditions is different for single-vehicle and multi-vehicle crashes. For single-vehicle crashes, the potential is higher at night, whereas for multi-vehicle crashes the opposite is the case. Joshua and Garber (1990) studied the relationship between highway geometric factors and truck accidents in Virginia using both linear and Poisson regression models. Miaou et al.,

(1992) used a Poisson regression model to establish the empirical relationship between truck accidents and highway geometric on a rural interstate in North Carolina.

In Turkey, among sub-system of transportation, the use of highway is 95 % whereas the use of railway, airway and maritime lines transportation is 5 % combined. General Police Headquarters, (2001). In accordance with the high rate of highway transportation use, thousands of accidents occur in Turkey each year. Because of these accidents, hundreds of people dying, injuring or become disabled; also resulting in big financial loses. The relatives of the people who are involved in the accidents also affected financially and spiritually. Therefore traffic accidents have become a great problem in our country that need to solve. Traffic accidents occur in accordance with many including man, the car and the highway (Ozgan, 2003). Traffic accidents results between 1997 and 2001 years determined two categories in city and interurban highways in Turkey (Table 1, 2 and 3).

Table 1. Traffic accident results in cities between 1997 and 2001 in Turkey.

Years	1997	1998	1999	2000	2001	Total	Ratio (%)
Number of accident	332358	375824	377330	404167	363528	1853207	100.0
Number of mortal accidents	1836	1626	1426	1386	1154	7428	0.401
Number of injured accident	39251	40868	40989	45153	40150	206411	11.138
Number of financial damage accidents	291271	333330	334915	357628	322224	1639368	88.461
Number of dead	2197	1847	1682	1542	1309	8577	0.463
Number of injured	59979	63254	62276	71635	62690	319834	17.258

It can see from the table that between 1997 and 2001 years, the financial damaging accident percentage in city is 88.461 %, injuring accidents are 11.138 % and mortal accidents are 0.401 %. The ratio of total injured number to total accident number is 17.258 %. The ratio of total number of dead to total accident number is 0.463 %.

Table 2. Traffic accident results on inter 8-0.01890345982 -0.03780691964 urban highways between 1997 and 2001 years in Turkey.

Years	1997	1998	1999	2000	2001	Total	Ratio (%)
Number of accident	55175	64325	61008	62218	45879	288605	100.0
Number of accidents causing death	2027	2072	1869	1608	1158	8734	3.026
Number of accidents causing injures	20145	20679	19231	17142	12698	89895	31.148
Number of accidents causing financial damage	33003	41574	39908	43468	32023	189976	65.826
Number of dead	2984	3088	2914	2399	1645	13030	4.515
Number of injured	46167	51298	47623	44242	31807	221137	76.623

It can see from the table that between 1997 and 2001 years the financial damaging accidents percentage in interurban highways are 65.826 %, injuring accidents are 31.148 % and mortal accidents are 3.026 %. The ratio of total injured numbers to total accident numbers are 76.623 %. The ratio of total number dead to total accident number is 4.515%. The results of accidents in city and interurban highways compared with together and given (Table 3).

Table 3. Comparison traffic accidents results in city and interurban highways in Turkey.

Results of the accidents	In city highways	On interurban highways	Results
The ratio of financial damage accidents to total accidents (%)	88	66	The number of financial damage accidents in cities more than interurban highway' about **1.33** times.
The ratio of injuring accidents to total accidents (%)	11	31**	Injuring accidents occurred on interurban highway more than injuring accidents in cities about **2.81** times.
Ratio of the number of accidents causing death to the total accidents (%)	0.4	3**	The number of accidents caused death on interurban highway more than in cities' about **7.5** times.
The ratio of the total injured number to total accidents number (%)	17	77**	The number of accidents caused injured on interurban highway more than in cities' about **4.52** times.
The numbers of total dead ratio to the number of total accidents are (%).	0.4	4.5**	The number of dead on interurban highway is more than in cities about **11.25** times.

It can see clearly from the table that interurban highways more dangerous than in cities' highways in Turkey.

The methods, using to determine the risky and dangerous section on highways are Gamgam Z. (2000);

- The Number of Accident Method,
- The Ratio of the Accident Method,
- The Number-Ratio Method,
- The Number Quality Control Method,
- The Ratio Quality Controll Methods

In these methods, distribution of the accidents according to kilometre determines from traffic accident reports and the risky and dangerous section establishs according to these datas. But, geometric properties of the way, environmantel conditions, highway' conditions, field of vision conditions at night and in the daytime, conditions of the sign of the traffic and signboard properties not to take into consideration in these methods.

In this study, the number of traffic accidents accordance to kilometre and geometrical properties of the highway, environmental conditions, highway conditions, field of vision conditions at night and in the daytime, conditions of the sign of the traffic and signboard take into consideration. These characteristic affect the accidents directly. So that, taking into consideration the risky and dangerous sections tried to determine for the highway. For this aim D100/22 State highway selected as a working route. The highway factor studied in details and an analysis performed on 22nd part of the D100 State highway. The risky kilometres on the 22nd part of the D100 State highway determined and accident risky of this highway measured.

2. Material and Method

2.1. Material

This study conducted in two parts. In the first part, D100/22 State highway section examined. This highway section's length is 44 km, number of accidents 134, injured persons are 253 and dead person are 10, which starts from Tokat province boundary to D865/03 State highway section on the way to Şebinkarahisar (Figure 1 and Figure 2).

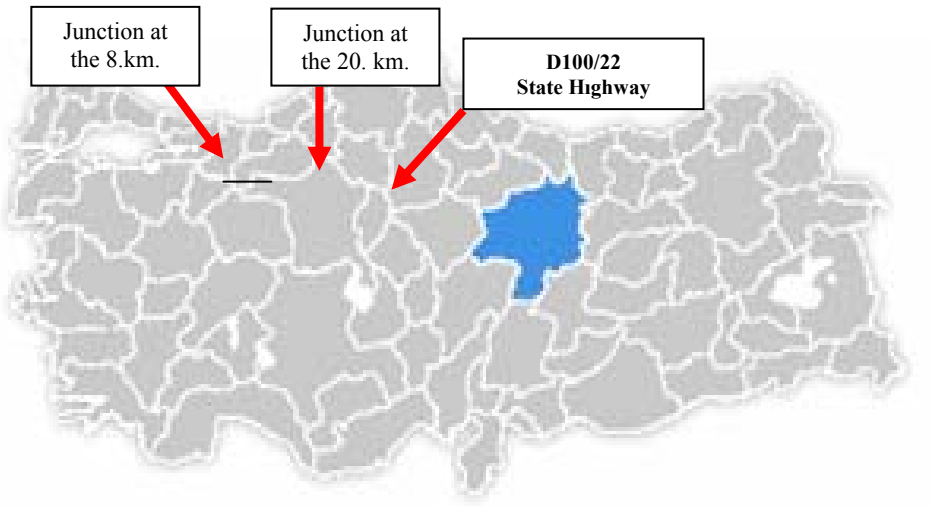

Figure1. Location of the Sivas in TURKEY

Figure 2. Lolcation of the D100/22 State highway section in Sivas

Generally characteristic of the D100/22 State highway are; average lane width is 3.50m, shoulder width 1.50m, platform width 10m, maximum gradient in bend between 8 and 10 %, maximum profile' gradient between 4-9 % and width' gradient changes between 2-4 %. Minimum horizontal bend' radius is 250m and this land is wavy in generally. This route has influenced by terrestrial climate. There is thick snow and covered with ice on highway' surface in the winter. Annual Average Daily Traffic (AADT) for D100/22 highway sections given (Table 4).

Table 4. AADT of D100/22 state highway based upon years.

Years	Car	Bus	Truck	Trailer	Heavy truck Ratio (%)	Total
1999	895	215	911	117	58,13	2138
2000	1006	129	681	39	45,76	1855
2001	754	125	548	61	49,32	1488
2002	894	129	623	151	50,25	1797
Total	3549	598	2763	368	51,23	7278

2.2. Method

In this study, "Highway Accident Risk" obtained from the studies done in two different processes. In the first processes, accident reports for the traffic accidents which occurred on the 22nd parts of the Sivas province city boundary on D100 State highway between 1999 and 2002 used. Accidents that occurred on each kilometre determined according to the official traffic reports. The number of accidents that occurred in each kilometre and

the number of dead and injured people are shown in Table 2. Apart from that, a "Risk Evaluation Score" developed for each kilometre of the highway by giving "1" point for the number of the accidents, "2" points for injured people and "3" points for fatalities in each kilometre. Accidents results related to D100/22 highway section between 1999-2002 years showed a table (Table 8).

Table 8. Accidents occurred on D100/22 highway section between 1999-2002 years.

Kilometres	The number of accidents and the condition of the victims						Risk evaluation scores	Kilometres	The number of accidents and the condition of the victims						Risk evaluation scores
	The numbers of accidents causing death	The numbers of accidents causing injures	The numbers of accidents causing financial damage	Total number of accidents	The number of dead	The number of injured			The numbers of accidents causing death	The numbers of accidents causing injures	The numbers of accidents causing financial damage	Total number of accidents	The number of dead	The number of injured	
1	1	1	2	2	2	1	12	24	-	1	1	1	-	1	3
2	-	1	1	1	-	1	3	25	-	1	3	3	-	2	7
3	-	-	1	1	-	-	1	26	-	2	3	3	-	9	21
5	-	2	3	3	-	5	13	27	-	1	3	3	-	1	5
6	1	5	8	8	2	12	39	28	-	2	3	3	-	10	23
7	-	-	1	1	-	-	1	29	-	1	3	3	-	1	5
8	-	3	4	4	-	15	34	30	1	2	3	3	1	5	16
9	-	2	5	5	-	7	19	31	-	2	2	2	-	9	21
10	-	2	4	4	-	4	12	32	1	3	4	4	1	22	52
11	-	2	3	3	-	5	13	33	1	8	9	9	1	19	51
12	-	2	5	5	-	2	9	34	-	1	3	3	-	8	20
13	-	2	2	2	-	4	10	35	-	2	3	3	-	3	9
14	-	2	2	2	-	5	12	36	-	2	3	3	-	9	22
15	-	7	7	7	-	17	41	37	-	-	1	1	-	-	1
16	-	2	8	8	-	4	16	38	1	1	2	2	1	5	15
17	-	2	3	3	-	7	17	39	-	1	1	1	-	4	9
18	-	1	1	1	-	1	3	40	-	2	2	2	-	10	22
19	1	1	2	2	1	3	11	41	-	-	-	-	-	-	
20	1	3	11	11	1	16	46	42	-	-	-	-	-	-	
21	-	2	3	3	-	4	11	43	-	-	1	1	-	-	1
22	-	6	7	7	-	22	51	44	-	-	-	-	-	-	
23	-	-	1	1	-	-	1								

In the second part of the study, observations, controls and topographic measurements on highway sections in day-time and night-time conditions collected from the accident reports for four years time period under consideration. In these controls and topographic measurements, characteristics such as the width of the highway, width of the presence of a banquette, inclination in the road, width of the road, length of the straight lane, condition of the curves and their internal inclination, subordinate correction roads, condition of horizontal and vertical traffic sign, whether these sings were in the correct place or not, night and day time vision conditions, type of the coating and its surface condition, driving comfort, position of the barriers, use of the land and environmental conditions, whether there are climbing lane or not, position of the landslide, drainage conditions of the highway, fuel-oil stations and resting areas were all subject to scoring. For each characteristics listed above, present or suitable ones given "0" points, lacking or inadequate ones given "0,5" points and non-existing ones given "1" points.

This "Risk Evaluation Score" (RES) calculated for each kilometre on this highway. By adding the "Highway Risk Evaluation Score" (HRES) which is obtained from the number of the accidents, the number injured and dead people for each kilometre to the "HRES" which obtained according to all characteristics of the highway, the "Total Risk Evaluation Score" calculated. "RES" which obtained in accordance with the positions of the traffic accidents that occured on each kilometre of the 22nd section of the D100 State highway between 1999 and 2002 years. By the risk evaluation scores that obtained for each km of D100/22 highway section collected to be meaningfully 5 categories and it coded from 1 to 5 Frequency scatter and percentage of the risk scores showed (Table9).

Table 9. The frequency & scatter percentage of risk scores for D100-22 highway section.

Valid	Frequency	Percent	Valid Percent	Cumulative Percent		Valid	Frequency	Percent	Valid Percent	Cumulative Percent
.00	4	9.1	9.1	9.1		19.00	1	2.3	2.3	70.5
1.00	5	11.4	11.4	20.5		20.00	1	2.3	2.3	72.7
3.00	3	6.8	6.8	27.3		21.00	2	4.5	4.5	77.3
5.00	2	4.5	4.5	31.8		22.00	2	4.5	4.5	81.8
7.00	1	2.3	2.3	34.1		23.00	1	2.3	2.3	84.1
9.00	3	6.8	6.8	40.9		34.00	1	2.3	2.3	86.4
10.00	1	2.3	2.3	43.2		39.00	1	2.3	2.3	88.6
11.00	2	4.5	4.5	47.7		41.00	1	2.3	2.3	90.9
12.00	3	6.8	6.8	54.5		46.00	1	2.3	2.3	93.2
13.00	2	4.5	4.5	59.1		51.00	2	4.5	4.5	97.7
15.00	1	2.3	2.3	61.4		52.00	1	2.3	2.3	100.0
16.00	2	4.5	4.5	65.9						
17.00	1	2.3	2.3	68.2		Total	44	100.0	100.0	

Risk scores groped 5 categories and coded as 1,2,3,4 and 5. The risk score limits for each one code number showed a table (Table 10).

Table 10. Risk score limits for coded numbers.

Risk scores limits	Corresponding code number
Between 0-10,9	1
Between 11-21,9	2
Between 22-32,9	3
Between 33-43,9	4
Between 44-54,9	5

The risk scores upon the km and coded datas given a table (Table 11).

Table 11. Risk scores and coded dates for each km on D100-22 highway section.

Km	Risk score	Coded risk group	Km	Risk score	Coded risk group	Km	Risk score	Coded risk group
1	12	2	17	17	2	29	5	1
2	3	1	18	3	1	30	16	2
3	1	1	19	11	2	31	21	2
4	0	1	20	46	5	32	52	5
5	13	2	21	11	2	33	51	5
6	39	4	22	51	5	34	20	2
7	1	1	19	11	2	35	9	1
8	34	4	20	46	5	36	22	3
9	19	2	21	11	2	37	1	1
10	12	2	22	51	5	38	15	2
11	13	2	23	1	1	39	9	1
12	9	1	24	3	1	40	22	3
13	10	1	25	7	1	41	0	1
14	12	2	26	21	2	42	0	1
15	41	4	27	5	1	43	1	1
16	16	2	28	23	3	44	0	1

According to the coded numbers, the dangerous situation for each km exanimated and the results given a table (Table 12).

Table 12. Risky state and coded numbers for each kilometre.

Coded numbers	**Number of km**	**%**	**Kilometres**	**Results**
1	19	45	2, 3, 4, 7, 12, 13, 18, 23, 24, 25, 27, 29, 35, 37, 39, 41, 42, 43, 44	Less dangerous km
2	15	34	1, 5, 9, 10, 11, 14, 16, 17, 19, 21, 26, 30, 31, 34, 38	Little dangerous km
3	3	6	28, 36, 40	Dangerous km
4	3	6	6, 8, 15,	High dangerous km
5	4	9	20, 22, 32, 33,	Highest dangerous km

As a result, number of the less dangerous km is 20th, the little dangerous km is 15th, dangerous km is 3th, high dangerous km is 3th and the highest dangerous km is 4th. The percentage and dangerous situation for each coded number is about 45 % all of the highway section is "less dangerous", about 34 % is little dangerous, about 6 % is dangerous, about 6 % is high dangerous and about 9 % is the highest dangerous.

Conclusions

The number of financial damage accidents in cities more than interurban highway' about **1.33** times. Injuring accidents occurred on interurban highway more than injuring accidents in cities about **2.81** times. The number of accidents caused death on interurban highway more than in cities' about **7.5** times. The number of accidents caused injured on interurban highway more than in cities' about **4.52** times. The number of dead on interurban highway is more than in cities about **11.25** times in Turkey.

The percentage of the less dangerous km for D100-22 state highway is about 43 %, percentage of the little dangerous km is about 34 %, percentage of the dangerous km is about 6.8 %, percentage of the high dangerous km is about 6.8 % and percentage of the highest dangerous km is about 9 %.

Traffic accidents report, environmental conditions and highway geometric characteristic must be taken into consideration to determination the risky and dangerous section on interurban highway. In this way all of the effects caused traffic accidents would have taken into consideration.

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