Road accident risk models: the use of SafeNET in Thessaloniki

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Abstract

The development of mathematical models in order to relate the number of accidents with the geometrical and functional characteristics of road networks is always an important issue in road safety. The first attempts started in the early 50s and since then a lot of research has been made towards this direction. As a result a number of tools have been developed worldwide. The Transport Research Laboratory (TRL) developed the SafeNET software package, which allows estimates to be made of the number of personal injury accidents per year for particular elements of a road network. Within the framework of this paper the results from the use of the SafeNET software package in the central area of the city of Thessaloniki are presented. The network consists of four links and four nodes. SafeNET has proved to be a very useful tool to assist the work of traffic engineers.

Keywords: road accident, risk models, SafeNET.

1 Introduction

The problem of how to select junctions or road sections in order to take measures for the improvement of road safety level has to do with the accident data availability, and more especially with the knowledge of the accidents, which would occur in the case where no measures are implemented. One way to deal with this problem is to take into account for the estimations the historical data (e.g., road accidents which took place during the last 3 to 5 years) but there is always the question of reliability due to regression-to-mean (RTM), due to trend effects etc. The use of Empirical Bayes (EB) approach appears to provide very
good estimations. There are various models/techniques which have been developed worldwide aiming at the establishment of a relationship between road accidents data on one hand and on the other with other parameters like the geometrical characteristics of junctions/road sections, traffic volume etc.

According to the results of a research in U.K. “the technique of generalized linear models (GLMs) with Poisson error structure is far more appropriate than conventional multiple linear regression models, based on least squares” although there are certain technical problems to be addressed [1]. This technique has been applied successfully in a series of Transport Research Laboratory (TRL) junction accident studies. An alternative strategy is the fitting of true multilevel models where “the accidents included in the model are regarded as a random sample of events from a population, and hence a regression relation is assumed for each” [2].

Accident prediction models have been developed for six types of highway in the framework of a study in U.K. [3]. According to the study results, accidents on highway links are not proportional to exposure (traffic flow and link length) and the presence of minor junctions has an important influence on link accident frequencies. Finally, the Empirical Bayes (EB) approach was found to be best followed by the predictive models among the three approaches used to estimate expected link accidents.

The influence of trend on estimates of accidents at junctions was considered by Mountain et al. [4]. According to the results, “accident risk at a sample of some 500 junctions in U.K. was shown to be declining annually by an average of 6%, with no significant difference in the value of trend between accident types”. According to the same results, “the factors which affected the proportions of accidents of various types included the method of junction control, speed limit and traffic flow”.

The problems of bias when using a mis-specified predictive model in the estimation of confounding factors in before and after studies of road safety schemes is considered by Hirst et al. [5]. The results show that, “under the assumption of a genuine change in risk over time simulations, if this is ignored, the estimation of regression-to-mean (RTM) and treatment effects can be biased”.

In a study aiming at modelling the impact of road characteristics and local spatial environment on road safety which carried out in Belgium [6], logistic modelling, including spatial autocorrelation, is used and compared to non-spatial regression. According to the results, local environment and road infrastructure plays a substantial role in the co-occurrence of road accidents.

Poisson regression is used to predict full green and green arrow accidents at traffic lights, using configuration-specific features [7]. According to the results, “the technical features of traffic lights are not able to control a driver’s action in such a way as to eradicate error” and also “prediction models provide an indication as to which configuration-specific features are of prognostic value in both types of accidents”.

The implementation of Bayesian modelling techniques to the assessment of the potential risk factors measured at group level was examined by MacNab [8]
through the use of hospital separation data for 83 local health areas in British Columbia, Canada. According to some of the study results there is a large variation in motor vehicle accident injury (MVAI) in males aged 0-24. These ecological studies are potentially useful in identifying priority areas for injury/accident prevention.

Two alternative models for the understanding of the nature and extent of the causes of road accident fatalities are proposed within a study in Yemen [9] and it is found that the consumption of a locally grown stimulant called Qat by the road users increases the risk of accidents.

In a study at Hong Kong [10] an algorithm is developed in order to estimate the number of traffic accidents and assess the risk of traffic accidents, where the risk is computed using the Empirical Bayes (EB) approach. The algorithm involves the combination of Geographical Information System (GIS) techniques and statistical methods. The results show that this algorithm improves accident risk estimation when comparing to the estimated risk based on only the historical accident records.

Another research [11] explores the effects of traffic stream flows on accident potential at urban priority-controlled, four-arm junctions. Using traffic accident data for five-year time periods and the corresponding 24-hour flows, a new exposure index is proposed consisting of an expression of the flows of the junction's interacting traffic streams.

Greece faces severe road safety problems and a major effort has been made towards the improvement of safety level in the country. Since a great percentage of the road accidents in urban areas take place in road junctions, emphasis has been given to the evaluation of their safety performance.

The Transport Research Laboratory (TRL) developed SafeNET software package, which allows estimates to be made of the number of personal injury accidents per year for particular elements of road network. Within the framework of this paper the results from the use of SafeNET software package in the central area of the city of Thessaloniki are presented.

2 Road safety in Greece and in Thessaloniki

In Greece, every year more than 2,000 people lose their lives and more than 30,000 are injured in more than 20,000 accidents. Data concerning road safety in the country for the 1st semester of the year 2004 compared to the 1st semester of the year 2003 are presented in Table 1.

Due to the importance of the problem, the authorities have decided to implement a strategic plan for the improvement of road safety known as «On the Road 2001-2005» [12]. As shown in Table 1 there is a considerable improvement in road safety due to the implementation of the strategic plan.

Road accidents, which took place in the Thessaloniki Metropolitan Area during the period 1993-1996, are presented in Table 2.

In the framework of a research which took place in Aristotle University of Thessaloniki [15] 122 junctions are selected for accident analysis. A number of
667 accidents occurred during the study period (1993-1998). The results of the analysis include, among others, the following:

- Accidents at 3-arm junctions: 22.6%
- Accidents at 4-arm junctions: 74.0%
- Accidents at 5-arm junctions: 3.4%

According to the same research, the distribution of accidents taking into account the proportion of traffic volumes of the vehicles involved is as follows:

- < 3 times: 29.7%
- From 3 times to 10 times: 40.2%
- >10 times: 30.1%

Table 1: Road accidents data in Greece (1st semester of 2004 compared to 1st semester of 2003).

<table>
<thead>
<tr>
<th></th>
<th>Year 2004</th>
<th>Year 2003</th>
<th>Difference</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fatal accidents</td>
<td>630</td>
<td>632</td>
<td>-2</td>
<td>-0.3%</td>
</tr>
<tr>
<td>Serious accidents</td>
<td>829</td>
<td>821</td>
<td>8</td>
<td>1.0%</td>
</tr>
<tr>
<td>Slight accidents</td>
<td>5.680</td>
<td>5.812</td>
<td>-132</td>
<td>-2.3%</td>
</tr>
<tr>
<td>Total</td>
<td>7.139</td>
<td>7.265</td>
<td>-126</td>
<td>-1.7%</td>
</tr>
<tr>
<td>Deaths</td>
<td>716</td>
<td>740</td>
<td>-24</td>
<td>-3.2%</td>
</tr>
<tr>
<td>Serious injuries</td>
<td>1.013</td>
<td>1.052</td>
<td>-39</td>
<td>-3.7%</td>
</tr>
<tr>
<td>Slight injuries</td>
<td>7.960</td>
<td>8.435</td>
<td>-475</td>
<td>-5.6%</td>
</tr>
<tr>
<td>Total</td>
<td>9.689</td>
<td>10.227</td>
<td>-538</td>
<td>-5.3%</td>
</tr>
<tr>
<td>Speed violations</td>
<td>183.531</td>
<td>202.614</td>
<td>-19.083</td>
<td>-9.4%</td>
</tr>
<tr>
<td>Drivers subjected to alcohol test</td>
<td>625.602</td>
<td>569.179</td>
<td>56.423</td>
<td>9.9%</td>
</tr>
<tr>
<td>Alcohol reading</td>
<td>19.674</td>
<td>20.565</td>
<td>-891</td>
<td>-4.3%</td>
</tr>
<tr>
<td>Percentage of drunk-drivers</td>
<td>3.1%</td>
<td>3.6%</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

Source: [13]

Table 2: Road accidents in Thessaloniki Metropolitan Area (1993-1996).

<table>
<thead>
<tr>
<th>Place of accidents &amp; casualties</th>
<th>1993</th>
<th>1994</th>
<th>1995</th>
<th>1996*</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban road cross-section</td>
<td>496</td>
<td>589</td>
<td>571</td>
<td>607</td>
<td>2.263</td>
</tr>
<tr>
<td>Urban junction</td>
<td>624</td>
<td>576</td>
<td>533</td>
<td>411</td>
<td>2.144</td>
</tr>
<tr>
<td>Rural road cross-section</td>
<td>228</td>
<td>237</td>
<td>219</td>
<td>110</td>
<td>0.794</td>
</tr>
<tr>
<td>Total</td>
<td>1.348</td>
<td>1.402</td>
<td>1.323</td>
<td>1.128</td>
<td>5.201</td>
</tr>
<tr>
<td>Deaths</td>
<td>87</td>
<td>112</td>
<td>94</td>
<td>57</td>
<td>350</td>
</tr>
<tr>
<td>Serious injuries</td>
<td>110</td>
<td>110</td>
<td>118</td>
<td>134</td>
<td>472</td>
</tr>
<tr>
<td>Slight injuries</td>
<td>1.717</td>
<td>1.776</td>
<td>1.690</td>
<td>1.376</td>
<td>6.559</td>
</tr>
</tbody>
</table>

*: Incomplete data

Source: [14]
Table 3: Distribution of various types of road accidents per road type.

<table>
<thead>
<tr>
<th></th>
<th>Two-way street</th>
<th>One lane of a two-way street with traffic island</th>
<th>One-way street</th>
</tr>
</thead>
<tbody>
<tr>
<td>One vehicle &amp; pedestrian</td>
<td>28.4%</td>
<td>32.2%</td>
<td>39.4%</td>
</tr>
<tr>
<td>One vehicle</td>
<td>29.4%</td>
<td>38.8%</td>
<td>31.8%</td>
</tr>
<tr>
<td>Two vehicles – same direction</td>
<td>16.2%</td>
<td>27.2%</td>
<td>56.6%</td>
</tr>
<tr>
<td>Two vehicles (from different directions)</td>
<td>40.1%</td>
<td>30.6%</td>
<td>29.3%</td>
</tr>
</tbody>
</table>

Source: [15]

The distribution of accidents involving pedestrians, when the total number of pedestrians who cross the road (taking into account all pedestrian crossings) is considered, is as follows:

- 0-100/hour: 58.5%
- 100-500/hour: 35.3%
- >500/hour: 6.2%

3 SafeNET presentation

SafeNET software is developed under the Transport Research Laboratory (TRL) accident prediction-modelling programme [16, 17]. TRL is an internationally recognised centre of excellence providing world-class research, advice and solutions for all issues relating to land transport [18]. SafeNET is an innovative software package to assist traffic engineers in the design of safer road network in their towns and cities. This software allows estimates to be made of the Personal Injury Accident frequency (number of personal injury accidents per year) for junctions of different types and road sections [19]. In order to calculate the frequency of personal injury accidents on a road network a user enters the vehicle flow, pedestrian flow, and geometric data for each junction and road section. Modeling of road networks through SafeNET can include: roundabouts, mini-roundabouts, traffic signal junctions, urban and rural priority T-junctions, urban crossroad and staggered junctions, urban single carriageway roads, urban roads including minor junctions and traffic calming measures [19]. It can be used as a stand-alone product or in conjunction with traffic assignment models such as TRL's CONTRAM. SafeNET was used to assess the effects of a scheme, which has been developed through research commissioned by RSD/DETR and carried out by the TRL [20]. Research included developing of models in order to predict accidents and also the application of these models for area-wide assessment. Devon County Council has recently applied SafeNET on large planning applications to predict accident generation using likely traffic flows [21].
4 The use of SafeNET in Thessaloniki

The use of SafeNET in the central road network of Thessaloniki is examined in the framework of a research, which was carried out in Aristotle University of Thessaloniki during the period 2003-04 [22]. The "rectangular-in shape network" consists of four (4) roads (links) and the associated four (4) intersections (nodes). All four intersections are signalized and each of them has 4 arms. More specifically the four roads are: Tsimiski Rd, Egnatia Rd, Dragoumi Rd and Venizelou Rd. The level of SafeNET used in the research is level 1 (for both links and nodes). This practically means that data concerning the intersections of the reference road network includes the identification number for each arm, its name, the traffic volumes and the pedestrian flows for each pedestrian crossing. Since data availability was limited in the framework of this research, it had been decided that level 1 should be used. It must be mentioned at this point that the accuracy/reliability of results is associated with the level used (0,1,2,3). Building of the network requires traffic volumes, which are based on traffic counts, refer to year 2001. Pedestrian flows at the crossings of each intersection refer to counts, which took place during the year 2003. Indicative overviews of the 3 out of 4 intersections (nodes) together with sketches, traffic volumes and pedestrian flows are presented in Figures 1 to 3.

Pedestrian crossing 1: 5,707 ped/12 hrs
Pedestrian crossing 2: 6,800 ped/12 hrs
Pedestrian crossing 3: 3,040 ped/12 hrs

movement 1: 2,425 vehicles/day
movement 2: 1,600 vehicles/day
movement 3: 3,163 vehicles/day
movement 4: 18,863 vehicles/day
movement 5: 20,525 vehicles/day
movement 6: 1,938 vehicles/day

Figure 1: Egnatia -Venizelou intersection (node 1).
Pedestrian crossing 1: 4,120 pedestrians/12 hours
Pedestrian crossing 2: 2,287 pedestrians/12 hours
Pedestrian crossing 3: 2,694 pedestrians/12 hours

movement 1: 35,794 vehicles/day
movement 2: 3,056 vehicles/day
movement 3: 4,956 vehicles/day
movement 4: 2,500 vehicles/day

Figure 2: Tsimiski-Venizelou intersection (node 2).

Ped. Cross. 1: 3,754 pedestrians/12 hours
Ped. Cross 2: 2,240 pedestrians/12 hours
Ped. Cross 3: 3,020 pedestrians/12 hours

movement 1: 28,513 veh/day
movement 2: 5,200 vehicles/day
movement 3: 4,725 vehicles/day
movement 4: 2,375 vehicles/day

Figure 3: Tsimiski-Dragoumi intersection (node 3).
Table 4: Accidents at nodes and links.

<table>
<thead>
<tr>
<th></th>
<th>Total number of accidents</th>
<th>Fatal casualties</th>
<th>Serious Injuries</th>
<th>Slight Injuries</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nodes</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Node 1</td>
<td>4.18</td>
<td>0.04</td>
<td>0.77</td>
<td>4.46</td>
</tr>
<tr>
<td>Node 2</td>
<td>3.19</td>
<td>0.03</td>
<td>0.59</td>
<td>3.41</td>
</tr>
<tr>
<td>Node 3</td>
<td>2.76</td>
<td>0.03</td>
<td>0.51</td>
<td>2.95</td>
</tr>
<tr>
<td>Node 4</td>
<td>4.68</td>
<td>0.04</td>
<td>0.86</td>
<td>5.00</td>
</tr>
<tr>
<td>Links</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Link 1</td>
<td>0.13</td>
<td>0.00</td>
<td>0.03</td>
<td>0.12</td>
</tr>
<tr>
<td>Link 2</td>
<td>3.51</td>
<td>0.06</td>
<td>0.87</td>
<td>3.38</td>
</tr>
<tr>
<td>Link 3</td>
<td>1.80</td>
<td>0.03</td>
<td>0.44</td>
<td>1.74</td>
</tr>
<tr>
<td>Link 4</td>
<td>1.31</td>
<td>0.02</td>
<td>0.32</td>
<td>1.26</td>
</tr>
</tbody>
</table>

Figure 4: Accidents at nodes per year as appeared on the screen of SafeNET.

The results obtained for the nodes and links are presented in Table 4. Graphical representation, as appeared on the computer screen of SafeNET, of the results concerning the total number of accidents at nodes and along links are included in Figures 4 and 5 (nodes and links are not presented in the same order as in Table 4).
5 Conclusions

Almost 50% of road accidents in the urban area of Thessaloniki take place at road junctions. This fact imposes the need for a considerable amount of resources to be assigned for the necessary improvements of road junctions. The use of SafeNET in the central road network of the city of Thessaloniki has been proved to be of great value in order to identify junctions or road sections with safety problems and thus to put priorities when the program of the interventions is designed.

References


[18] Transport Research Laboratory, www.trl.co.uk

[19] Transport Research Laboratory, www.trlsoftware.co.uk


[21] TRLNEWS, November 2004