DISSERTATIONES GEOGRAPHICAE UNIVERSITATIS TARTUENSIS
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ROAD USER PERCEPTION TOWARDS ROAD SAFETY IN ESTONIA

DAGO ANTOV

TARTU UNIVERSITY PRESS

Institute of Geography, Faculty of Biology and Geography,
University of Tartu, Estonia

The Faculty Council of Biology and Geography, University of Tartu, has on August 23, 2006 accepted this dissertation to be defended on the degree of Doctor of Philosophy (in Geography).

Supervisors: Prof. Siim Sööt, University of Illinois at Chicago, U.S.A
Prof. Tõnu Oja, Institute of Geography, University of Tartu

Opponent: Professor Christer Hydén, Lund University, Faculty of Engineering

This thesis will be defended at the University of Tartu, Estonia, on October, 19, 2006 at 10:15 in the Scientific Council room, in university main building, Ülikooli 18, Tartu.

The publication of this printing has been funded by the Institute of Geography, University of Tartu.

ISSN 1406–1295
ISBN 9949–11–446–2 (trükis)
ISBN 9949–11–447–0 (PDF)

Tartu Ülikooli Kirjastus
www.tyk.ee
Tellimus nr. 509

CONTENTS

LIST OF PUBLICATIONS

This thesis is based on the following papers, which are included as appendices at the end of the thesis and are referred to in the text by their Roman numerals.

I Antov, D., Sööt, S. Toward Improved Traffic Safety: Road Use Perception and Behavior in Estonia. Journal of the Transportation Research Board. Transportation Research Record No 1818, Washington, D.C., 2002. pp. 1–6.

II D. Antov, T. Rõivas, T. Oja. The public perception towards the road safety measures in Estonia. Transaction: The Built Environment, volume 82. Online ISSN: 1743–3509, Print ISBN: 1–84564–019–5 Edited By: C. A. Brebbia, Wessex Institute of Technology, UK, T. Bucciarelli, F. Garzia and M. Guarascio, University of Rome, 2005. pp. 633–642.

III D. Antov, T. Rõivas, H. Rõuk & Ü. Mander. Pedestrian safety at urban crossings in Estonia. WIT Transactions on Ecology and the Environment. The Sustainable City IV. Urban Regeneration and Sustainability. Editors: Ü. Mander, C. A. Brebbia and E. Tiezzi. WITPress Southampton, Boston, 2006. pp. 797–806.

IV D. Antov, T. Rõivas and H. Rõuk. Drivers behaviour at urban pedestrian crossings. Paper submitted to Urban Studies (An International Journal for Research in Urban and Regional Studies) at August 2006.

V Dago Antov, Tiia Rõivas, Tõnu Oja. Safety effect of seat belt usage — a case of Estonia. Paper submitted to Transportation Research, Part F, at August 2006.

Author's contribution

I, II The author is fully responsible for the data collection and analysis, and participated in writing the manuscript.

III, IV The author participated in study design, data collection and analysis. The author is fully responsible in writing the manuscript.

V The author participated in study design, data collection and analysis and participated in writing the manuscript.

1. INTRODUCTION

"Pedestrians comprise the greater part of human society.
Moreover, it's the better part." Ilf and Petrov, 1931

Motorised road transport plays a central role in European societies. Most of the goods needed for everyday life are transported by road and the current generation has far greater opportunities for motorised travel in the course of work and leisure than their forefathers. This advantage has been achieved, however, at a large cost. High levels of motorization contribute to serious consequences such as human and economic costs measured in terms of the numbers of accidents and of people killed and injured in these accidents. The experience of many countries has shown that it is perfectly possible to introduce measures that greatly reduce these human and economic costs [ETSC 2006].

Road accidents and their consequences are a significant social problem. At the same time, this topic can be considered to be one of the indicators of the sustainable development of urban systems. More than 10,000 pedestrians and cyclists are killed every year in EU countries, representing more than 20 per cent of all road deaths. The small proportion of pedestrian and cyclist casualties that occur in rural areas are relatively severe and should not be forgotten, but this review is concerned with the majority, which occur in urban areas.

Pedestrian safety is also one of the most serious problems in traffic, especially in urban areas. If one compares Estonia's figures with those of the neighbouring country Finland, the pedestrian road traffic risk in Estonia is somehow 2–4 times higher. The situation is extremely alarming in urban areas, which account for approximately 85 per cents of all pedestrian accidents in Estonia. It is documented that every fourth urban pedestrian accident occurs at non-signalized pedestrian crossings, often referred as zebra crossing, or in their vicinity [Paper III].

Road safety is increasingly studied in an international context, for example the EU target of halving the number of road accident deaths. The target in the United States, where pedestrian fatalities account for just over ten percent of road fatalities, the target is more modest but nevertheless there are active programs to reduce the risk to pedestrians.

Accepting the target of 50% reduction of road fatalities Estonia follows the main line of road safety development targets worldwide. The pedestrian road safety risk and the need of improvement pedestrian safety in Estonia have been put in one of the most important measures in Estonian national traffic safety programme.

The goals of this thesis are to highlight the road accidents as a social and public health problem, analyze the public perception factors towards road safety in Estonia, and to investigate drivers' behavioural factors at the vicinity of urban non-signalized crossings in order to recommend measures of safety improvement.

2. DATA AND METHODS

As stated above, this study contains three main parts. First part is a theoretical framework of road traffic accidents and road safety analysis, both in international context and in Estonia. The method used here is a traditional accident analysis, based on international and national casualty accident databases.

Second part of the study contains public opinion and road user attitudes [Papers I and II] towards road-safety measures, where a road-user questionnaire has been used. Here I hypothesize that the public believes that drivers are becoming more aggressive and that their perception is that road safety is growing as a problem. This is based on the fact that while the economy is improving leading to more cars and more driving therefore driving accidents are also growing as a societal problem. This is fed by the public media that dramatizes automobile accidents as well as some behavioural aspects, like drunk driving. While this emphasis by the public media is constructive, if it makes highways safer, but it may lead to a misperception that fatalities caused by drunk driving are on the increase and cause the main safety problem, counter to factual data.

Specifically I hypothesize that the following perceptions have changed over that last several years:

- People believe that drunk driving is on the increase and it perceived to be the main variable contributing to the road safety problem in Estonia;
- Drivers are less likely to yield to pedestrian, because of intensive traffic and poor design of crossings;
- Pedestrians are less likely to help themselves (1) by crossing against traffic signals (2) not using reflectors, and (3) crossing the road on unsafe locations and situations;
- High speeds of the motor vehicles is a growing problem.

Since highway fatalities have declined substantially over the last ten years, to some readers these hypotheses may seem counter intuitive. If the public is well aware of the declining fatalities it may be difficult to persuade them, especially drivers that better driving habits are necessary. If we can accept the above listed hypotheses, then it indicates that Estonians should be receptive to programs and campaigns to improve highway safety and to encourage better driving behaviour.

Third part of the study is focused on one of the main road safety issues in Estonia — drivers' behaviour towards pedestrians, especially on urban non-signalized crossings. This remains one of the most dangerous locations, due to the official road accident statistics [Papers III and IV]. Here I have used a field-surveys approach, where the aim of the survey is to obtain data about driver's speed (i) and drivers' attitudes to yielding to pedestrians in the vicinity of pedestrian crossings (ii).

In this third part of the study I test the following hypotheses:

- Over time drivers are less likely to yield to pedestrians;
- Driver routinely exceed the safe speed near pedestrian crossings;
- Interaction of these two factors can cause especially high risk of non-signalized urban crossings, which is illustrated with accident statistics.

Again the same logic applies here as it does for the first set of hypotheses. I anticipate that if the hypotheses can be accepted it suggests that the public would be receptive to programs to improve highway safety.

The data collected for the survey contain international and national statistics from different databases:

1. International Road Traffic and Accident Database IRTAD (http://www.cemt.org/irtad/IRTADPUBLIC/irtaddatabase.htm)
2. European Union Road Federation (ERF) [ERF, 2006. European Road Statistics 2006. European Union Road Federation (ERF), International Road Federation (IRF), Brussels Programme Centre, June 2006.] (http://www.erf.be/section/european_transport_statistics)
3. European Commission, Directorate General of Energy and Transport, (http://ec.europa.eu/transport/roadsafety/index_en.htm)
4. United Kingdom, Department for Transport (http://www.dft.gov.uk/stellent/groups/dft_transstats/documents/sectionhomepage/dft_transstats_page.hcsp)
5. World Health Organisation WHO (http://www.euro.who.int/hfadb).
6. European Traffic Safety Council ETSC. European Transport Safety Council Road accident data in the enlarged European Union- Learning from each other. Brussels 2006.
7. US Department of Transportation DOT, National Highway Traffic Safety Administration, FARS database, 2003.

Estonian national road-safety data are held and published by the Estonian Road Administration:

8. 2005.aastal Eestis toimunud inimkannatanutega liiklusõnnetuste statistika. Maanteeamet, 2006 (http://www.mnt.ee/atp/?id=250)

Different **survey methods** have been used to prepare this manuscript.

For analysis of the road users' attitudes towards road-safety measures (Papers I and II), household interview surveys of LiMo-project data have been used. This project consists of a regular survey of road user's behaviour in Estonia, which contains both interviews and field surveys on certain road locations in Estonia. LiMo (acronym for '*Liikluskäitumise monitooring*' — Road user behaviour monitoring in Estonian) project was started in 2001 by the initiative of Estonian Road Administration, and the surveys conducted between 2001 and 2005 have been planned, data analysed and reports written by the author of this thesis, acting as a project manager. Reports of these surveys are available in LiMo reports [Stratum 2001; Stratum 2002; Stratum 2003; Stratum 2004a; Stratum 2005].

LiMo survey has two main parts. First is questionnaire with a sample of 1000 road users all over Estonia (age between 15 and 85). The similar sample size and main has been used for all surveys (pilot on 2001 and regular 2002–2005) in order to keep the comparability and reliability of data. The second part of the survey contains field surveys on urban and rural roads in Estonia, in order to survey road users' behavioural aspects, like yielding to pedestrians on urban non-signalized crossings, turning signal usage, daytime running lights usage, seat belt, pedestrian reflectors and child restraint usage, red signal infringements, etc. This information contains also data of safety behavioural aspects like drinking and driving and speeding, which have been collected from different sources.

In addition, data from the international survey SARTRE 3 (S3, Social Attitudes To Road Traffic Risk in Europe, volume 3) have been used [INRETS 2004, Cauzard, 2006]. SARTRE is an international drivers' survey containing more than 100 questions about travel habits and safety attitudes. Survey has been launched now three times, the last survey with Estonian participation took place in 2002–2004. Also here, an author of this thesis has been acted as a national project manager, responsible for the preparation of the study, data collection and first analysis, as well as international comparison and analysis of the data in two aspects- seat belts usage and drunk driving. S3 sample was at least thousand active drivers in each of participating countries. Estonian data was collected in 2002, and the sample contains information from 1002 active drivers (driving more than 200 km a year).

The data behind the papers III and IV have been collected mainly for the purposes of this study. The method for data collection is a field survey with two different approaches. The first approach was to collect data on drivers speed behavioural at the vicinity of zebra — crossings. The data were obtained in a special field survey that was designed to analyse data collected by monitoring real speeds and delays when driving with traffic on the urban streets. The specially equipped car, had a GPS receiver, video recorder and data storage devices, used the in-flow driving method at previously chosen routes in Tallinn. The car's speed and location was recorded every second while in motion. Later the location of non-signalized crossings on the chosen routes was assigned, and thus it was possible to survey actual driving speeds at the vicinity of zebra crossings. It is important to understand that situations involving waiting for crossing pedestrians (contacts) were eliminated from the survey this time, as the aim of the survey is to survey the speed behaviour at the crossing vicinity.

Each route was driven at least six times, mainly at off-peak hours, where speed choice was relatively free. In eliminating situations involving contact with pedestrians, the total number of measured situations was 120 at 29 crossings, at 24 of which the speed limit was 50 km/h, and at 5 crossings it was 70 km/h. The speed was measured at 4 locations in the vicinity of the crossing — at 100 m (coded as -100) and 50 m before the crossing (coded as –50), at the crossing (coded as 0) and at 50 m after the crossing (coded as +50) (III).

The second approach was to investigate drivers' behavioural aspects at zebra crossings with a clear obligation to yield. The field survey was conducted in the capital city, Tallinn, and some other bigger cities, at 16 crossings. The main goal of surveillance was to find which factors could affect drivers' attitudes to give way to pedestrians. The survey was conducted at the daytime, at off peak hours with different traffic and pedestrian volume during one-hour surveillance periods, twice in each crossing. The situation when there was a pedestrian or a group of pedestrians clearly representing their wish to cross the road. The determined parameters in the mentioned situations were: the sequence number of the motorist stopped at zebra crossing and thus giving way to pedestrian(s) counting started when pedestrian walked to the crossing and first motor vehicle approaching the crossing. Such situations were defined as contacts. Also some other background data like the number of pedestrians waiting to cross at same time (pedestrian group size), hourly pedestrian and motor vehicle traffic were determined [III].

3. THEORETICAL FRAMEWORK

3.1. Road accidents as the global public health problem

Road safety has long been considered one of the main worldwide social and public health problems. The problem of deaths and injury as a result of road accidents is now acknowledged to be a global phenomenon in all countries of the world concerned about the growth in the number of people killed and seriously injured on their roads.

Some recognized studies show that in 1990 road crashes as a cause of death or disability were by no means insignificant, but lying in ninth place out of a total of over 100 separately identified causes. However, by the year 2020 forecasts suggest that as a cause of death, road crashes will move up to sixth place and in terms of years of life lost and 'disability-adjusted life years' will be in second and third place respectively. [Murray et al 1996].

Change in rank order of disability-adjusted life years (a health-gap measure that combines information on the number of years lost from premature death with the loss of health from disability) for the 10 leading causes of the global burden of disease.

1990		2020	
Rank	Disease or injury	Rank	Disease or injury
1	Lower respiratory infections	1	Ischemic heart disease
2	Diarrhoeal diseases	2	Unipolar major depression
3	Perinatal conditions	**3**	**Road traffic injuries**
4	Unipolar major depression	4	Cerebrovascular disease
5	Ischemic heart disease	5	Chronic obstructive pulmonary disease
6	Cerebrovascular disease	6	Lower respiratory infections
7	Tuberculosis	7	Tuberculosis
8	Measles	8	War
9	**Road traffic injuries**	9	Diarrhoeal diseases
10	Congenital abnormalities	10	HIV

[Source: Murray et al 1996].

Every day around the world, more than 3000 people die from road traffic injury. Low-income and middle-income countries account for about 85% of the deaths and for 90% of the annual disability adjusted life years lost because of road traffic injury. About one person in 200 in the world's population dies from injuries received in traffic [Trinca et al. 1988].

It is expected by World Health Organization (WHO) that road traffic deaths will decline by about 30% in high-income countries but increase substantially in low-income and middle-income countries. Without appropriate action, by 2020, road traffic injuries are predicted to be the third leading contributor to the global burden of disease and injury [WHO 1999].

Traditionally considerable emphasis is placed on fatalities, the most serious consequence of traffic accidents. Fatality data are more complete than data on traffic injuries or material damages, and the internationally recognized definition of fatality involves less uncertainty than for any other type of losses. This is not to say that fatality data are free from uncertainties and errors.

Moreover, the solutions to improving traffic-related fatalities statistics, especially pedestrian fatalities, are not always easily formulated. In a study of Illinois' 102 counties (in the United States) a regression analysis of pedestrian fatalities for eleven years (1990–2000) did not suggest any obvious programs to promote pedestrian safety [Sööt et al. 2003]. Pedestrian fatalities were negatively related to the proportion of the population that is working and the proportion that is over 65 in age. In the latter case, perhaps as the senior population increases there are fewer walkers and the demographic changes in Estonia, with an aging population, may lead to improved statistics. Such cross-cultural observation, however, may not prove to be fruitful.

3.2. International comparison

The statistical report on road accidents in the European Conference of Ministers of Transport (ECMT) Member, Associate and Observer countries is available on 39 countries, namely Austria, Albania, Azerbaijan, Belgium, Belarus, Bosnia and Herzegovina, Bulgaria, Croatia, Czech Republic, Denmark, Estonia, Germany, Greece, Finland, France, Former Yugoslav Republic of Macedonia, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Moldova, the Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Slovakia, Slovenia, Spain, Sweden, Switzerland, Turkey, Ukraine, United Kingdom and Yugoslavia (Serbia and Montenegro) has been drawn up by the ECMT Secretariat who took over the activities of the Belgian Delegation to the Road Safety Committee, which was previously responsible for the preparation of the report, in collaboration with the Belgian Road Safety Institute (Brussels) [ECMT 2004].

The differences to be noted between countries as regards the number of killed (death within 30 days) per million populations do not necessarily mean that any given country's current road safety policy is better or worse. Such differences may also be attributable to the widely differing traffic conditions to which attention is drawn [OECD/ECMT 2006].

The trend observed the previous years was confirmed in 2001 with a drop of 5 percent of the number of fatalities, a drop of 3 per cent of casualties and a drop of 2 percent of the number of accidents causing casualties (Table 1). Motor-vehicle population, however, increased by 10 per cent, during the same period.

Table 1. Road accidents in ECMT countries, 1998–2001.

Year	Killed (death within 30 days)	Casualties (killed + injuries)	Accidents causing casualties	Motor vehicle population. [1]
1998	107 071	2 439 271	1 766 620	270 901
1999	105 205	2 460 758	1 783 125	280 244
2000	102 111	2 417 654	1 751 787	289 284
2001	101 855	2 365 896	1 724 117	297 633

[1] Motor vehicle population = cars, buses, coaches, vans, lorries, special road vehicles, road tractors, thousands.

ECMT countries cover too varied a range of geographical and socioeconomic factors (climatic and geographic conditions, composition of the road vehicle population, traffic engineering, presence of international and tourist traffic, density and quality of road system, quality of land use planning, population density, road user attitudes and behaviour, standard of living, etc.) for straightforward general comparisons.

An overall comparison of road risk levels can only be valid for countries with similar vehicle ownership ratios, i.e. number of motor vehicles per 1 000 population. Where car ownership ratios differ, the number of killed (death within 30 days) per million vehicles is an inadequate criterion for comparison because the curve plotted for deaths does not follow the same pattern as that for vehicles.

While the volume of traffic (number of vehicles/km) is a better indicator of the risk involved, the above observation also applies in this case. Moreover, the data are either not available or insufficiently reliable in many countries. The most valid of the criteria available for comparison is the number of killed (death within 30 days) per million populations.

Comparison of the data for population, surface area, motor vehicle population and number of killed for ECMT countries, the United States and Japan (Table 2) illustrates this.

Table 2. Road traffic data comparison between ECMT countries, USA and Japan [Data source: OECD/ECMT 2006].

2001	ECMT	USA	Japan
Population	801 140 000	285 318 000	125 035 000
Surface area, km^2	23 920 547	9 359 373	377 727
Motor vehicle population	297 633 000	221 230 000	75 186 000
Killed (death in 30 days)	101 855	42 116	13 078
Population density (per km^2)	33	30	336
Vehicles per 1000 population	372	775	592
Killed per million population	127	148	79
Killed per million vehicles	342	190	134

Several studies have estimated the cost of road traffic injuries in Europe. This is estimated to reach €180 billion per year in the countries of the European Union, twice the annual budget for all its activities, and to account for about 2% of the gross domestic product. Various studies done in the 1990s produced estimates of 0.5% of gross domestic product in the United Kingdom, 0.9% in Sweden, 2.8% in Italy and an average of 1.4% in 11 high-income countries. In the countries of central and Eastern Europe, the cost of crashes has been estimated to be about 1.5% of the gross domestic product, or US$ 9.9 billion. These differences are explained by differences between countries in the valuation of the costs of lives lost and of injuries and disabilities [Elvik 2002; Racioppi et al. 2004].

3.3. International targets

The development of sustainable transport policies implies reconciling environmental, social and economic objectives and will require further improvement on a wide range of fronts for inland transport.

Death and injury from accidents are the most important issue in making transport systems more sustainable. Current rates of death and injury from road accidents are regarded as far from acceptable by governments even in countries at the forefront of road safety. Accident rates in other modes, though much lower are still not regarded as acceptable [ECMT 2005].

The worrying number of accidents and their social and economic consequences led the ECMT Council of Ministers, in Bucharest in 2002, to unanimously adopt a common quantitative objective for all ECMT Member countries. ECMT Ministers of Transport adopted the target of a 50% reduction in the number of victims killed in road traffic accidents by 2012 in comparison with 2000. Subsequently, the European Commission set a target for EU Members of reducing by 50% the number of road fatalities by the year 2010 compared to 2000 [CEC 2001.]

3.4. National targets

Some countries have adopted national targets rather than ECMT targets and still others have adopted both ECMT and national targets (Table 3). Most countries have targets for fatalities, while a few countries such as Canada, Great Britain, and Hungary have targets for injuries, as well as fatalities. Some countries have only overall national targets, while others have sub-targets as well. There are also differences in what measure is used. Some countries have targets based on the percentage change in absolute numbers of fatalities and/or injuries, while others have adopted targets based on percentage change of fatality/injury rates using some measure of exposure (e.g., population, vehicle distance travelled). Furthermore, some targets are short-term (e.g., to be achieved in five years), whereas others are longer term (e.g., by 2014 or later).

Table 3. National road safety targets. [OECD/ECMT 2006].

Country	National target
Australia	–40% in fatalities per 100 000 population by 2010 compared to 1999
Austria	–50% fatalities by 2010 compared to 1998–2000 Other specific targets
Belgium	–50% fatalities by 2010 compared to 1998–2000
Bulgaria	–50% fatalities by 2010 compared to 1991–2004
Czech Republic	–50% in fatalities by 2010 compared to 2002
Denmark	–40% fatalities and seriously injured by 2012 compared to 1998
Estonia	Less than 100 fatalities by 2015
Finland	Less than 250 fatalities by 2010
Greece	–50% fatalities by 2010 compared to 2000
Hungary	–50% fatalities and injury accidents by 2015 compared to 2001
Iceland	Fatalities per 100 000 population should not be higher than the best performing countries by 2016 –5% reduction every year in killed and seriously injured casualties
Ireland	–25% fatalities by 2006 compared to 1998–2003 several sub targets
Latvia	–50% fatalities and –20% injured persons by 2006 compared to 1999
Lithuania	–50% fatalities and –20% injury accidents by 2010 compared to 2004
Malta	–50 % fatalities and –50% injury accidents by 2014 compared to 2004
Netherlands	Less than 580 fatalities by 2020. Several sub targets
Norway	–30% killed and seriously injured by 2015 compared to 2004.
Poland	Less than 3500 fatalities in 2010 (compared to 5640 in 2003, ie –38%)
Portugal	–50% fatalities by 2010 compared to 1998–2000 Several sub targets
Romania	–50% fatalities by 2012 compared to 2002.
Slovakia	–50% fatalities by 2010 compared to 2002.
Slovenia	–50% fatalities by 2005 compared to 1995. Several sub targets
Spain	–40% fatalities by 2008 compared to 2003.
Sweden	–50% fatalities by 2007 compared to 1996
Switzerland	–50% fatalities and –50% seriously injured by 2010 compared to 2000.
United Kingdom (Great Britain)	–40% in fatalities and serious injuries. Several sub targets

3.5. Breakdown of casualties by road user category

Adding together the number of killed and casualties by road user category respectively for the 30 ECMT Member countries listed below[1], for which this breakdown is available for 2001, we can obtain the following figures:

Table 4. Number and percentage of casualties between road user groups.

2001	Killed (number and percentage)		Casualties (killed+ injuries)	
Pedestrians	27 478	29.4%	316 750	13.8%
Bicyclists	5 015	5.4%	163 921	7.1%
Moped drivers	2 444	2.6%	149 608	6.5%
Motor cyclists	7 727	8.3%	174 768	7.6%
Car drivers	26 376	28.2%	814 274	35.4%
Car passengers	17 688	18.9%	521 354	22.7%
Others	6 776	7.2%	156 885	6.8%
Total	93 504	100%	2 297 560	100%

[1] Listed 30 countries: Austria, Belgium, Bulgaria, Switzerland Czech Republic, Germany, Denmark, Spain, Estonia, France, Finland, Hungary, Croatia, Italy, Luxembourg, Lithuania, Latvia, FYR of Macedonia, Norway, the Netherlands, Portugal, Poland, Romania, Russia, Sweden, Slovenia, Turkey, Ukraine, UK, Yugoslavia.

The greater proportion of serious accidents occurs in urban areas. Roads in built-up zones display an accident rate up to three times greater than in other road categories. Pedestrians and cyclists are especially vulnerable, and 95 per cent of pedestrian accidents in Britain are recorded in urban areas, with one-half of these occurring in town centres [Hoyle and Knowles 2001].

4. ESTONIAN SITUATION

4.1. Recent development

One of the main factors contributing to the increase in road crash injury is the growing number of motor vehicles. While the motor vehicle and road infrastructure has brought social benefits, it has also led to societal costs to which road traffic injuries have contributed significantly [WHO 2004]. Since 1949 the original paper by Smeed [Smeed 1949], several studies have shown a general correlation between motorization and the number of road crashes and injuries [Rumår 2003; O'Flaherty 2005].

Estonia is a good example. Motorization has been very rapid in Estonia, as well as in other transforming countries; the relatively low population density of Estonia has been conducive to developing a roadway system that can still accommodate large numbers of vehicles.

Motorization has tripled in last twenty years. In 1986 there were 123 cars per 1000 inhabitants (188.5 thousand cars for 1.53 million people). When trucks, buses, and motorcycles are included, this ratio reached 157. By 2005 (Figure 1) the car ratio reached 367 and 435 for all motor vehicles (per 1000 inhabitants).

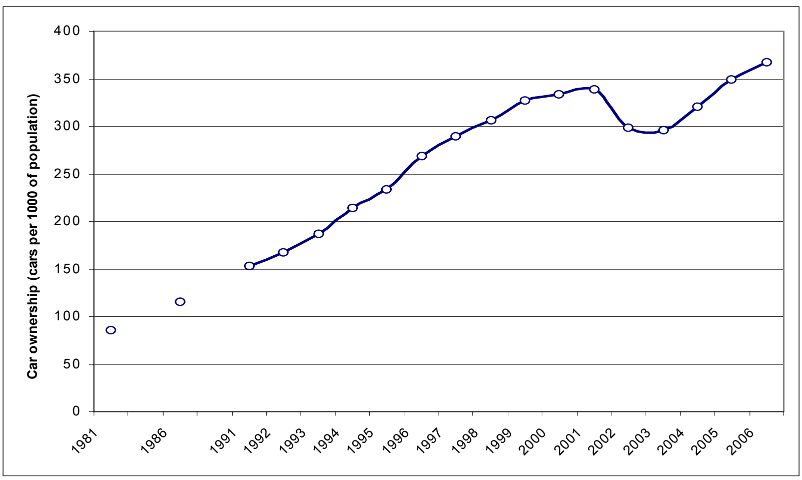

Figure 1. Estonian car ownership development (1980–2006).
Data source: Estonian Motor Vehicle Registration Center (ARK) [http://www.ark.ee/atp/?id=197#]

Please note that some reduction in motorization (2002–2003) is mainly statistical, as ARK decided to eliminate from the registration database motor vehicles which were not actually in use.

As the degree of motorization increases, there is a decrease in the number of deaths per registered vehicle and per population (Figure 2); the largest rate in Figure 2 is three times the smallest.

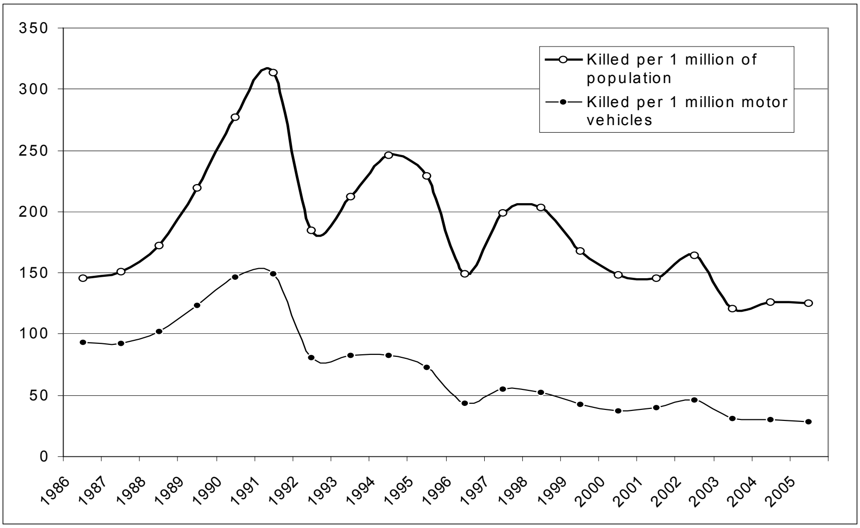

Figure 2. Changes in the number of traffic deaths per motor vehicles and population in Estonia, 1986–2005.

Even when there is a general trend of decreasing road fatalities, the number of injuries is still increasing (Figure 3).

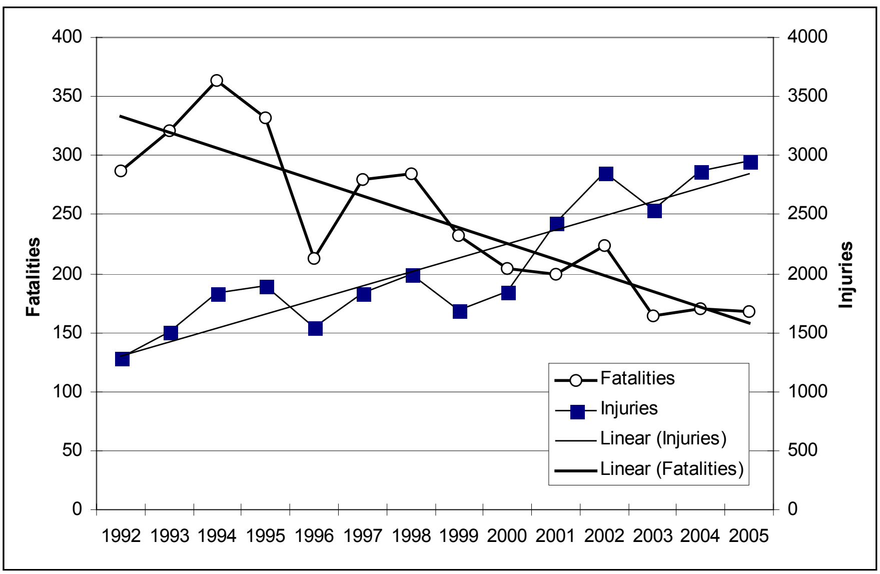

Figure 3. Registered data and trend lines of road fatalities and injuries in Estonia.
This could be explained by a number of factors:

– Some under-reporting of especially slight injuries in Estonia. As there is no formal definition of slight and severe injury in use in Estonia, it is hard to explain it in formal terms anyway. But some analysis can show that the injury / fatality ratio is much lower than in western European countries (Figure 4), but development trend is found by the author to be similar [Stratum 2004 b]. The under-registration of some types of road accidents is a problem in many countries. A 1991 review on under-reporting studies worldwide included studies from the UK, USA and Canada that reported complete coverage of road crash fatalities while in Germany 5…9 per cent of road crash fatalities were not reported to the police [James 1991]. A 1994 International Road Traffic and Crash Database (IRTAD) Special Report on the under-reporting of road traffic crashes quoted studies indicating a 3 percent level of fatality under-reporting in Spain and 2 percent in Switzerland [IRTAD 1994].

– There is a clear trend of decreased severity of accidents in Estonia. It is explained by improving motor vehicle fleet, and infrastructure development, involving an introduction of a number of passive and active safety measures.

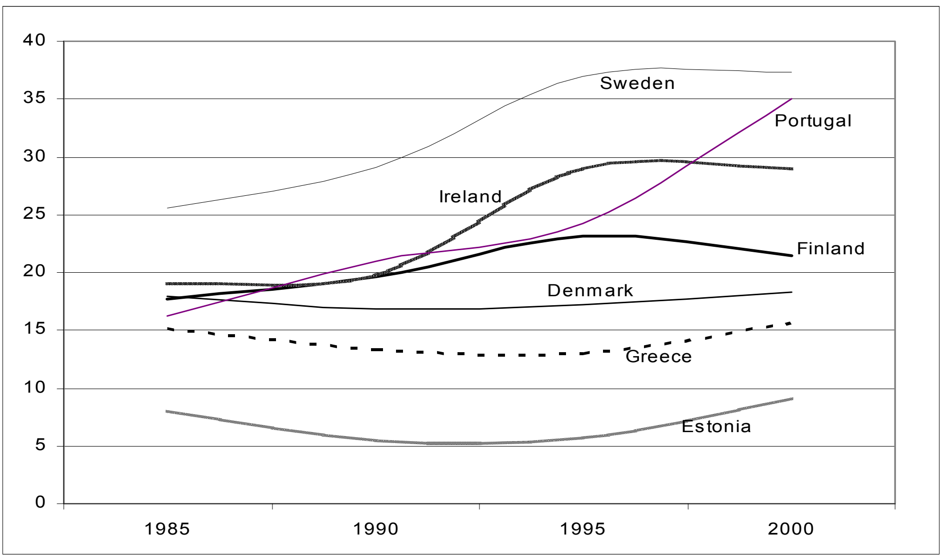

Figure 4. Injury/fatality ratios in some European countries, 1985–2000

In spite of positive trends in the number of fatalities, Estonia remains among the worse performing countries in enlarged European Union and Estonian national indicators are worse than EU average (Table 4).

Table 4. Road fatalities country rankings — 2003 [ERF 2006].

Country	Per million of population	Country	Per 100 mill.pkm[1]	Country	Per 100,000 passenger cars
Malta	40	UK	54	Malta	77
Sweden	59	Sweden	54	Sweden	130
UK	61	Finland	63	UK	136
Netherlands	63	Netherlands	69	Denmark	148
Finland	73	Denmark	70	Netherlands	149
Germany	80	Germany	76	Finland	167
Denmark	80	Italy	78	Italy	177
Ireland	84	France	81	Luxembourg	181
France	101	Luxembourg	86	France	206
EU-25[2]	***103***	***EU-25***	***102***	***EU-25***	***220***
Italy	105	Malta	103	Ireland	224
Austria	115	Belgium	110	Denmark	228
Belgium	117	Austria	111	Austria	230
Luxembourg	118	Ireland	139	Belgium	252
Slovakia	120	Spain	153	Portugal	257
Estonia	**121**	Slovenia	154	Slovenia	272
Slovenia	121	Portugal	156	Spain	289
Spain	130	**Estonia**	**162**	Cyprus	321
Hungary	131	Czech Rep.	202	**Estonia**	**378**
Cyprus	134	Greece	235	Czech Rep.	390
Czech Rep.	142	Slovakia	251	Greece	418
Greece	146	Hungary	280	Hungary	477
Portugal	148	Cyprus	293	Slovakia	476
Poland	149	Poland	323	Poland	506
Lithuania	205	Lithuania	360	Lithuania	564
Latvia	229	Latvia	517	Latvia	820

[1] pkm — Annual passenger km of cars and motorized two wheelers.
[2] Average of European Union 25 member states after enlargement.

Fortunately Estonia has achieved a better road-safety record than its southern neighbours Latvia and Lithuania. Still it is much behind its Nordic neighbours, Sweden and Finland. Baltic countries have made substantial progress since 1988, as the number of fatalities per 10 000 motor vehicles have been reduced from 9.6 to 3.7 in Estonia, 19.5 to 9.1 in Latvia, 15.3 to 5.0 in Lithuania and 3.2 to 1.6 in Finland, but the differences between Baltic and Nordic countries have remained too large.

In the United States motor vehicle fatalities per million passenger kilometres have declined since 1945 by 50% every twenty years. If a fixed exponential decline such as this can be applied to the data in the previous paragraph then there is some sense of how long it may take to achieve the data characteristic other Nordic nations.

With motorization not only does the number of fatalities change, but also the types of fatalities. In the USA, 12.2% of all 2002 fatalities were pedestrians [US DOT, National Highway Traffic Safety Administration, FARS database, 2003].

In only few countries, Canada and the Netherlands as examples, do pedestrian fatalities constitute so low a fraction of all fatalities as this. In many countries the percentage of fatalities that are pedestrians is much higher (for example, 35% in the UK, 42% in Poland, 45% in Israel, and 60% in Hong Kong) [Hutchinson 1987].

The fatality risk of pedestrians, car passengers and drivers in the Baltic countries, including Estonia are much bigger than in countries with good safety performances such as Finland (Figure 5). Especially some road accident types like vulnerable road users' (pedestrians and cyclists) accident and single vehicle accidents on rural roads are predominating in Estonia. There are different explanations on that. One is relatively low rates of passive safety equipment usage, like seat belts [V] or child restraints, which causes high severity of accident results in case of crash happens. Secondly, it is also evident that the most disconcerting data describe the disparity in pedestrian fatalities. It can be seen in both Figure 5 and Table 5 that the Estonian pedestrian data are three times higher than in Finland. Clearly pedestrian safety and more effective use of safety equipment [V] need to be a key part of programs designed to lower fatality rates.

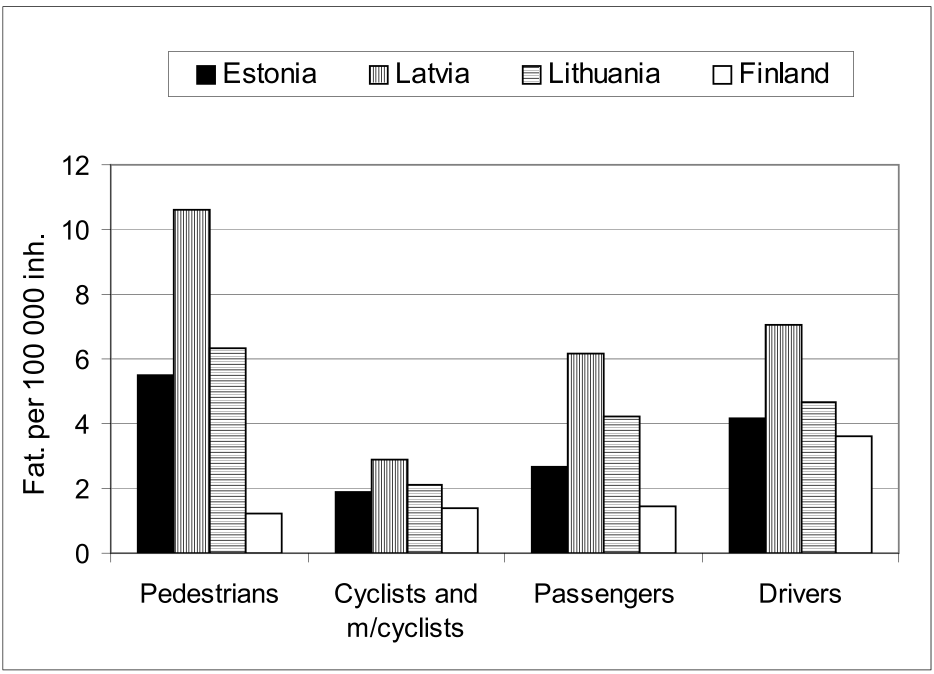

Figure 5. Number of fatalities per 100,000 of population by road user groups, 2000. [Pihlak, Antov, 2002]

Table 5 shows that pedestrians account for a remarkably high proportion of all road fatalities. If one assumes the position that programs to address pedestrian fatalities are easier to implement than addressing strictly driver behaviour, then there is substantial potential to decrease road-related fatalities. These potential programmes are discussed in a subsequent section.

Table 5. The share of road accident types (%) in Estonia, Latvia and Finland. [Pihlak, Antov 2002]

Road accident type	Estonia	Latvia	Finland
Single vehicle accident	32.8	24.7	25.3
Accident between motor vehicles	15.2	19.5	49.0
Accident with mopeds or cycles	10.8	8.2	
Collision with obstacle	1.0	6.9	12.4
Pedestrian accident	38.7	39.7	13.3
Other types	1.5	1.0	
Total	100	100	100

4.2. Estonian National Road Safety Programme

As the road safety situation was alarming and after discussions, Estonian Parliament accepted the Estonian National Road Safety Programme at May 28, 2003. This target was set by a group of road safety specialists covered by the initiative of the Estonian Road Administration. Estonian National Traffic Safety Programme declares that in 2015 the number of fatalities should be decreased to 100 [Estonian Road Administration 2002].

The target of less than 100 fatalities annually was first proposed by an Estonian team, participating at the international road safety training programme in Sweden, at 1997. [Antov et al, 1997]. Later, different experts have proposed their scenarios of fatalities development, but in the final version of National Traffic Safety Programme this target was set as an official vision.

Accepting the target of 50% reduction of road fatalities Estonia follows the main line of road safety development targets, set by other EU countries as well as recommendations of European Commission of halving the number of road fatalities.

Estonian National Road Safety Programme highlights some road user groups, which are under risk today. These are based on accident statistics and analysis:

- Pedestrians and bicyclists;
- Children and elderly road users;
- Motor vehicle drivers with less experience.

The pedestrian road safety risk and the need of improvement pedestrian safety in Estonia have been put in one of the most important measures in this programme.

5. BEHAVIOURAL AND SAFETY ASPECTS OF VULNERABLE ROAD USERS

5.1 Road accidents involving pedestrians

The relatively higher risk of vulnerable road users, such as pedestrians and riders of two-wheelers is an additional traffic safety burden. It also contributes to nationally different shares of vulnerable road user categories in the traffic volume to the unequal distribution of road safety among European Union Member States. New Member States, including Estonia, have the highest percentage of pedestrian deaths, whereas the respective percentage of riders of motorised two-wheelers is still very low [ETSC 2006], although there are alarming signs for the future development.

The share of pedestrian accidents remains high and the number of casualty (fatal or injurious) accidents has regrettably increased since 1997 (Figure 6), especially in urban areas. Walking is a necessity. Walking or cycling, together with public transport, provides the main means of moving independently for a range of social groups including:

- Children and young people who are not qualified to drive a car;
- Adults accompanying smaller children;
- Elderly people who are less able or less inclined to use the car;
- Many wheelchair users; and
- People who are denied or choose not to have access to private motor vehicles.

Due to the statistics these groups constitute for the biggest risk of road accidents.

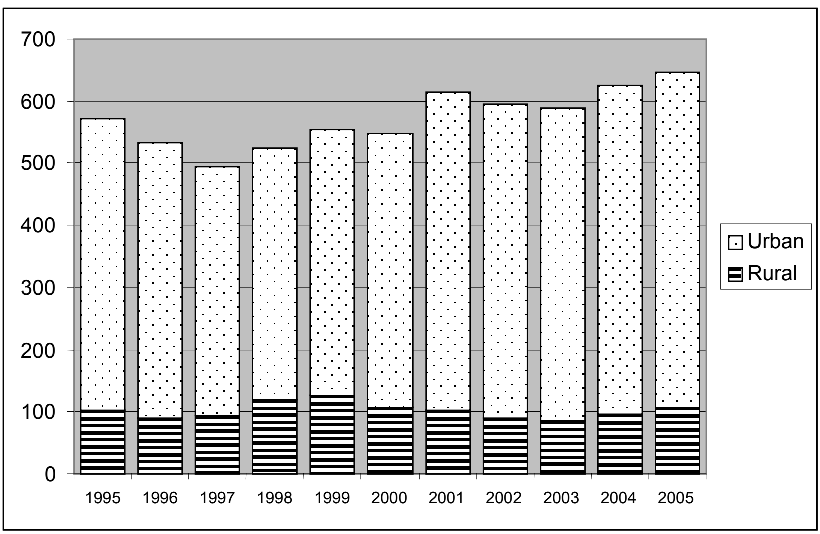

Figure 6. Pedestrian casualty accidents in Estonia, 1995–2005.

Fortunately the proportion of pedestrians remains relatively stable at between 25–35 per cents of all persons killed in road crashes in Estonia (Figure 7). As fatality numbers decline this is a hopeful sign of the future.

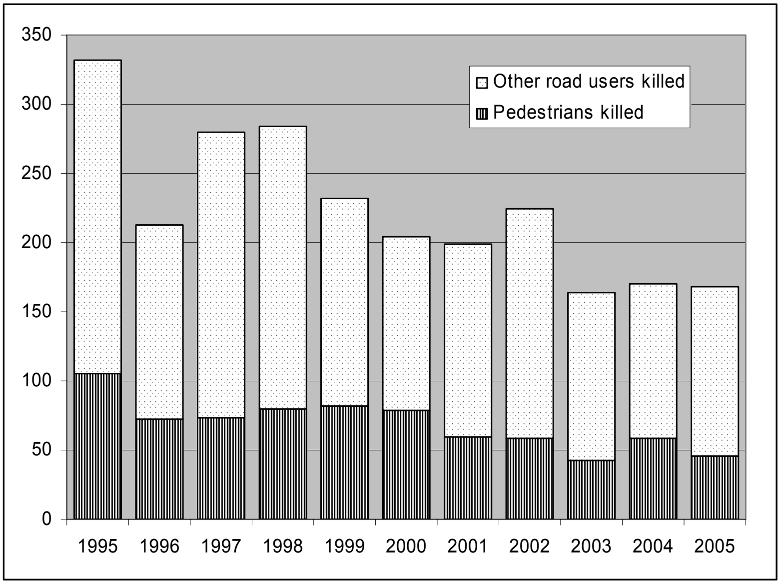

Figure 7. Pedestrian proportion of road victims in Estonia.

But when accounting the proportion of children road casualties, we get that 40…45% of fatalities and injuries involve young pedestrians, which is the biggest share, followed by passengers of motor vehicles and cyclists (Table 6). Similar is with elderly road users, where pedestrians proportion of casualties is 55…65%.

Table 6. Proportion of road user types involved in accidents among children up to 15 years old (average of 2001–2005).

	Motor vehicle driver	Pedestrian	Cyclist	Moped driver	Passenger	Others
Fatalities	2%	45%	12%	2%	38%	2%
Injuries	2%	41%	13%	3%	41%	0,2%

The pedestrian road traffic risk problem is common to many countries. These result from a complex of factors, but underlying all other problems is the fact that the modern traffic system is designed largely from a car-user perspective. There has been a lack of coherent planning of route networks for pedestrians and cyclists.

The key factors of pedestrian safety could be highlighted as follows [ETSC 1999]:

- ***Vulnerability*** Even at relatively low impact speed, pedestrians receive severe injuries, mainly because their only protection is their clothing.
- ***Flexibility*** Pedestrians are very flexible in their behaviour and flexibility is one of the main advantages as well as disadvantages of these modes. A motor vehicle driver can never be sure when or where to expect a pedestrian or a cyclist.
- ***Invisibility*** Pedestrians and cyclists can be difficult to see: they are small compared to a car, and can be hidden by one. At night the problem is more severe.
- ***Differing abilities*** Pedestrians and cyclists include children with lack of experience, elderly people with reduced capability, and people with reduced mobility.
- ***Consciousness of effort*** Making a detour for pedestrians and cyclists means extra use of their muscle power. They are therefore highly motivated to find and keep to the easiest routes, often the most direct ones.

5.2. Safety at crossings

Junctions and crossings are places where many pedestrians need to cross the road despite the risks in doing so, and in Tallinn, for example, over 20 per cent of pedestrian crashes occur at non-signalised crossings. This ranks second in road elements after straight street sections, which includes the locations at the vicinity of crossings as well (Figure 8). Safe layout and sharing of the road space with the help of signs, markings and distinctive surfacing can simplify the tasks facing pedestrians and cyclists at junctions and thus reduce casualties.

Pedestrian crossings are perceived to be safe places to cross the road, although this is not necessarily the case. While crossings give some protection to the young and elderly, many crashes occur in their vicinity: the 50m either side of a crossing is particularly dangerous. Dropped kerbs at crossings assist those with physical impairments while tactile surfaces help those with visual impairments. Refuge islands or a continuous central reservation provide help in crossing.

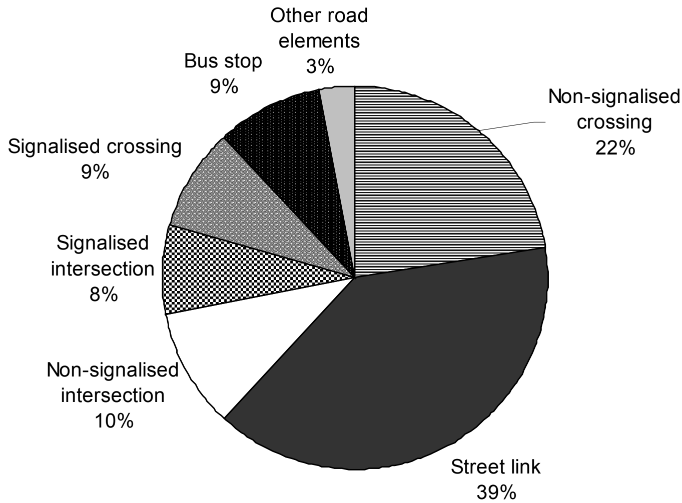

Figure 8. Location of pedestrian accidents in Tallinn, 2002–2005.

Zebra crossings are also often used because of their relatively low cost. Signalised pedestrian crossings can improve safety especially on higher speed or high traffic level roads [Jensen, 1998]. The choice of facility to provide will depend upon local circumstances.

Speed plays an important role in determining the severity of the outcome of collisions. If the collision speed exceeds 45 km/h the likelihood for a pedestrian or cyclist to survive the crash is less than 50 per cent. If the collision speed is less than 30 km/h more than 90 per cent of those struck survive [Nilsson 1993]. Speed management, therefore, is a key element in a safe traffic system for vulnerable road users.

6. BEHAVIOURAL AND PERCEPTUAL ASPECTS OF ROAD USERS

This section of the study tests the hypotheses and interprets the results. It begins with the perception of the public regarding road use. It then proceeds to report the results of the field data collected on actual driver behaviour.

6.1. Data on public perception of driver behaviour

An important initial step in implementation strategies to achieve the national goal of decreasing the number of motor vehicles fatalities in half is determining how the general public feels about current road-use behaviour and how it has changed in recent years. To this end a number of regular surveys have been designed and administered that included questions about the subject's perception of road-use behaviour and how conditions have changed during the last year [I, II].

The subjects were asked about mandatory circumstances covered by national traffic laws including:

- Daytime headlight use;
- Turning signal use;
- Yielding to pedestrians in zebra-crossings;
- Red-signal adherence (by pedestrians and drivers) at signalized intersections and crossings;
- Drinking and driving;
- Speeding (urban and rural roads);
- Seat-belts use (front and rear seats);
- Child-restraint use;
- Use of reflectors by pedestrian on rural roads.

Table 7. The average scores for the questions asked, 2002–2005 [Stratum 2005]

Year	2002	2003	2004	2005
Drinking and driving	1.90	1.72	1.80	2.13
Usage of pedestrian reflectors	2.29	2.17	2.15	2.17
Usage of seat belts, back seat	2.21	2.17	2.04	2.20
Speeding on rural roads	2.43	2.48	2.41	2.39
Speeding on urban streets	2.84	2.96	2.83	2.81
Yielding to pedestrians at non-signalized crossings	3.18	2.91	2.98	2.94
Red signal infringement by pedestrians	3.17	3.06	3.02	2.97
Turning signal usage	3.44	3.54	3.40	3.29
Usage of child restraint systems	3.56	3.25	3.48	3.32
Red signal infringement by drivers	3.50	3.51	3.62	3.59
Usage of seat belts, front seat	3.62	3.61	3.68	3.68
Daytime running lights usage	4.22	4.21	4.25	4.14

* Subjects were asked to rate the adherence to the listed items and their responses were assigned the following point values: 1 – poor, 2 – unsatisfactory, 3 – satisfactory, 4 – good and 5– very good.

Public perception of Estonian drivers has also studied in SARTRE3 survey at 2000. 1002 active drivers were questioned about a number of road safety issues in this questionnaire. When looking at results of this survey, drunk driving is also looked as the main cause of road crashes in Estonia (Table 8).

Table 8. Public perception towards listed causes of road accidents. [Cauzard, 2006].
How often do you think each of the following factors is the cause of road accidents?

	Per cent of answers: often, very often or always
Drinking and driving	97,3
Driving too fast	91,4
Following too closely to vehicle in front	81,4
Poor brakes	71,7
Bad weather conditions	70,9
Taking drugs and driving	68,0
Poorly maintained roads	64,8
Driving when tired	61,8
Bald tyres	61,4
Defective steering	52,1
Faulty lights	30,2
Taking medicines and driving	29,2
Using a mobile phone (handy) and driving	23,8
Using a mobile phone (hands free) and driving	18,6
Traffic congestion	4,2

6.1.1 Perception of drunk driving

The data in Table 7 indicates that while the level of perception is very low, at a level of approximately two throughout the study and the lowest of the twelve measures, there is actually a perceived improvement over time. I therefore cannot accept the first part of the hypothesis, that the perception is that drunk driving is getting worse.

Regarding the second part of the hypothesis that drunk driving is the biggest problem among the twelve items the data generally support the hypothesis. Specifically, however, in 2005 the 2.13 value in Table 7 is the lowest of the twelve variables but it is not statistically lower than the 2.17 values for 'usage of pedestrian reflectors.' The drunk driving variable is clearly statistically significant for each of the other three years, 2002, 2003, 2004, and perhaps 2005 is an exception.

Overall it is clearly that there is room for improvement even though the perception improved in 2005. Still, drink driving is likely the most serious violation of the twelve items tested and with the very low scores in Table 7 it is important to address this problem directly and effectively. According to national statistics [Maanteeamet 2006] the share of drunken driving casualty accidents has decreased, with the annual number remaining near 400 a year (Figure 9).

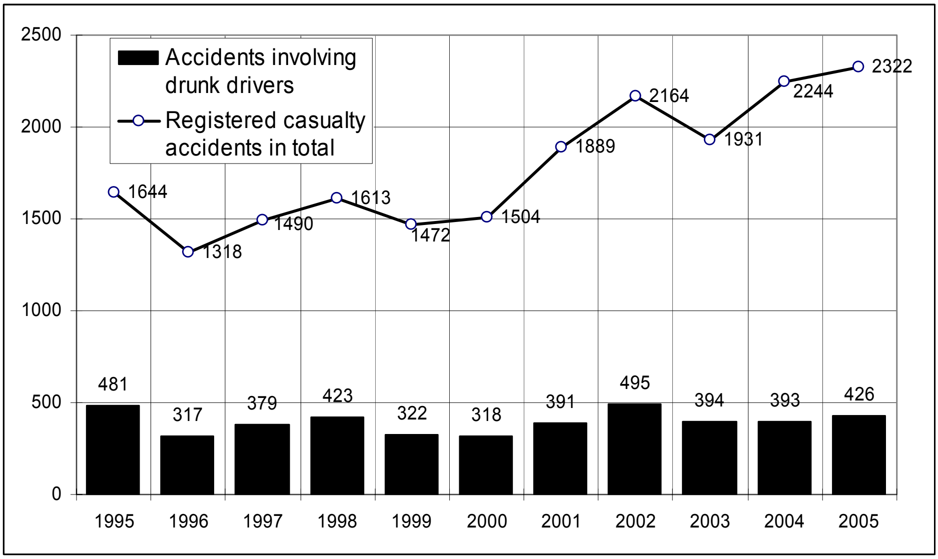

Figure 9. Registered casualty accidents and accidents involving drunk drivers in Estonia.

Further, since driving under the influence (alcohol) has the lowest marks in Table 7, the burden tends to shift to other road users especially pedestrians. The recognition of the drunk-driving problem makes it imperative for road users to be vigilant, especially in the evening hours and other periods when driving under the influence is most prevalent.

6.1.2. Perception of yielding to pedestrians

The perception of drivers giving way to pedestrians at urban non-signalised crossings has been ranked below the 'satisfactory' level of listed mandatory safety measures since 2003. In the first survey it was above the minimum satisfactory at 3.18 but it dropped below 3.0 during each of the subsequent years and was a 2.94 in 2005. More importantly our hypothesis of declining values can be supported at the 0.01 level of significance. This subject is described in greater detail in papers III and IV.

6.1.3 Perception of behaviour by pedestrians

Pedestrians also have an important role in traffic safety. They must be vigilant to their environment and remain alert to vehicular traffic in their vicinity. They should also obey traffic rules and ensure their safety by wearing reflectors at night. On the first point Table 7 shows that the hypothesis that pedestrians are perceived to be less and less obedient to traffic signals is supported. The perception level has steadily dropped from 3.17 in 2002 to 2.97 in 2005.

On the second point of using reflectors I can also accept the hypothesis. Over time the perception that pedestrians use reflectors has also declined from 2.29 in 2002 to 2.17, though the big drop was in the first year (2002–2003). These two hypotheses can be accepted at the 0.01 confidence level.

The two hypotheses confirm that pedestrians are perceived to be contributing to a deteriorating highway safety environment. It is not only drivers that should be targeted in a safety program but also pedestrians.

6.1.4 General observations

Perhaps the most enlightening aspect of the data in Table 7 is that very few scores are improving over time. Only three of the twelve items tested show improvement (Table 9). Since we know that the number of fatalities is decreasing there seems to be a disconnect between perception and reality. It is encouraging that the respondents do not believe that the situation is improving, especially if this makes them more alert as they travel. Perhaps the past campaigns to make highways safer and the dramatic news of highway fatalities is raising the public awareness of the necessity of improve road behaviour and that future campaign could further be productive.

Table 9. Summary of statistically significant difference from 2002 to 2005

Difference	Improving	No statistical difference	Becoming worse
Number of variables	3	3	6

Another point of concern among the subjects tested is the low values for many items tested. Seven of the twelve variables have average scores less than three, the level associated with a ‘satisfactory’ response. Further only one item scores above four, daytime use of headlights. It may also be the variable that is least associated with improving highway safety.

6.2 Analysis of Drivers

In this section I examine actual driver behaviour rather than public perception as in the previous section. The data for this comes from a field survey of drivers. During the last five years regular field surveys about drivers' behaviour at urban non-signalised crossings have been carried out. These surveys have used similar methods of surveillance (video recording, fixed locations, and similar observance period) [III]. Each year we collected data on approximately 1300 drivers at about 18 locations. The data was collected in approximately 35 hours over 60 workdays under possibly similar traffic conditions.

Two aspects of potential risk are studied here. First are drivers giving way to waiting at the kerbside pedestrian. Even though the law demands drivers stop and yield at crossings, it is often broken by drivers and this contributes to accidents. Second vehicle speeds in the vicinity of non-signalised crossings. As speed play an important role in the seriousness of potential accident damages, this is highly important to clarify the main aspects of drivers' speed behaviour.

6.2.1 Drivers attitude to give way

Drivers are obligated to yield to pedestrians when they are in or noticeably approaching a crosswalk. Our field work shows that in sixty percent or more of the cases observed the drivers ignored their obligation (Figure 10). The difference between 2005 and 2002 is not significant.

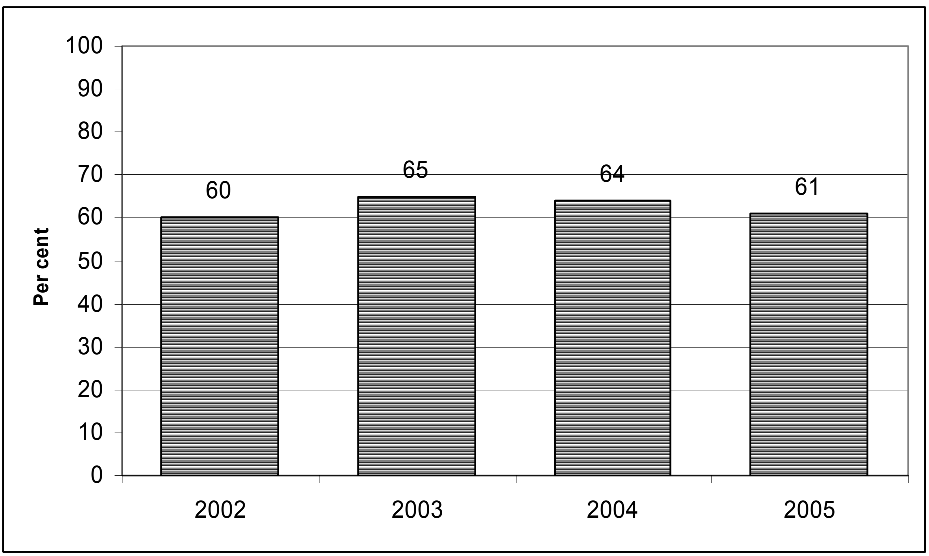

Figure 10. Proportion of drivers ignoring the obligation to give way at non-signalised urban pedestrian crossings.

This proportion is calculated as a per cent of situations, where the driver in a clear view of the crossing has to choice between stopping and yielding or passing. As can be seen, 60 to 65 per cent of such cases, drivers do not stop and yield, in spite of traffic rules [Stratum 2005]. The situation of the last three years is improving, but with clearly over fifty percent of the drivers ignoring the rule to yield, this needs immediate attention. Either the law needs to rewritten or it must be better enforced. It is rarely good to allow drivers to routinely disregard driving laws.

The test of the hypothesis that drivers over time are less likely to yield does not need to be applied since the difference between 2002 and 2005 is no effective. While the hypothesis is not accepted, the fact that the proportion is over sixty percent in each of the years indicates that this remains a problem. The use of these data could potentially be used in a campaign to educated drivers about their responsibility to yield to pedestrians.

6.2.2 Drivers' speed choice

Previous surveys indicate that the safety effects of zebra crossings depend upon the speed of vehicular traffic and the quantity of traffic. It is thus important to determine vehicular speeds at crossings, but especially if the crossing itself has any influence on drivers speed choice when approaching the crossing [III].

I analysed data at these crossings to test our hypothesis that drivers routinely exceed the speed limits near pedestrian crossings. The main results of data analysis are presented as follows:

1. The average speeds at crossings are rather high. At almost 60 per cent of runs the speed was higher than a speed limit. Only at 12 per cent of runs the speed was less than 40 km/h. The situation was especially dangerous at crossings were the speed limit of 70 km/h is allowed. The smallest measured speeds were between 55 and 60 km/h! These data support our hypothesis.
2. The change in speed at the vicinity of zebra crossing is minor. When comparing average speeds of different runs at the vicinity of zebra crossings I got a picture as shown on Table 10.

Table 10. Average speed at the vicinity of pedestrian crossings, km/h [III].

Speed limit	Speed, km/h	Distance to crossing, m			
		–100	–50	0	+50
		Recorded speed			
50	Average	47.2	45.7	44.6	44.7
	Max	63.0	56.1	55.1	56.5
	Min	32.4	27.7	27.1	15.6
70	Average	70.1	70.4	69.9	70
	Max	77.4	78.1	78.1	78.5
	Min	60.8	60.2	57.6	57.6

3. When comparing speeds at 100m to the crossing and at crossing only in 59 per cent of cases the speed at crossing was less than at 100m distance.
4. Braking, if ever, starts near the crossing. After passing the speed comes regularly up again in a very short distance after zebra crossings. The typical speed change at the vicinity of crossings is illustrated at the Figure 11.

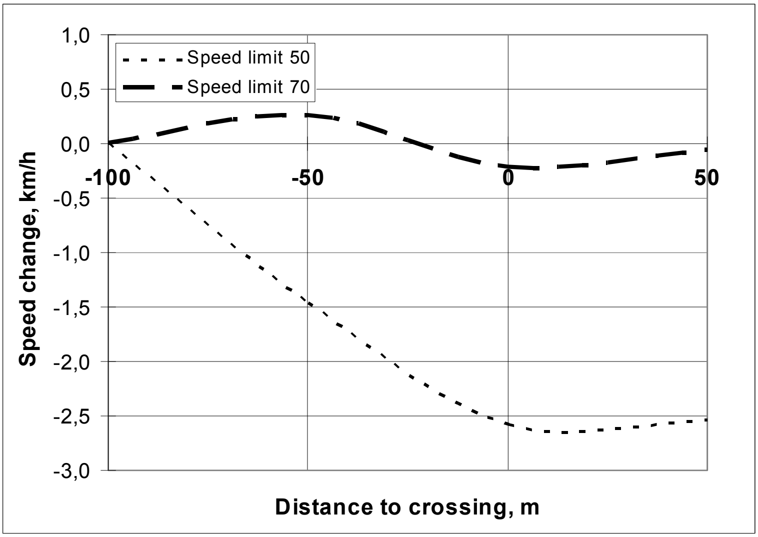

Figure 11. Typical speed change at the vicinity of crossings [III].

5. The situation is especially critical at the crossings with speed limit of 70 km/h. On these sites an average speed is dangerously high throughout the vicinity of the zebra crossing and does not allow braking safely when driver observes the pedestrian waiting at the roadside. Thus these sites do not follow the traffic rules of giving way and should be discarded or replaced by signalized ones.
6. The fact that high speeds in urban areas in Estonia are often used is also supported by SARTRE3 survey of active drivers. When comparing the data of 21 participating in these survey countries, we can found that Estonian situation is perceived among the most critical. The data of figure 12 shows the proportion of drivers answering to the question: *In general, how often do you drive faster than the speed limit in built-up areas?* as often, very often or always [Cauzard 2006].

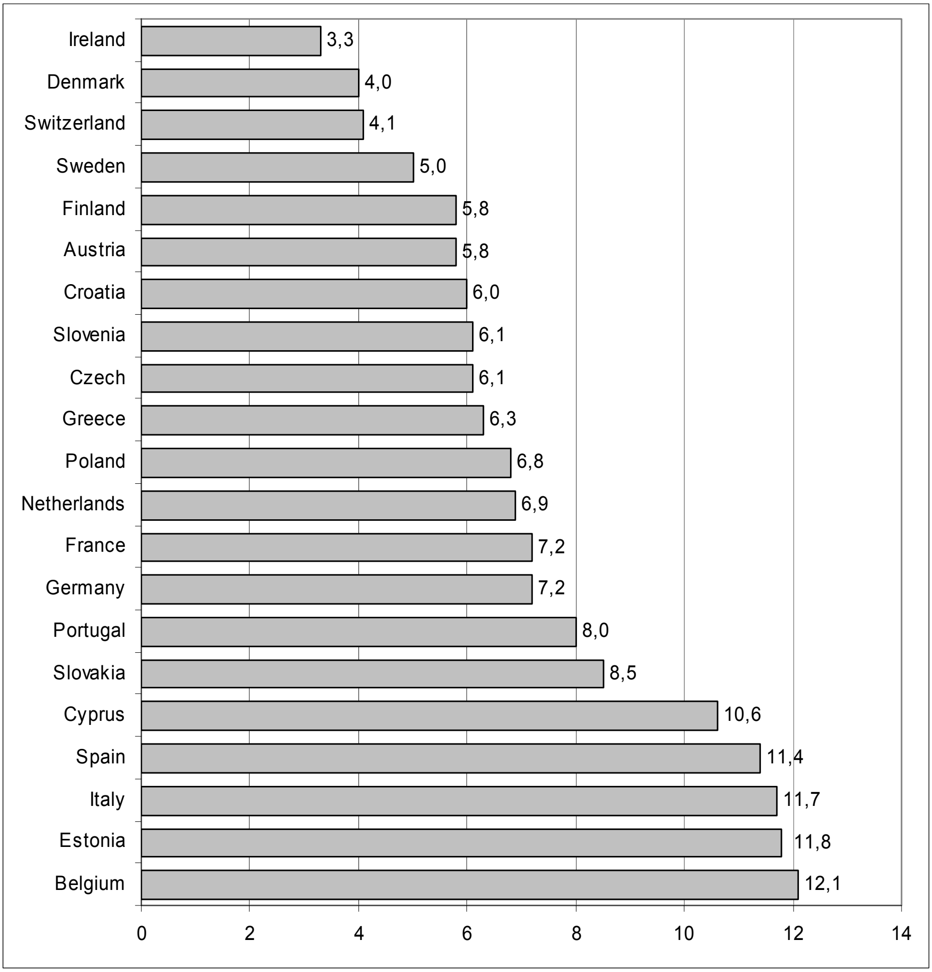

Figure 12. The portion of drivers answering that they drive often, very often or always faster than speed limit in built-up areas.

While I cannot apply classical hypothesis testing methods here the data suggest that speeds at crossings are high and the potential for serious accidents is real. Pedestrians must be informed that they needs to be attentive to approaching vehicles and that even though they have the right of way, drivers are known to ignore the obligation to stop.

The most effective way to eliminate human errors of behaviour is to adapt road environment as well as regulations to human limitations. If safety demands a lower speed than actually adapted by drivers, like here in case of non-signalised crossings, speed-reducing measures could be introduced as shown in many countries. As shown in Swedish survey of 71 Swedish municipalities

(1985) by Hydèn and Odelid, the most of them had introduced different engineering measures, like humps (used by approximately 75% of municipalities), road narrowing (15%) and lateral displacement (7%) [Varhelyi 1996] on urban non signalised crossings. Here we can see big changes to implement in Estonia, as the usage of engineering measures, nothing to say about measures of automatic speed adaptation, is only in a very beginning.

6.3 Interpretation

The results of the hypothesis underscore the point that both public perception and driving habits need attention. As anticipated several of the hypotheses were accepted even though they run counter to long-term declines in the number of fatalities. Similarly driving behaviour shows little improvement.

Since not all of the hypotheses were accepted, the overall results of the hypothesis testing may be considered to be mixed but this result was anticipated. There is clear evidence that there is a need for highway safety improvements and since the public perception is that the general safety situation is not improving, the setting is fertile for aggressive campaign to address the problem. If the opposite were true, in which the prevailing attitude was that things were good and improving, a public campaign to address driving behaviour would be a much harder sell.

The most important finding in this study is that although highway fatalities are declining, the public awareness is ripe for a campaign to encourage both drivers and pedestrians to change their behaviour in order to make progress toward achieving the highway safety statistics more representative of the rest of the European Union.

7. DISCUSSION

Between 1995 and 2005 758 pedestrians died in Estonia accounting for approximately 1/3 of all road deaths. The small proportion of pedestrian and cyclist casualties that occur in rural areas are relatively severe and should not be forgotten, but this review is concerned with the great majority that occur in urban areas. The overall long-term trend in road-related deaths has been downward but for pedestrians and cyclists the number of injuries has not declined, despite a decline in walking and cycling as more people take to their cars for local journeys. However, as energy prices rise this trend may be influenced in future by the encouragement to travel by foot, bicycle or public transport. It should be a high priority for those responsible for traffic systems in our urban areas to focus more directly on the needs and physical vulnerabilities of pedestrians and cyclists, including people with reduced mobility.

The situation with pedestrians is recognized also by public and there are great expectations among road users in Estonia towards improving the safety situation of vulnerable road users. When comparing with some other European countries, Estonian drivers are more considerate towards the improvement of pedestrian safety [Cauzard 2006].

Table 11. Drivers' attitude towards pedestrian safety development**.** *When planning for the future, how much consideration do you think the Government should give to pedestrians?*

	Per cent of answering: Very much
Belgium	69,1
Estonia	68,1
Cyprus	63,9
Greece	62,3
Denmark	60,4
France	59,5
Ireland	56,3
Italy	55,9
Finland	53,0
Portugal	48,5
Sweden	47,4
Switzerland	46,7
Poland	45,4
Spain	44,6
Croatia	40,8
Austria	37,8
Germany	35,7
Czech Rep.	30,0
Netherlands	27,9
Slovakia	27,4
Slovenia	27,4

There is a big need for strategic planning of safety measures, including pedestrian safety in Estonia. These key measures are well documented in international literature. The key strategies for achieving a safe traffic system for pedestrians and cyclists are [ETSC 1999]:

1 Development of traffic management methods and experiences. Managing the traffic mix, by separating different kinds of road use to eliminate conflicts where conditions are favourable to separation;
2 Creating safer conditions elsewhere for integrated use of road space, for example through speed and traffic management, increased user and vehicle conspicuousness, and vehicle engineering and technology;
3 Modifying the attitudes and behaviour of road users through information, training, enforcement of traffic law, but also using infrastructure measures influencing safer self behaviour of drivers--lowering the speeds at locations where the crash risk is high;
4 Mitigating the consequences of crashes through crash protective design and encouraging the use of passive and active safety measures;
5 Changing priorities in the minds of professionals and policymakers responsible for the traffic system development through sharing of experience and promotion of research findings, and encouraging them to convince the public of the need for change.

Our study indicates that the public does not need much convincing that changes are needed. Indeed a campaign to reduce accidents seems to be welcomed.

By implementing known countermeasures it should be possible to achieve considerable increases in the use of healthier and more environmentally friendly means of transport and still reduce the numbers of deaths and injuries among pedestrians and cyclists. Deep commitment is needed from policymakers at local, national and EU levels to bring about this positive scenario. At the same all travellers need to remain alert, aware and attentive[1] to the risks to themselves and others as they enjoy with increased mobility that come with rising living standards

The purpose of analysis of road accident data and performing road behaviour surveys is to improve road safety and this can be achieved in many ways. One is to improve road safety on the basis of researched effects of measures and another to educate the public by publishing information, most commonly in the form of research and survey reports.

In the third part of the study we discussed the safety problems occurring at urban non-signalized crossings. Non-signalised crossings have been widely used on urban roads in Estonia. This is mainly because of two reasons:

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[1] In English a 'Three A's' campaign could be promoted: Remain Alert, Aware and Attentive. A similar program may be fruitful in Estonia.

– It is relatively cheap to introduce the zebra crossing, when comparing with signalised one and when not using special safety measures, like refugee islands or special road lighting;

– According to the Estonian Road Traffic Act, drivers approaching a non-signalised zebra-marked crossing must adapt their speed so as they can stop in order to give way to pedestrians who are just entering the crossing. Thus the responsibility for safety has been put on road users, and even in case of an accident the driver could be easily judged, as choosing inadequate speed or poor behaving.

Unfortunately this kind of practice has been lead to rather unsafe situations, where urban non-signalised pedestrian crossings could be ranked inside of most risky road elements for vulnerable road users, in spite of traffic rules obligations.

Thus this is believed by decision makers and responsible engineers that non-signalized crossings, especially in urban areas, are effective as a measure to help pedestrians in crossing streets. Here the safety has remained without attention, as believed that traffic rules are enough to protect road users from injuries.

It is endorsed that this precondition is misleading in this study.

The road accident which potentially can occur on non-signalized crossing has some provisions- first there should exist a situation where at least two road users, one of them as pedestrian in our case, will have a possible contact. When acting as traffic rules demand, the driver should stop and yield to pedestrian at marked non-signalized crossing. But this commencement of actions needs some preconditions — the driver has to observe the pedestrian, and then make several decisions while moving — breaking for stopping and yielding, or to continue the driving thus believing to pass the crossing safely before the pedestrian reaches the driving line.

Driver’s capability of observing pedestrians is depending also on a number of factors- driver’s psycho-physiological situation, driver’s attitude of safe behaviour, driver’s apprehension of being caught by enforcement and punished, as well as driver’s personal capability of observing the crossing as a location which demands some special actions to take. The last is something which could be improved using engineering measures, as largely discussed internationally.

Zegeer's study [Zegeer et al 2005] makes precise comparisons, by matching marked and unmarked locations, taking into account numerous factors, including traffic and pedestrian volume, geometry and the like.

Key results from the study were as follows:

- on two-lane roads, marked crosswalks alone were no safer than unmarked crosswalks;
- on low-volume multi-lane roads, marked and unmarked crosswalks provided the same amount of protection;

- on multi-lane roads with high traffic volumes (upwards of 12,000 vehicles per day), a marked crosswalk by itself, without other safety enhancements, was associated with greater pedestrian danger;
- the presence of a raised median provided significantly greater protection on multi-lane roads compared to no median;
- as traffic volume rose, crash rates went up for marked and unmarked crosswalks, but they rose much more steeply for marked crosswalks when rates are above 10,000 vehicles a day.

Zegeer emphasized that the important finding was not that marked crosswalks should not be used, but that they should be used appropriately together with engineering measures. This is an important recommendation also for the Estonian local authorities and policymakers responsible for safety. There is big need to reconstruct pedestrian crossing in a modern safe way. Some crossings should be liquidated or replaced by signalized one; especially where safety standards are impossible to apply or where high speed limits can not be lowered. But further surveys on engineering measures influence on speed behaviour are highly needed in Estonia. This is especially important when only first examples are introduced and the experience and perception among decision makers and engineers is uncommon. Some results of this study could be used for further development of safety standards.

It is also important to study the potential influence of many factors influencing on safety risk, when these factors are combined with each other. For example drunk driver is driving with high speed and approaching the relatively invisible pedestrian crossing with pedestrian crossing the roadway. In a number of studies it has been shown, that it is instructive to compare the extent to which the risk of involvement in a casualty crash varies with a driver's blood alcohol concentration (BAC) and with travelling at a speed above the safe limit. Here is an example is a case-control study of crash risk and BAC was conducted by the Road Accident Research Unit in Adelaide in 1979 [Kloeden et al. 1997]. The results of this study indicate that if the blood alcohol concentration is multiplied by 100, and the resulting number is added to 60 km/h, the risk of involvement in a casualty crash associated with that free travelling speed is almost the same as the risk associated with the blood alcohol concentration. Hence, the risk is similar for 0.05 and 65; for 0.08 and 68; for .12 and 72, and so on. Even travelling at 5 km/h above the 60 km/h increases the risk of crash involvement as much as driving with a blood alcohol concentration of 0.05.

8. CONCLUSIONS

The first part of this study shows that road safety situation in general remains among the most important social and public health problems. As the safety is often figured through the number of road fatalities this could possibly lead to misleading that the positive trend of registered fatalities is enough to ensure the safety characteristics and no further, often also expensive measures will not be needed to introduce. The general public perception is influenced by the attitudes of media as well by public information road safety campaigns.

In the second part of the study I found a deteriorating public perception of the role of both drivers and pedestrians. Perception of drivers yielding to pedestrians is declining but pedestrians are also perceived to be less careful by not properly using reflectors and ignoring pedestrian traffic signals. Also while the perception of drunk driving is not getting worse, it is understood to remain a serious a traffic safety hazard. Lastly, while speeding was not perceived to be getting worse, the average perception for both rural and urban drivers was found to be less than satisfactory. These findings suggest that the public would be receptive to a campaign to focus attention on both drivers and pedestrians abut the necessity to be careful on the road and to respect other road users.

It was shown in the second part of this survey that public perception could and should be used for planning and evaluating the information activities in order to promote safe behaviour. I also show that public perception and actual behaviour often have great disparities, when the majority of road users are to believe to be better than average drivers (i) and that the probability to be in casualty accident is still relatively low (ii).

An important finding here is that existing shape of non-signalised crossings does not have much of an influence lowering speeds at the vicinity of crossings, and thus with accidents, the results are often extremely serious. Here the key results of this study support the findings of Zegeer (2005), Draskóczy and Hydén (1994) and Varhelyi (1996). There is a serious need to reconstruct pedestrian crossings in a modern safe way. Some crossings should be liquidated or replaced by signalized one; especially where safety standards are impossible to apply or where high speed limits can not be lowered.

We have shown that a large proportion of the crashes at non-signalized crossings may have been avoided had the case vehicles been travelling at a slower speed. We have shown that even modest reductions in travelling speeds can have the potential to greatly reduce crashes and injury frequency. Large though these potential safety benefits are, it is probable they are still considerable underestimates. This is because we have only considered the effect of reduced travelling speed on the collision configuration that we actually observed and not taken into account possibilities for crash avoidance and the lower potential for injury at lower speeds. I also recommend the following:

1. The tolerance allowed in the enforcement of speed limits be reduced or removed.
2. The level of enforcement of speed limit at urban crossings to be increased.
3. The penalties for speeding and illegal drink driving to be reviewed to align them more closely to the risk of being involved in a casualty crash.
4. The level of public awareness of the risk of involvement in a casualty crash associated with speeding to be increased with the aim of developing a culture of compliance with safety speed, similar to that which has developed in relation to compliance with blood alcohol limits during the past 5 years.

It is also recommended that further surveys on how engineering measures influence speed behaviour be conducted in Estonia. This is especially important when only first examples are introduced and the experience and perception among decision makers and engineers is unknown.

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SUMMARY IN ESTONIAN

Eesti liiklejate hoiakud liiklusohutuse suhtes

Tänapäeval peetakse liiklusohutust üheks olulisimaks ühiskondliku tervise probleemiks. Igal aastal hukkub ainuüksi Euroopa Liidus enam kui 40 000 inimest aastas, neist üle 10 000 jalakäija ja jalgratturi. Just nimetatute, ehk siis vähemkaitstud liiklejate ohutus on tõsiseks probleemiks pea kõikides Euroopa Liidu liikmesriikides.

Jalakäijate ohutus on üheks tõsisemaks probleemiks ka tänases Eesti liikluses, sest iga kolmas liikluses hukkunud inimene on jalakäija. Kui võrrelda naaberriikide- Eesti ja Soome liiklusohutuse üldnäitajaid, selgub, et Eestis on risk hukkuda 2–4 korda kõrgem kui Soomes. Sellest tulenevalt on nii Euroopa Komisjon kui paljud liikmesriigid, sealhulgas ka Eesti, püstitanud ülesande vähendada liiklusõnnetuste arvu ja tagajärgi, nähes ette meetmed liikluses hukkunute arvu vähendamiseks 50% võrra.

Käesoleva töö peamisteks eesmärkideks on hinnata mõningaid aspekte jalakäijate liiklusohutuse parendamisel. Eelkõige on vaatluse all reguleerimata ülekäigud linnades ja asulates.

Liiklusõnnetuse toimumine reguleerimata ülekäigurajal on seotud eelkõige juhtide oskuse, võime ja sooviga peatuda ülekäiguraja ees teeandmiseks jalakäijale. Võimaliku õnnetuse tagajärjed aga sõltuvad paljuski sõiduki kiirusest kokkupõrkehetkel. Seega on jalakäijate reguleerimata ülekäiguradade ohutuse hindamiseks oluline teada saada juhtide käitumisharjumusi.

Rahvusvaheliselt on teada fakt, et jalakäija hukkumise tõenäosus liiklusõnnetuses sõltub otseselt sõiduki kiirusest kokkupõrkehetkel. Kui sõiduki kiirus kokkupõrkehetkel ületab 45 km/h on jalakäijal tõenäosus ellu jääda alla 50%, samas kiiruse 30 km/h on see 90%. Seega on just juhtide kiirusevalik üheks oluliseks näitajaks reguleerimata ülekäikude ohutuse hindamisel. Käesolevas töös on antud ülevaade uuringutest, mis puudutavad juhtide kiiruskäitumist reguleerimata ülekäiguradadel ja nende läheduses.

Teiseks oluliseks eelduseks reguleerimata ülekäigukohtade ohutuse parendamisel on juhtide hoiakud sõidutee ületust ootavate jalakäijate suhtes. Käesolevas töös on käsitletud inimeste üldisi hoiakuid antud teema suhtes, eelkõige aga uuringu tulemusi, mille eesmärgiks oli hinnata juhtide käitumist ülekäiguradadel ja eelkõige nende tendentside muutumist ajas.

Töö tulemusena on esitatud soovitused ohutumate ülekäiguraja lahenduste kasutusele võtmiseks, samuti loetletud teisi olulisi meetmeid Eesti Rahvuslikus Liiklusohutusprogrammis toodud eesmärgi- saavutada olukord, et aastal 2015 ei hukkuks Eestis liiklusõnnetuste tõttu enam kui 100 inimest, saavutamiseks.

ACKNOWLEDGEMENTS

I appreciate the advices of the supervisors of this thesis prof. Tõnu Oja, Institute of Geography, University of Tartu and prof.Siim Sööt, University of Illinois at Chicago, U.S.A. Also I thank prof. Ülo Mander for his suggestions and recommendations.

I also want to acknowledge my colleagues and friends from Inseneribüroo Stratum, especially Harri Rõuk, Margus Nigol, and Tarmo Sulger, elaborating and cooperating in preparation of studies.

My special gratitude goes to Mrs Tiia Rõivas, for her efforts to encourage and support me on my way of writing this manuscript.

PUBLICATIONS

DRIVERS' BEHAVIOUR
AT URBAN PEDESTRIAN CROSSINGS

Dago Antov, Tiia Rõivas and Harri Rõuk

ABSTRACT

Pedestrian safety is one of the most serious problems in Estonian traffic. One of the alarming issues in Estonian road safety is the pedestrian safety. Thus, every third person killed on the roads is a pedestrian.

The main goal of this paper was to find which factors could affect on drivers attitude to give way.

In the result of obtained data we could follow up, that the main factor influencing on drivers willingness to give way at non-signalized urban crossings was motor vehicle traffic volume..

The second part of the study involved drivers speed choice at the vicinity of pedestrian crossings. Here we considered that:

1. The average speeds at crossings are rather high. At almost 60 per cent of runs the speed was higher than a speed limit.

2. The change in speed at the vicinity of zebra crossing is minor. The situation is especially critical at the crossings with speed limit of 70 km/h. On these sites an average speed is dangerously high at the whole vicinity of zebra crossing and does not allow breaking safely when driver occurs the pedestrian waiting at the roadside.

1. Introduction

Road accidents and their consequences are a significant social problem. At the same time, this topic can be considered to be one of the indicators of the sustainable development of urban systems. More than 10,000 pedestrians and cyclists are killed every year in EU countries, representing more than 20 per cent of all road deaths. The small proportion of pedestrian and cyclist casualties that occur in rural areas are relatively severe and should not be forgotten, but this review is concerned with the majority, which occur in urban areas.

Pedestrian safety is also one of the most serious problems in Estonian traffic, especially in urban areas. If one compares Estonia's figures with those of the neighbouring country Finland, the pedestrian road traffic risk in Estonia is somehow 2–4 times higher. The situation is extremely alarming in urban areas, which share about 85 per cents of all pedestrian accidents in Estonia. It is documented that every fourth urban pedestrian accident occurs at non-signalized pedestrian crossings, often referred as zebra crossing, or in their vicinity.

It is a well studied fact that the road traffic risk of pedestrian fatality or injury is related to drivers' behavioural aspects, such as choice of speed when approaching a crossing and also the driver's willingness to yield to pedestrians at non-signalized crossings.

2. International comparison

After establishing the independence during last 15 years the motorization level has been raised rapidly in Estonia — from 154 (2000) to 367 (2005) registered cars per 1000 inhabitants. This rapid motorization has caused a number of negative consequences, like pollution and road accidents. Even if the safety development characteristics during the last decade have been generally positive, the differences in road safety situation between the old EU member states and Estonia are remained rather big.

Even if Estonia has had a visible progress in road safety the country remains among the countries with poorest road safety data in the EU. One of the alarming issues in Estonian road safety is the pedestrian safety.

The per capita risk of death of pedestrians in EU-15 countries in 1996 is shown in Figure 1. Data is from IRTAD (International road traffic and accident database http://www.bast.de/htdocs/fachthemen/irtad/english/irtadlan.htm) and Estonian Road Administration annual statistics. These figures represent the pedestrian's per capita risk. To obtain a better understanding of the risk to pedestrians, each country needs to collect information on the amount of walking which is not available today.

Due to the data of Estonian Road Administration during the period of 1998 and 2002 the police reported 1142 fatalities on Estonian roads. Of these, pedestrians accounted for 361 fatalities (Figure 2). Thus, every third person killed on the roads is a pedestrian. In Estonia, the police only record pedestrian accidents in which at least one vehicle was also involved. The police do not record single pedestrian accidents, such as falls or collisions with bicyclists.

Thus taking account the risk data of old EU countries in 1996 and when comparing the pedestrian risk indicators with Estonian ones, we can get that the pedestrian fatality risk is somehow three times higher, than in old EU in average and even 7..8 times higher than in countries with the best safety characteristics, like the Netherlands and Sweden.

The Estonian National Road Safety Programme was accepted by Estonian Parliament in 1988. This plan contains a clear goal: the number of fatalities should be reduced by at least 50 per cents by the end of 2015, thus the number of fatalities should not exceed 100 in 2015. The goal is absolute, i.e., it must still be attained in the event of changes in traffic conditions, such as increasing motorization and traffic. It is also a quantitative goal, which means, for instance, that attempts will be made to attain the safety development especially in certain groups, like less protected road users- pedestrians and cyclists, but without preference to other groups. Thus a pedestrian safety has been highlighted in Estonian road safety policies as one of the main issues to develop.

As can obtain from the Figure 3, pedestrian risk is especially high in urban areas, where pedestrian accidents obtain almost half of all registered injury or fatality accidents. But the biggest city, capital Tallinn, with the population of 400,000 inhabitants, shows the share of pedestrian fatalities of all fatal road accidents even as 63 per cent (Figure 3).

The Estonian situation seems especially critical when comparing with the indictors of the neighbouring country- Finland, with rather similar climatic conditions of traffic, but different level of motorization and safety development. The same concludes when comparing the capitals- Tallinn, Estonia and Helsinki, Finland (Figure 4).

The problems associated with pedestrian safety are far greater than are reflected by the official safety statistics. This is one reason why analyses of pedestrian safety are necessary.

3. Pedestrian risk and motor vehicle's speed

The choice of exposure is crucial to any comparison of own risk across different modes of transport. The reason for this is that the speeds and durations of the individual trips differ between the various modes of transport.

Walking and cycling are about 7 to 8 times more dangerous per person kilometre than is travel by private car, whereas travel by private car is more dangerous per trip than walking. Cycling is twice as dangerous per person hour travelled relative to walking and private car travel. If trips of less than 300 metres are included, the number of casualties per million pedestrian trips drops to 1.1 (instead of 1.7). The other figures of the table do not change significantly if trips of less than 300 metres are included (Zilmer, 1992). About 70 to 75 per cents of all pedestrian casualties are falls.

Figure 1 illustrates how the fatality and injury risk of pedestrians is depending on motor vehicle's speed at a collision situation. It could be obtained, that the pedestrian fatality and injury risks are highly depending on collision speed. Thus the probability of staying alive in collision is about six times higher when collision speed is 30 km/h instead of 50 km/h. On 70 km/h collision speed the probability of being killed in accident is almost 95 per cent, when only 15 per cent on collision speed of 40 km/h (Figure 5). But all these speeds are common on zebra crossings, as speed limits, and the actual speeds of individual motor vehicles could be even much higher.

4. International risk evaluation of zebra crossings

According to the Estonian Road Traffic Act, a zebra crossing is a part of the road, which is provided for pedestrians when crossing the carriageway and which is specially marked. If there is a zebra crossing in the vicinity, pedestrians must use it when crossing carriageways. Drivers approaching a non-signalised zebra crossing must adapt their speed so as they can stop in order to give way to pedestrians who are just entering the crossing. If necessary, drivers shall stop to allow pedestrians to pass. Drivers approaching a zebra crossing must not overtake or pass another vehicle if that vehicle obstructs a full view of the crossing.

In Estonia like in many other countries, zebra crossings consist of broad stripes which are parallel to the direction of the road. There are no special regulations where non-signalised zebra crossings could be established on roads with certain speed limit. Thus the most of zebra crossings are located at urban streets with regular speed limit of 50 km/h, but sometimes we can found zebra crossings also on streets or roads with special speed limit of 70 km/h. Also there is a usual practice to mark zebra crossings on intersections.

The risk to pedestrians crossing roads at various points in traffic systems has been studied in a series of studies from England (Mackie and Older, 1965; Jacobs and Wilson, 1967), Norway and Sweden (Ekman, 1988). The same method was used in all these studies. The number of accidents in which crossing pedestrians was involved was compared to the number of pedestrians crossing with a fixed period (12 min. counts outside the rush hour were used). One study found that the risk involved in crossing road sections at up to 45.7 metres from a zebra crossing including the crossing itself was 30 per cent higher than that at over 45.7 metres from a zebra crossing, whereas three other studies found that the risk was up to 50 per cent lower. Three studies found that the risk involved in crossing roads at or near non-signalised junctions, at distances of up to 18.3 metres from the junctions and up to 45.7 metres from a zebra crossing was up to 127 per cent higher in comparison to that at non-signalised junctions lacking zebra crossings, although two other studies found that the risk was up to 35 per cent lower. The effects of other circumstances, such as central islands, road lighting and road width were not eliminated in the studies.

Gårder et al. (1978) found from conflict studies conducted at 115 junctions in Malmö and Stockholm that the risk to pedestrians was lowest when zebra crossings were marked either less than 2 metres or more than 10 metres from the near side of the intersecting road. The risk was twice as high (significant) when zebra crossings were marked at between two and ten metres of the near side of the intersecting road, in comparison to marking at less than two metres from the intersecting road.

In New Zealand, the risk to crossing pedestrians has been found to be 15 per cent lower at non-signalised zebra crossings, in comparison to crossing roads at any other point. Pedestrian exposure was estimated through interviews. No allowance was made for possible differences in the occurrence of other measures, quantities of car traffic and speed of car traffic, (Keall, 1995).

A before-and-after study of the construction of 62 zebra crossings in London showed that the safety effects of the crossings was dependent on the accident rate (all accidents) during the before period. At places where there had been fewer than 2 accidents per year on a 100 metre section with the crossings located at the centres of the sections, the number of pedestrian accidents increased significantly by 50 per cent. In contrast to this, the number of pedestrian accidents dropped significantly by 50 per cent on sections where there had been more than 3 accidents per year. There was an attempt to reduce the effects of bias in the results. (Landles, 1983)

An American with/without accident study of pedestrian crossings marked with 2 continuous white lines (parallel to the stop lines, but without zebra stripes) at 400 non-signalised junctions showed that the risk to crossing pedestrians was about twice as high at the pedestrian crossings in comparison to unmarked crossings. The pedestrian crossings at the 400 junctions were marked only on one arm of the primary road, whereas the other arm was unmarked. Only pedestrian accidents occurring at the crossings themselves were included in the study, which is critical, as the location of the unmarked crossings must therefore be determined and accidents occurring in the vicinities of the crossings are important in a risk assessment. The traffic was counted for 24 hours at 40 systematically-selected junctions. At these 40 junctions, the risk to crossing pedestrians was only 40 per cent higher at pedestrian crossings in comparison to unmarked crossings. (Herms, 1972)

Draskóczy and Hydén (1994) point out that the give-way rules possibly influenced the effect of the pedestrian crossings. Even though most studies indicate a negative safety effect of pedestrian crossings, there are exceptions, e.g., from England and Norway. England and Norway have clear give-way rules which require vehicles to give way to pedestrians, whereas other countries, such as Sweden had no such rules. Draskóczy and Hydén thus suggest introducing clear give-way rules in the Swedish Road Traffic Act, so that zebra crossings should reduce the number of accidents in which crossing pedestrians are involved.

Swiss traffic regulations were amended in 1994, so that vehicles must give way when the behaviour of a pedestrian clearly indicates that he or she intends to use a zebra crossing. Earlier, pedestrians needed to signal to drivers that they wished to cross the road. It was possible to conclude on the basis of behaviour studies that the average number of vehicles that drove past before waiting pedestrians crossed the road dropped from 2.6 in the before period, to 1.5 in the after period. The proportion of motorists who stopped/braked and allowed pedestrians to cross the road increased from 12.5 per cent in the before period, to 31.6 per cent in the after period one year after amendment of the give-way rules. (Ewert, 1995)

Based on literature, Varhelyi (1996) notes about non-signalised zebra crossings:

- The presence of pedestrians at zebra crossings has little or no influence on the speed of approaching vehicles
- Between 4 and 30 per cent of vehicle drivers give way to pedestrians at zebra crossings.
- Drivers are more willing to slow down or stop for crossing pedestrians when the approach speed of the vehicle is low.

A Swedish interview survey showed that crossing pedestrians feel safer at zebra crossings than they are away from them (Herrstedt, 1981). This should possibly be considered in the context that pedestrians walk about 10 per cent faster when crossing a road away from a zebra crossing than they do at such crossings (Dewar et al., 1995).

5. Motor vehicle user behaviour at the vicinity of zebra crossings

In the context of the provision being made for them and the changes in behaviour being required and asked of drivers and pedestrians themselves need to be educated and encouraged to take steps that are open to them to reduce their own exposure to risk in the course of the increasing use they are being encouraged to make of walking and cycling as means of transport. They need to be fully consulted and informed about the routes being created or improved for them, and especially of any situations in which, for the sake of safety, any route is made somewhat less attractive or convenient in some other respect. Both pedestrians and cyclists also need to be encouraged to use reflective clothing and devices that increase their conspicuity to drivers. In all these ways it should be possible to achieve considerable increases in the use of healthier and more environmentally friendly means of transport and still reduce the numbers of deaths and injuries among pedestrians, and thus contribute to sustainable safety.

Because of differences in design, behaviour patterns, knowledge of safety design and planning, concerning zebra crossings, it is difficult to assess the rapid safety effect of reconstructing zebra crossings in Estonia. Effects of up to ±50 per cent on the number of accidents involving crossing pedestrians have been attained or estimated through the construction of zebra crossings on road sections. Zebra crossings on road sections should be marked at the point where it is safest for pedestrians to cross the road. Also at junctions, zebra crossings give the best safety effect for pedestrians when they are carefully planned. When located and redesigned optimally, zebra crossings should be considered by pedestrians to be “guides to the safest route”.

This study includes some of the areas in which new knowledge on pedestrian safety can be of relevance.

5.1. Motorists' observance of their obligation to give way at zebra crossings

The idea behind zebra crossings is to reduce the risk for crossing pedestrians and to reduce their waiting time. Technical approaches that can increase the proportion of motorists who do observe pedestrian rights of way should be investigated more closely. In this research we were interested in drivers' behavioural aspects at zebra crossings with clear give way obligation. The field survey was conducted in the capital city — Tallinn and some other bigger cities, at 16 crossings with rather different shape. The main goal of surveillance was to find which factors could affect on drivers attitude to give way. The survey was conducted at the daytime, at off peak hours with different traffic and pedestrian volume during one hour surveillance periods, twice in each crossing. The situation when there was a pedestrian or a group of pedestrians clearly representing their wish to cross the road. The determined parameters in the mentioned situations were: the sequence number of the motorist stopped at zebra crossing and thus giving way to pedestrian(s) counting started when pedestrian walked to the crossing and first motor vehicle approaching the crossing. Such situations were defined as contacts. Also some other background data like the number of pedestrians waiting to cross at same time (pedestrian group size), hourly pedestrian and motor vehicle traffic were determined.

We were also interested which of surveyed factors could possible have influence on drivers attitude to give way. Thus some regression analysis was performed. When comparing the average sequence number of the first stopped car (SN) and other obtained in survey data, we could assume that pedestrian group size (Figure 6), as well as pedestrian traffic volume (Figure 7) had only minor influence on driver's behaviour, when motor vehicle traffic volume was found to be the main factor here (Figure 8). This result is also illustrated with figures below. Thus we can follow up that in more strain traffic situations drivers are much less favourable to give way than in low volume traffic.

5.2. Motorists choice of speed at the vicinity of zebra crossings

The former surveys contain indications that, when installing zebra crossings and road lighting, the safety effects obtained for pedestrians depend on the speed level of vehicular traffic and the quantity of traffic. It is thus important to determine the speed values at crossings, but especially does the crossing itself has any influence on drivers speed choice when approaching the crossing.

It should be highlighted that the technical data was obtained from another survey, which aim was to analyse data about real speeds and delays when moving on urban street network. The equipped with GPS receiver, video recorder and data storage devices car used the in-flow driving method at previously chosen routes in Tallinn. The car speed and location was fixed in every second during the movement. Later the location of non-signalized crossings located at the chosen routes was assigned and thus it was possible to survey the actual driving speeds at the vicinity of zebra crossings. It is important to understand that situations with waiting for crossing pedestrians (contacts) were eliminated from the survey this time, as we were interested only on empty crossing influence on speed choice.

Each route was driven at least six times, mainly at off peak hours, where speed choice was relatively free. When eliminating the contact situations with pedestrians the total number of measured situations was 120, at 29 crossings, of which on 24 was introduced the speed limit of 50 km/h and at 5 crossings — 70 km/h. The speed was measured at 4 locations at the crossing vicinity — at 100 m (coded here as –100) and 50 m (coded as –50) before the crossing, at crossing (coded as 0) and at 50 m after the crossing (coded as +50).

The main results of data analysis are presented as follows:

1. The average speeds at crossings are rather high. At almost 60 per cent of runs the speed was higher than a speed limit. Only at 12 per cent of runs the speed was less than 40 km/h. The situation was especially dangerous at crossings were the speed limit of 70 km/h is allowed. The smallest measured speeds were between 55 and 60 km/h!

The running speed distribution measured at crossings is presented at the figures 9 and 10.

2. The change in speed at the vicinity of zebra crossing is minor. When comparing average speeds of different runs at the vicinity of zebra crossings we got a picture as shown on figure 11.

It is important to note, that when comparing speeds at -100 and 0 only in 59 per cent of cases the speed at crossing was less than at -100. Respective data at -50 and 0 show the 57 per cent of cases. Thus nearly at half of measured cases the speed was not lowered at crossing when comparing with speed at 100 and 50 m to the crossing (Figure 12).

The data obtained from the survey shows also that the braking, if ever, starts near the crossing. After passing the speed comes regularly up again in a very short distance after zebra crossings. The typical speed change at the vicinity of crossings is illustrated at the figure 13.

The situation is especially critical at the crossings with speed limit of 70 km/h. On these sites an average speed is dangerously high at the whole vicinity of zebra crossing and does not allow breaking safely when driver occurs the pedestrian waiting at the roadside. Thus these sites do not follow the traffic rules of giving way and should be discarded.

6. Summary and conclusion

This report is based on field surveys and data analyses about pedestrian safety. The key topics are; accident and risk developments for pedestrians, motorists' behavioural aspects at zebra crossings, particularly their obligation to give way and also speed choice at the vicinity of zebra crossing, as well as safety effect for pedestrians of zebra crossing design. The key results are summarized below:

- The pedestrian casualty risk in Estonia is in average approximately 2… 6 times higher than in other old EU countries.
- 44 per cent of pedestrian casualties occurred in urban areas during the period of 1998–2002. Pedestrian accidents are predominant in urban areas.
- One of risky sites for pedestrians remains to be pedestrian crossings.
- The driver's attitude to give way at pedestrian crossings is low in Estonia. This attitude is poorly depending on pedestrians, but strictly on motor traffic volume. In the situation of give way obligations drivers are first worried about the time lost at crossing and potential risk of rear-end collisions, after when comes risk of pedestrian collision.
- Even if there are clear regulations for motorists to give way, a number of drivers simply ignore this regulation. Thus in average only every third driver stops at crossing when there is a pedestrian indicating his/her wish to cross the road.
- The average speed and speed distribution of motorized vehicles has a major influence on pedestrian safety. There is a clear relationship between the permitted speed and the severity of pedestrian injuries in accidents. The proportion of fatalities among pedestrian casualties increases in step with increasing permitted speed. In other words - speed kills.
- Existing shape of pedestrian crossings does not have big influence on drivers' speed choice. An average driving speed on pedestrian crossings is high and this speed is not significantly lowered when approaching the pedestrian crossing.
- Especially bad situation is recognized at pedestrian crossings where the speed limit for motorists is 70 km/h. The normal regulation of giving way to pedestrians does not apply here usually. The drivers are regularly ignoring the give way obligations, do not lower speed and pedestrians are in case of crossing the road just having the big enough gap between motor vehicles.
- There is big need to reconstruct pedestrian crossing in a modern safe way. Some crossings should be liquidated or replaced by signalized one, especially where safety standards are impossible to apply or higher than regular speed limit wanted to keep.

Altogether, the main task considering pedestrian safety is to lower the casualty rate for crossing pedestrians. Most of the pedestrian accidents occur in urban areas. Elderly pedestrians, drunken pedestrians and pedestrians in darkness are important target groups in treatments against fatal accidents. Thus this is highly needed to introduce new modern standards in pedestrian crossing design in order to lower speeds and improve driver's visibility at the vicinity of pedestrian crossings.

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FIGURES

Figure 1. Per capita risk of death of pedestrians in EU-15 countries in 1996 and Estonian average of 1998–2003

Country	Population, mill.	Number of fatalities		Fatalities per million of population		Percentage of fatalities where pedestrians involved
		Total	Pedestrians	Total	Pedestrians	
Austria	8,02	1027	157	128	20	15
Belgium	10,18	1336	155	131	15	11
Germany	81,91	8758	1178	107	14	14
Danmark	5,29	514	68	97	13	13
Spain	39,68	5483	960	138	24	18
France	58,21	8541	1043	147	18	12
Finland	5,13	404	70	79	14	17
Greece	10,48	2063	469	197	45	23
Italy	57,25	6688	987	117	17	15
Ireland	3,58	453	113	127	32	25
The Netherlands	15,60	1180	109	76	7	9
Portugal	9,82	2730	624	278	64	23
Sweden	8,82	537	74	61	8	14
UK	58,29	3740	1039	64	18	28
EU-15	*372,24*	*43474*	*7048*	*117*	*19*	*16*
Estonia*	1,35	228	72	169	53	32

Figure 2. Pedestrian accidents, Estonia 1998–2002

		All	Pedestrian	Share of pedestrian accidents
		1998–2002	1998–2002	
Total		1142	361	32%
	Total urban	323	160	50%
	signalized crossing	23	22	96%
Urban	non signalized crossing	15	14	93%
	intersections	43	17	40%
	road sections	300	138	46%
	Total rural roads	818	201	25%
	signalized crossing	0	0	–
Rural	non signalized crossing	0	0	–
	intersections	41	9	22%
	road sections	777	192	25%

Figure 3. Road accidents in the City of Tallinn, Estonia (1999–2002)

	Road accidents 1999–2002				Percentage, %			
	Registered accidents	Participants	Fatalities	Injuries	Registered accidents	Participants	Fatalities	Injuries
Tallinn.	1853	3642	97	2109	100	100	100	100
of which:								
Pedestrian accident	1056	2178	61	1035	56	59	63	49
Cycle accident	158	314	3	158	9	9	3	8
Other accident types	639	1150	33	916	35	32	34	43

Figure 4. Comparison of Finnish and Estonian road safety indicators (2001)

Indicator	Finland	Estonia	Helsinki, Finland	Tallinn, Estonia
Population, thousands	5 181	1 361	555	400
Motor vehicles registered, thousands	2 499	401	214	133
Fatalities in road accidents	433	199	12	26
Injuries in road accidents	8411	2444	791	551
Fatalities per 100,000 population	8,4	14,6	2,2	6,5
Injuries per 100,000 population	162	180	142	138
Pedestrians killed	62	60	7	13
Pedestrians injured	725	585	167	262
Pedestrians killed per 100,000 population	1,2	4,4	1,3	3,3
Pedestrians injured per 100,000 population	14.0	43.0	30,1	65,5

Figure 5. Probability of pedestrian fatality (FAT) and injury (INJ) depending on motor vehicle's collision speed. (Nilsson, 1993).

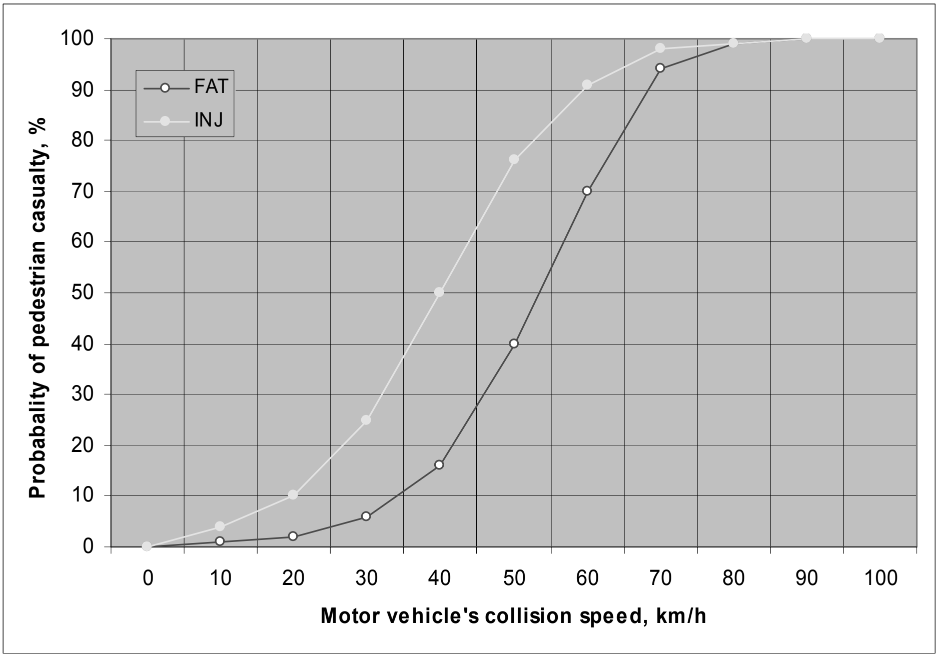


Figure 6. Dependence between the average sequence number of the first stopped car (SN) and pedestrian group size.

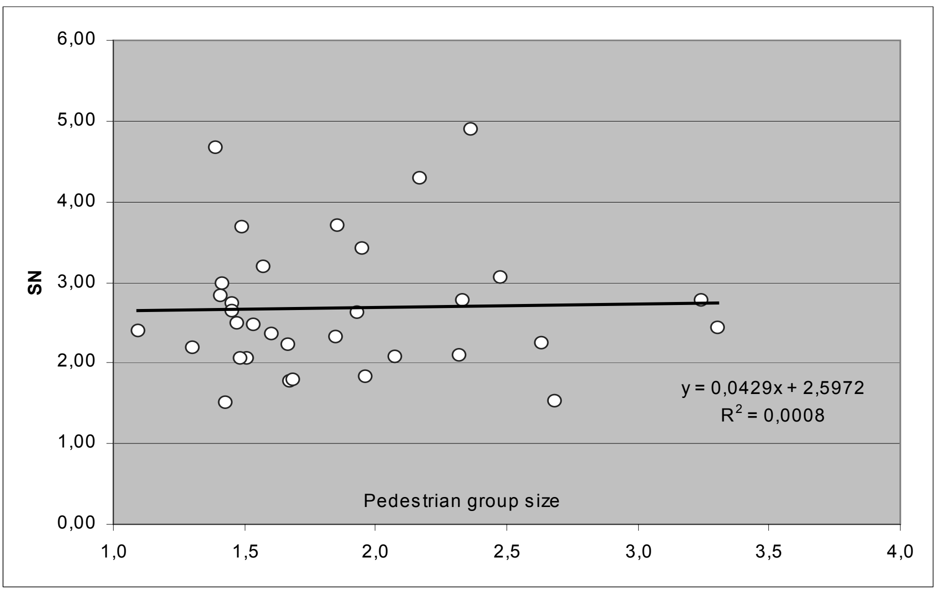


Figure 7. Dependence between the average sequence number of the first stopped car (SN) and pedestrian traffic volume.

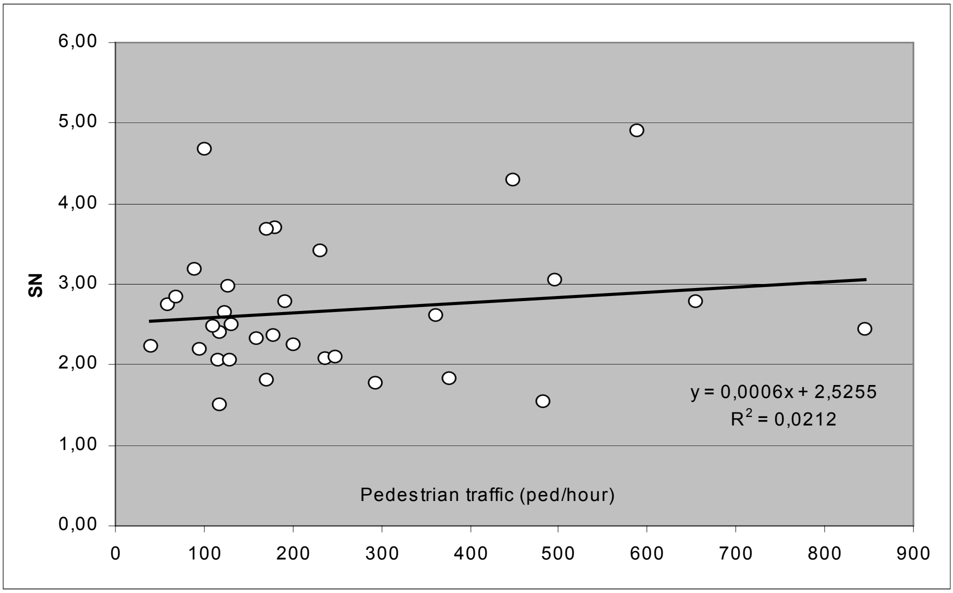


Figure 8. Dependence between the average sequence number of the first stopped car (SN) and motor vehicle traffic volume.

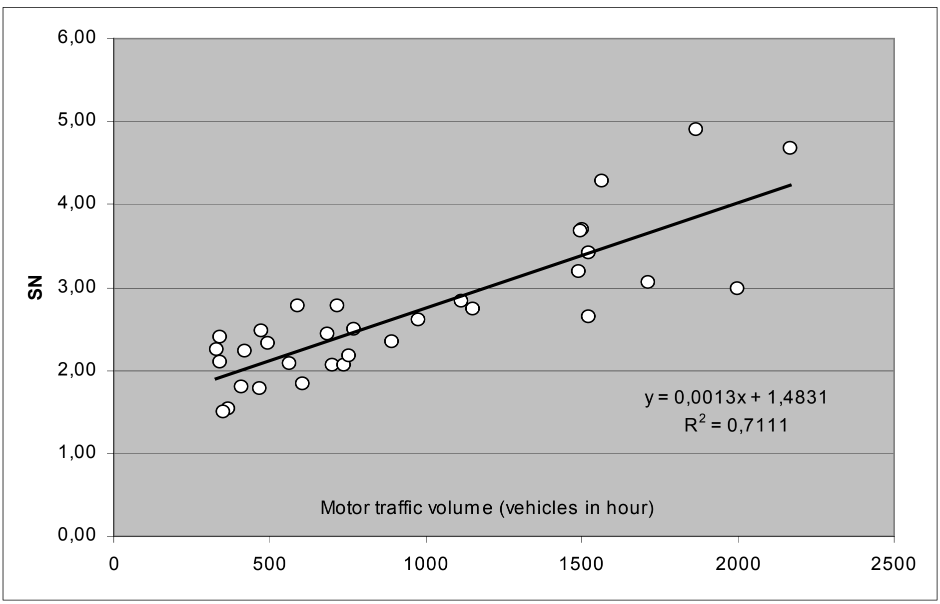


Figure 9. Running speed distribution measured at crossings with speed limit of 50 km/h.

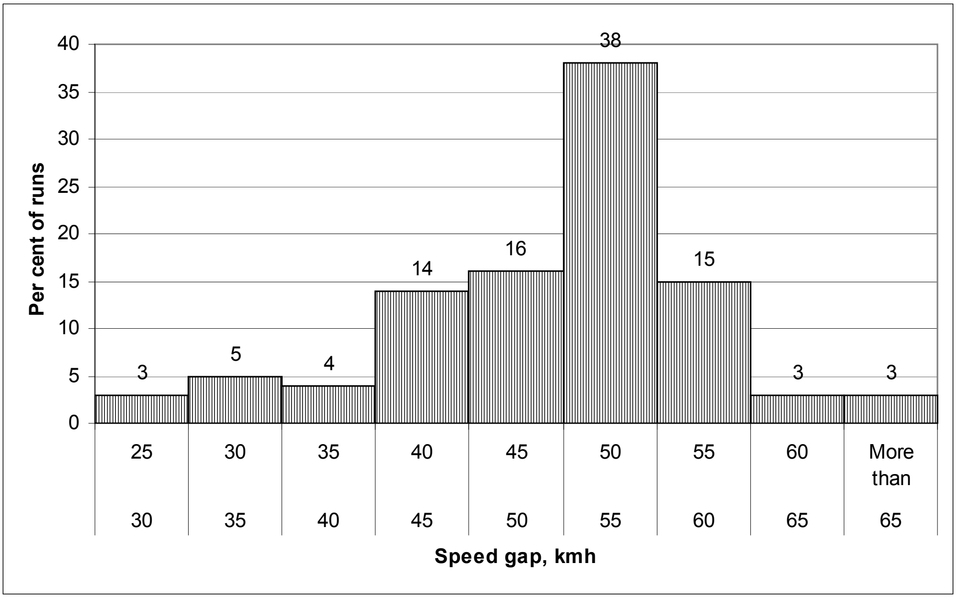


Figure 10. Running speed distribution measured at crossings with speed limit of 70 km/h.

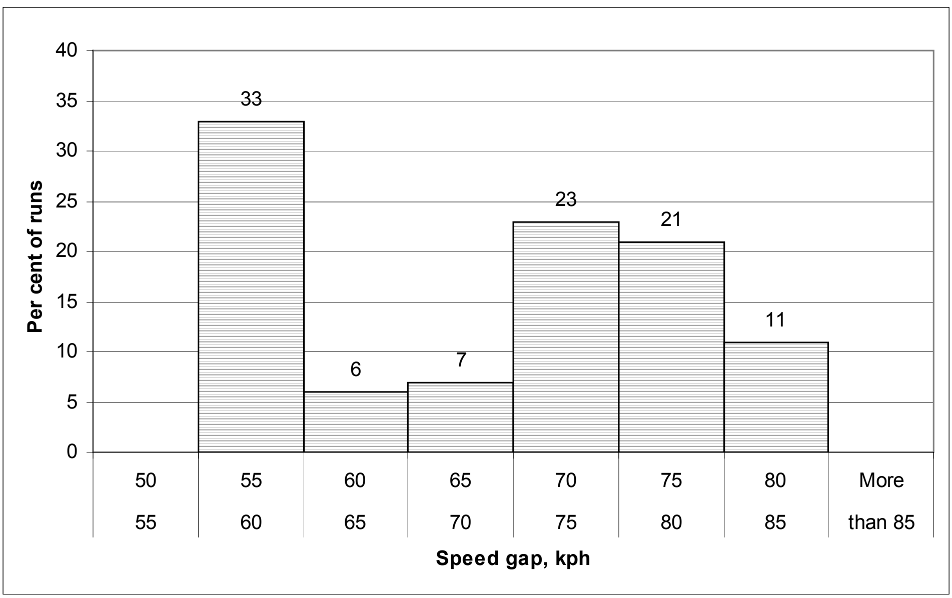


Figure 11. Average speed at the vicinity of all pedestrian crossings, kph

Speed limit	Distance:	–100	–50	0	50
	Average	47,2	45,7	44,6	44,7
	max	63	56,1	55,1	56,5
50	min	32,4	27,7	27,1	15,6
	Average	70,1	70,4	69,9	70
	max	77,4	78,1	78,1	78,5
70	min	60,8	60,2	57,6	57,6

Figure 12. Average speed at crossing's vicinity.

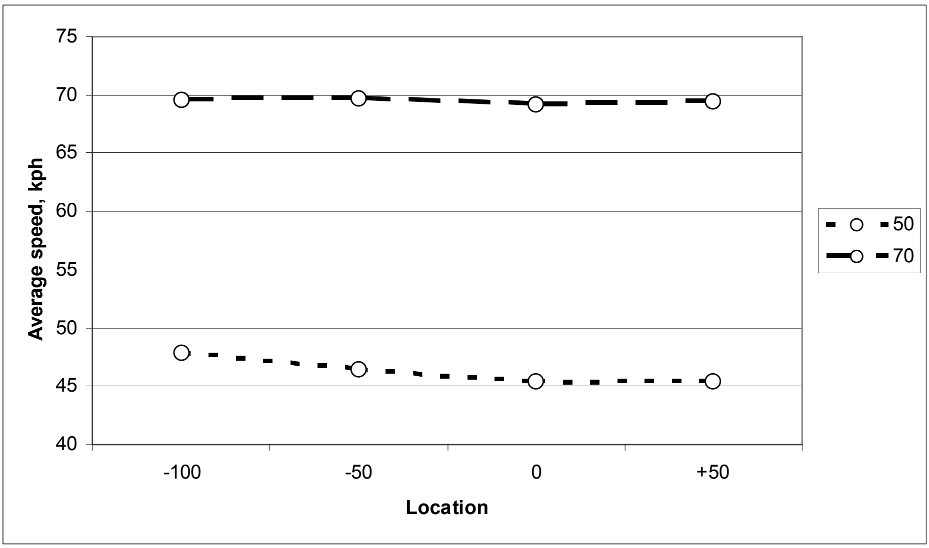
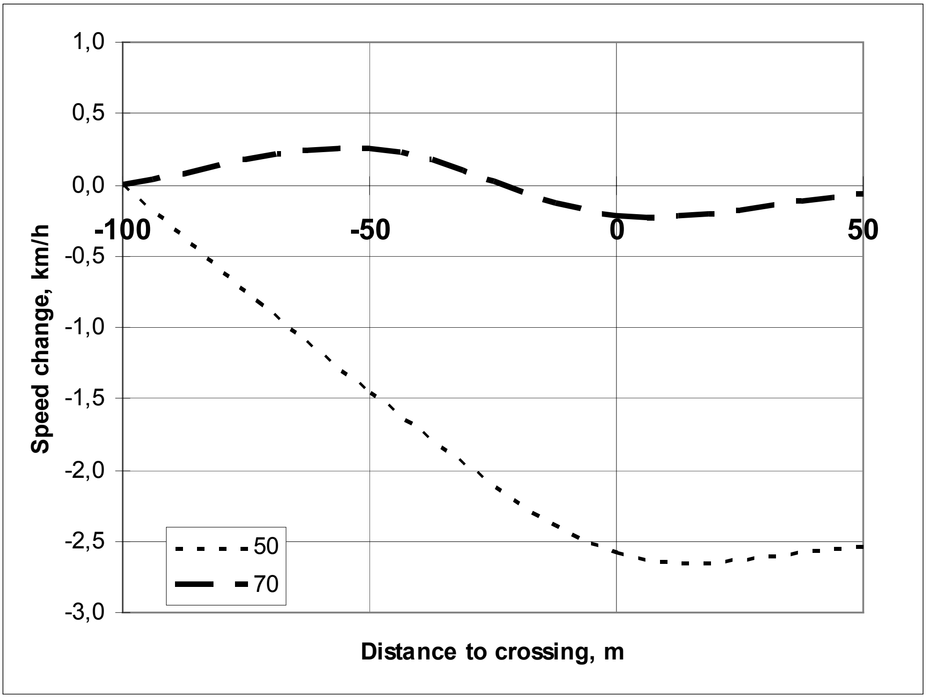


Figure 13. Typical speed change at the vicinity of crossings



SAFETY EFFECT OF SEAT BELT USAGE — A CASE OF ESTONIA

Dago Antov [1, 2], Tiia Rõivas[1], Tõnu Oja[1]

[1] Institute of Geography, University of Tartu, Estonia
[2] Stratum Ltd.

Abstract

Attitude to seat-belt usage and impact of seat-belt wearing to fatality is addressed based on the SARTRE questionnaire data provided in Estonia in 2004. Statistical analysis of the data shows that acknowledgement of the need to wear seat-belt is higher than actual behaviour. The seat belts usage in Estonia has developed remarkably, but when comparing with some neighbouring countries the seat belt usage remains to be rather low, especially on back seat and urban driving. The severity of road accidents has been constantly decreasing together with seat belts rate increase among the persons, involved in accidents with fastened seat belts. Same time, this connection among persons with non fastened seat belts remains unclear. There is statistically significant relationship between the seat belt usage rate and fatality risk.

Key words: seat-belt, traffic safety, road accidents.

1. Introduction

During last years Estonia has received remarkable success in road safety development, when considering the number of fatalities, even when the number of injuries is growing. The national Estonian goal is to reach the situation where the number of fatalities is less than 100 in 2015. To reach this goal Estonia has planned to introduce a number of measures, including the road infrastructure development, activated enforcement, improved road safety education as well as development of legal issues.

The reasons and background of road safety development are complicated task to explain, but the big role here lies probably on legislation, and the introduction of mandatory measures what effectively follow good examples from neighbouring Scandinavian countries. The main introduced mandatory measures, already used in Estonia are listed below:

Measure	Introduced in
Mandatory seat belt usage on front seat, if equipped	1973
Motor cycle helmet usage	1973
Urban speed limit 50 kmph	1993
Mandatory seat belt usage on back seat	1992
Daytime running lights usage 24 h a day	1995
Pedestrian reflectors usage on rural roads in darkness	1995
Children safety restraint equipment usage	1996
Studded or winter tyres usage in winter	1997
Mobile phone usage restrictions in urban traffic	2001
BAC legal limit 0.2 per mills	2001

Often there is a big need to explain the efficiency of certain safety measures. As the cultural, economical and infrastructure changes play here also big role, it might be sometimes difficult to use international data in order to prove the efficiency of certain measures. Also the statistics availability and credibility is also important.

Because of some statistical reasons it is very hard to explain the efficiency of road safety measures in Estonia. First, as the Estonian absolute figures are rather small, which is result of a small population of the country- 1.4 millions, thus also the accident figures are small and their annual statistical changes significant. Second- information available on safety measures usage is limited or with big losses.

One of the measures which still could be analysed is the seat belt usage. Here we can find both information on seat belt usage in real traffic and in accident cases.

Even there is a big number of unregistered seat belt information; it allows making some preliminary conclusions on seat belt efficiency.

Seat-belt usage effect has been studied worldwide. Among young adult drivers in New-Zealand seatbelt use was reported as “always” or “nearly always” by 87% of the males and 95% of the females, but as a rear seat passenger it was 34% for males and 47% for females. (Begg, Langley, 1999). Another study provided among police officers in south-eastern US included work related and non-work related seatbelt usage information (Oron-Gilad et al., 2005). Factor analysis revealed five influential and significant factors; (1) travel context, (2) crime context, (3) confidence in seatbelt design, (4) speed and distance of travel, and (5) seatbelt ergonomics. These results confirm that seatbelts themselves in police cruisers currently represent a real safety concern of police officers in high threat circumstances.

An earlier study from 1980ies reports that Swedish and U.S. subjects judged their own driving skills and safety in relation to other drivers and as in earlier studies, most subjects showed an optimism bias: a tendency to judge oneself as safer and more skillful than the average driver, with a smaller risk of getting involved and injured in an accident (Svenson et al., 1985). Different measures of the optimism effect were strongly correlated with one another, with driving experience and with the judged importance of human factors (as opposed to technical and chance factors) in causing accidents. Degree of optimism was positively, but weakly, correlated with reported seatbelt usage and worry about traffic accidents. Seatbelt usage was positively related to the extent to which belts are judged to be convenient and popular, and more modestly related to the belt's perceived contributions to safety. These results suggest that providing more information about the effectiveness of seatbelts may not be as efficient a way of increasing seatbelt usage as emphasizing other factors, such as comfort and social norms, which cannot be outweighed by optimism.

Predictors of using seatbelt and other safety measures were studied in Spanish high risk injury area (Babio, G.O., Daponte-Codina, A. 2006). Data from a cross-sectional survey was analyzed. The behaviors were explored as dichotomous variables. The educational level and community size measured by number of inhabitants were directly associated with all the behaviors studied. Females were more likely than males to use seatbelts and less likely to ride a motorcycle. Seatbelt and helmet use increased with age. Those exposed to both traffic in the city and on the road were more likely to use seatbelt and helmet than those only exposed in the city. Other variables included in any of the models were: being married or living with a partner, health-related variables as smoking habit, wealth-related variables as home ownership, and an ecological measure of wealth that is the average family income of the community.

The reasons why seatbelt legislation did not achieve the expected reduction in mortality in Japan are reported by (Nakahara et al. 2003). Seatbelt legislation was enacted in Japan in September 1985 and penalties were introduced in November 1986. The driver deaths per vehicle km travelled (D/VKT) were calculated to adjust for changes in traffic volume. Decreases in D/VKT were compared with the reduction expected after legislation. The association between percentage changes of driver D/VKT, seatbelt use rate, and seatbelt non-use rate were explored. Although the decrease in D/VKT after the law was enforced was larger than the absolute number of deaths, it was far less than predicted. The percentage decrease in seatbelt non-use rate showed the strongest correlation with the percentage decrease in driver mortality. Mortality did not increase among other road users after the law was enacted.

A study to determine and clarify the relationship between young drivers' intentions (motivation to use/non use seatbelt) and their behaviour (self-reported use) is reported by Chliaoutakis et al (2000). Also, the study evaluated the seatbelt wearing rates among young drivers in relation to their trip-type. The sample consisted of 200 young Greek drivers of both sexes. The statistical analysis included factor analysis and multiple regression analysis. The seatbelt use was measured in relation with seven trip-types. Through factor analysis, a seven factor scale of seatbelt use and a four factor scale of seatbelt non use were created which included Greek young drivers' basic motivations for wearing or not wearing a seatbelt. A model, constructed by the multiple regression analysis, revealed the factors related with the seatbelt use. The factors positively related were 'imitation', 'self-protection', and 'legality'. The factor of 'discomfort' is negatively associated with the seatbelt use. Furthermore, mileage was negatively related with seatbelt use.

Janssen (1994) has shown that drivers adopt slightly higher speeds and shorter following distances over the year after they switch from non-use to use of seat-belts. The question does such behavioural adaptation continue to grow, so that the benefit for seat-belt users becomes dubious was addressed by Reinhardt-Rutland (2001). One problem in answering this is reported to be the weak theoretical basis of behavioural adaptation. In the paper, Reinhardt-Rutland develops Fuller's learning model as an alternative. The sharp braking associated with near-misses and other circumstances pitches an unbelted motorist towards the internal fittings of the automobile, thus eliciting rapidly accelerating visual expansion leading to defensive and fear responses. This looming phenomenon acts as a negative reinforcer by which safer driving behaviours become learnt. Seat-belt use removes looming. Learning due to negative reinforcement is persistent, so those switching from non-use to use of seat-belts only lose their safer driving behaviours over a long time. Also, in the years after seatbelt legislation is introduced increasing numbers of new licence-holders will have always used seat-belts, so looming will never affect their learning. The analysis suggested that seat-belt use has dubious long-term effectiveness for motorists, while engendering a more dangerous roadway environment for non-motorists.

2. Material and methods

European SARTRE 3 (Social Attitudes to Road Traffic Risk in Europe) study was launched in 2002 following the two first similar projects, and this time already a number of new EU countries participated, including Estonia. SARTRE is a research project which aims to study the opinions and reported behaviour of car drivers throughout the European continent. The project is based on ad hoc gathering of data, which involves a representative questionnaire survey.

Within the project an extensive questionnaire was provided that included also questions on seatbelt — usage and data from this study was used for current paper.

Descriptive statistics and regression analysis is used to analyse the data.

3. Results and discussion

3.1. Road users' knowledge and attitudes

When analysing the road users' knowledge and attitudes towards the seat belt usage, we can sum up that there is no doubts about seat belt usage safety effect among Estonian drivers. Information based on European SARTRE 3 questionnaire study (INRETS 2004) shows, that more than 90 per cent of Estonian road users agree that seat belt usage can reduce the risk of road accident.

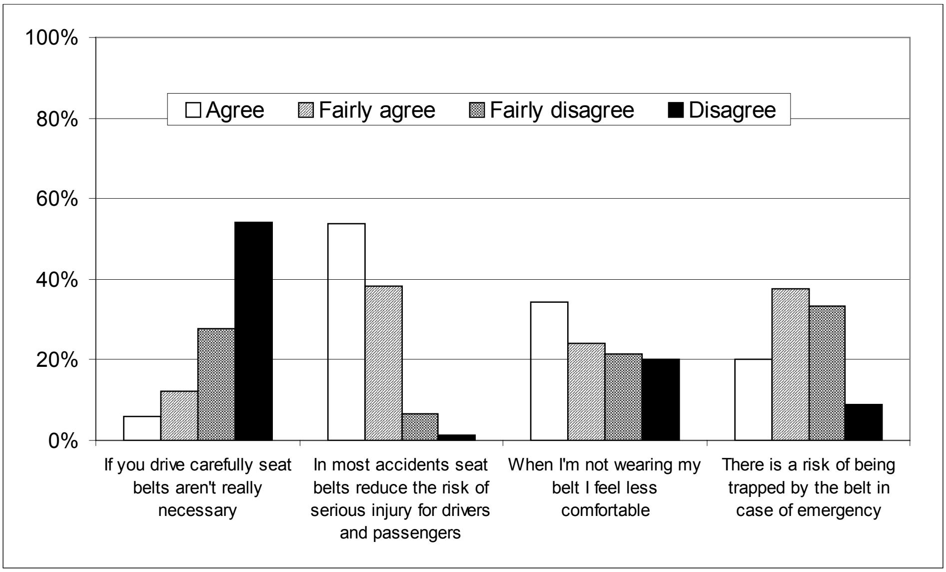


Figure 1. Drivers' attitudes towards the seat belt usage in Estonia.

Drivers' and motor vehicle occupants' knowledge does not mean much when the measures are not actually followed by road users themselves. This is also a case of Estonia. Thus there is a conflict between drivers' answers on question: When driving the car, how often do you wear the seat belt when making a journey on country roads? And the field survey data of seat belts usage. 80 per cent of drivers answered the question, that they wear seat belts always or very often.

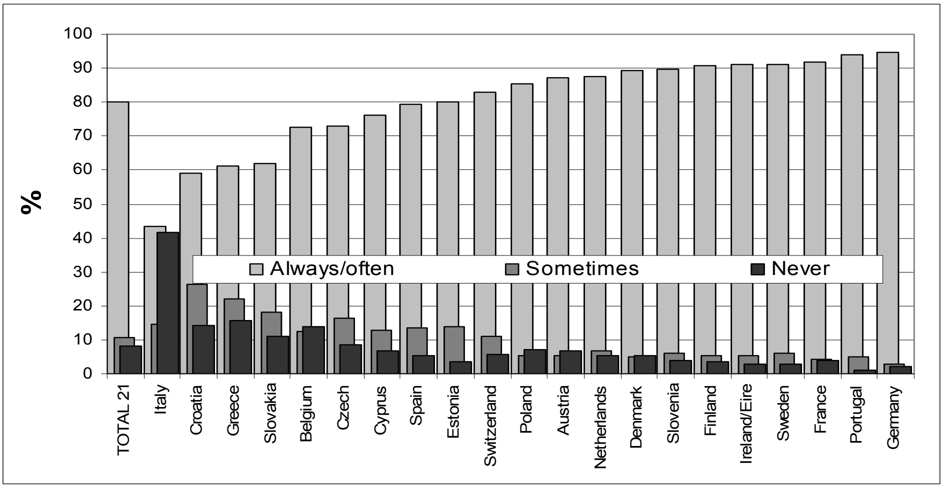


Figure 2. Drivers' self response on seat belts usage when driving on country roads in Europe.

Since 1999 the seat belt usage has been regularly surveyed in Estonia (LiMo 2004). The general information on seat belt usage rates could be seen in the following figures. Due to these surveys the seat belts usage has developed remarkably, but when comparing with some neighbouring countries the seat belt usage remains to be rather low, especially on back seat and urban driving.

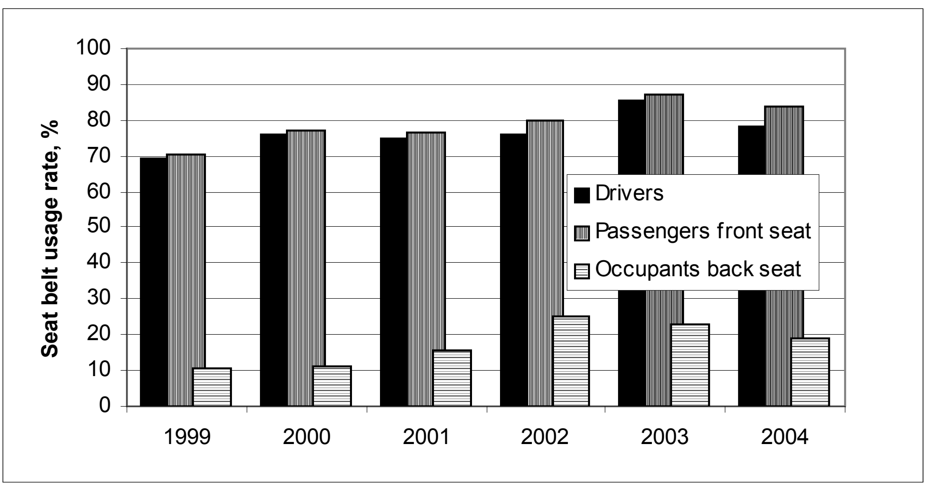


Figure 3. Seat belt usage rate development, 1999–2003 [2].

Table 1. Seat belt usage among persons involved in casualty accidents

Seat belts:	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003
Fastened	39%	40%	26%	26%	17%	16%	17%	24%	21%	22%	30%	34%	35%	44%
Non fastened	45%	36%	49%	52%	42%	41%	31%	38%	30%	40%	38%	29%	28%	26%
No equipped	15%	24%	24%	22%	11%	9%	7%	4%	4%	5%	2%	3%	2%	2%
No information	0%	0%	0%	1%	29%	34%	45%	34%	46%	33%	30%	35%	36%	28%

3.2 Seat belt use and road accidents

Information on seat belts usage among persons being involved in road accidents has much longer history, but unfortunately especially last ten years information is with big misses. Still we can try to make some analysis on seat belt usage safety effect.

When comparing the severity of road accident with the number of casualty accidents, considering that the bigger ratio indicates the higher fatality risk, we can draw picture as shown on the figure.

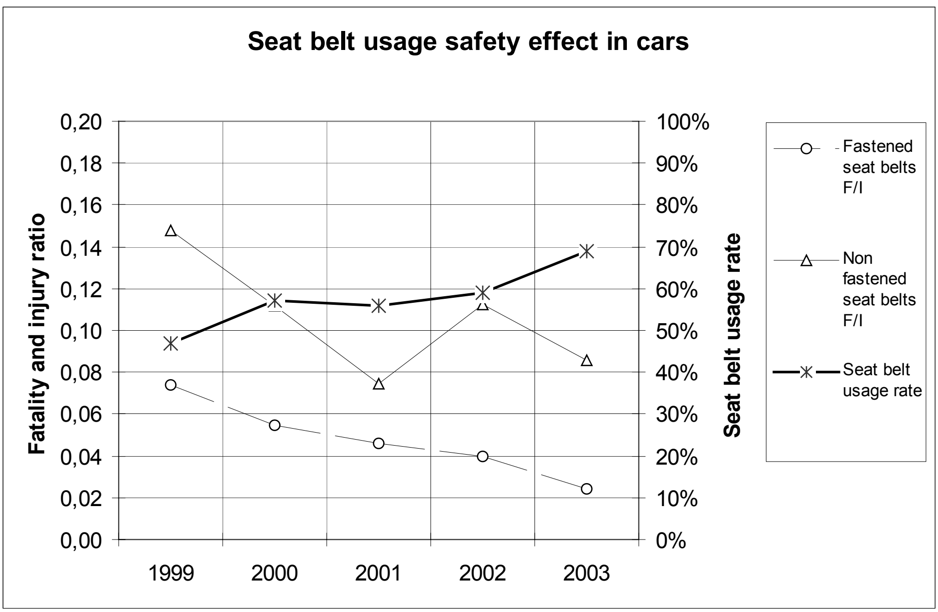


Figure 4. Seat belt usage safety effect in cars.

Based on information shown on the figure, we can finalize that the severity of road accidents has been constantly decreasing together with seat belts rate increase among the persons, involved in accidents with fastened seat belts. Same time, this connection among persons with non fastened seat belts remains unclear. From one hand, this could be explained by different usage rates on front and back seats, indicated below.

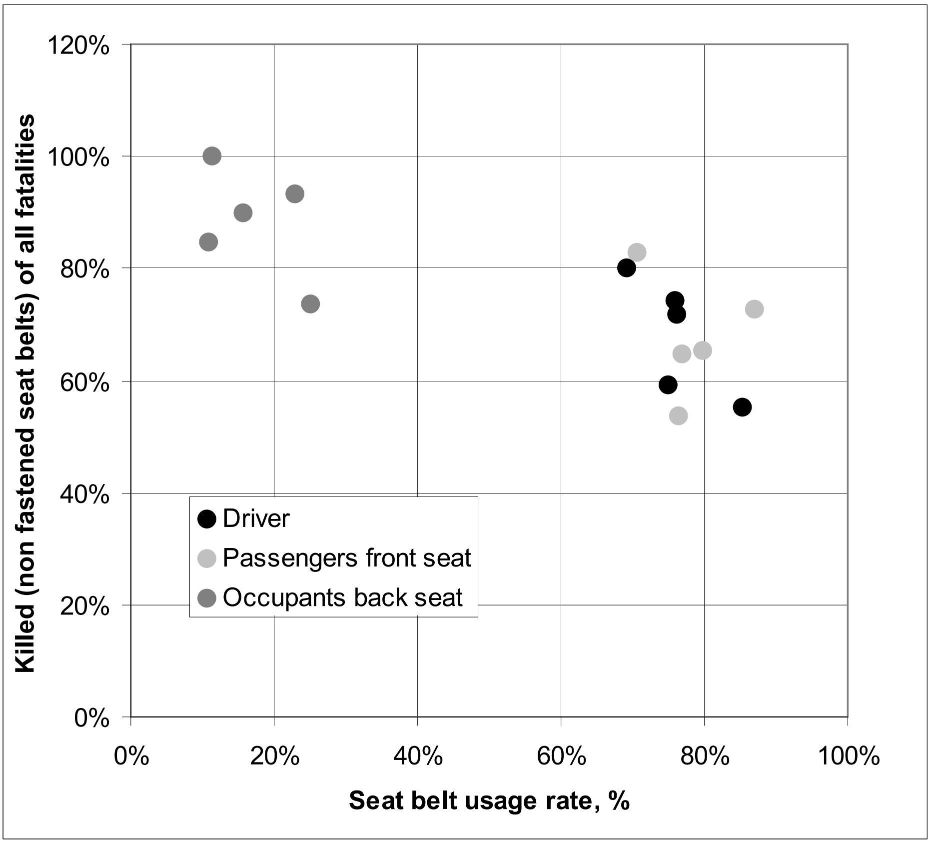


Figure 5. Fatality risk and seat belts usage rates.

There is statistically significant relationship between the seat belt usage rate and fatality risk.

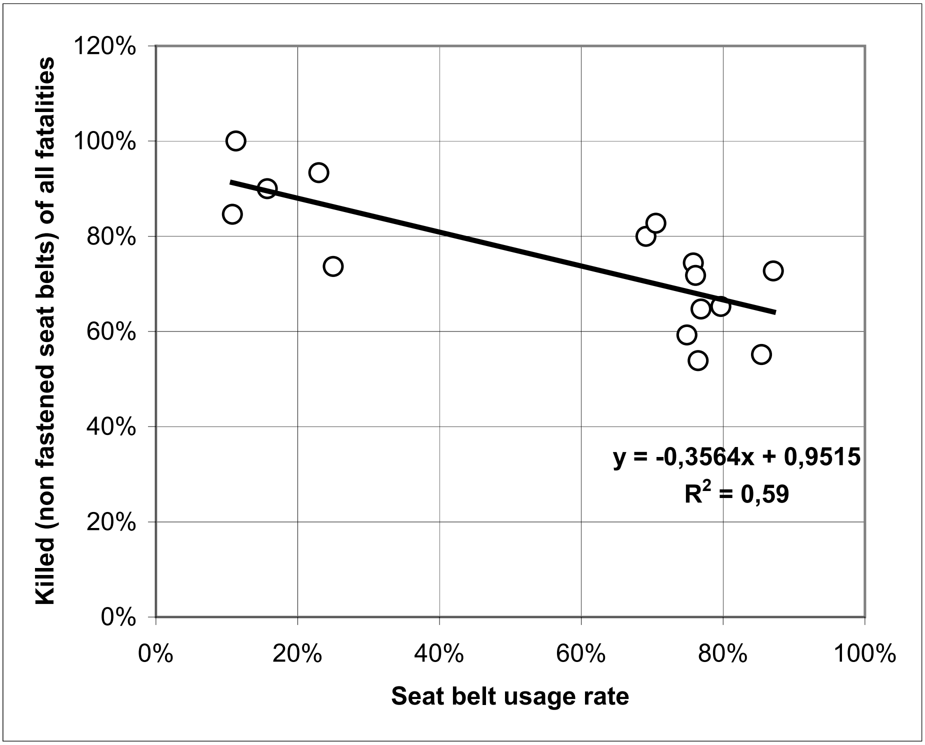


Figure 6. Relationship between seat belt usage and fatality risk.

Even the analysis is based on rather few information, we can summarize that there does exist a clear connection between the accident severity and seat belt usage rates. Thus a seat belt usage growth has had a remarkable effect on safety improvement in Estonia. When all drivers and passengers would use seat belts, it will be possible to decrease the number of fatalities more by 10 … 30 per cents.

Table 2. Seat belt safety effect (%) [3].

Type of road user and accident result	Best result	In most cases
Drivers		
Fatality	–50	–55 …–45
Severe injury	–45	–50…–40
Passengers at front seat		
Fatality	–45	–55…–35
Severe injury	–45	–60…–30
Occupants at back seat		
Fatality	–25	–35…–15
Severe injury	–25	–40…–10

This result is very much in harmony with some international studies. For example, Norwegian literature study (Elvik 1997) of the safety effect of many safety measures has shown the effect as shown in table below:

ICF Consultancy together with Imperial College Centre for Transport Studies in London have performed a statistical model of preventive effect of three main important road safety measures- speeding, drunk driving and seat belt usage. The results of this study concerning seat belt usage is given in table 3.

Table 3. Impact of seat belt non-use on crash casualties (source: ICF Consultancy, 2003).

Member State	Vehicle occupant casualties		Non-use among crash casualties%	Preventable casualties with 100% use	
	Fatalities	Injuries		Fatalities	Injuries
Austria	640	49504	45	143	11064
Belgium	813	70630	61	247	21509
Denmark	261	9178	62	80	2828
Finland	254	8967	34	43	1520
France	5104	313756	30	766	47064
Germany	5214	361700	32	838	58114
Greece	1271	32261	84	532	13492
Ireland	226	11962	48	54	2880
Italy	3736	264321	85	1590	112499
Luxembourg	43	1699	61	13	517
Netherlands	557	50051	52	144	12969
Portugal	1187	57982	37	220	10770
Spain	3531	128578	48	851	30970
Sweden	339	27401	25	43	3486
United Kingdom	1811	294030	31	276	44888
Totals	**24987**	**1682020**	**49**	**5840**	**374570**

If using the similar model for Estonian situation, taking account information about seat belt usage in fatal accident situations and usage level in general we can get a result that if achieving 100 per cent level of usage 20 fatalities and near 400 injuries could be saved annually in Estonia, which is about 12% of road casualties!

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CURRICULUM VITAE

Dago Antov

Date and
place of birth: July, 25, 1956, Tallinn, Estonia
Nationality: Estonian
Contact address: Stratum OÜ, Juhkentali 34, 10132 Tallinn, Estonia
e-mail: dax@stratum.ee

Qualifications

- Dipl.Eng Civil Engineer, Chair of Road Engineering, Tallinn Technical University 1979
- MSc, Geoinformatics and Cartography, Institute of Geography, University of Tartu, 1998

Professional activities

1979–1988 Tallinn Technical University, Tallinn, Estonia
Head of Road and Traffic Laboratory

1988 to present: Stratum OÜ, Head of the Board, and Project manager
Project leader at a number of traffic and transportation safety projects, local team leader for a number of international projects.

Training projects

- Advanced International Training Programme on Traffic Safety Management for Central and Eastern Europe. Swedish National Road and Transport Research Institute, Linköping, Sweden, 1997
- Certificated Road Safety Auditor. Road Safety Audit training programme. TMS Consultancy, University of Warwick, Science Park, Coventry, UK, 2002

Educational activities:

- Lector of Transportation Geography in University of Tartu, 2003 – to present
- Lector of Roads and traffic planning, Estonian Academy of Arts, Faculty of Architecture, 2006

Memberships

- Member of ICTCT, the International Co-operation on Theories and Concepts in Traffic Safety since 1990. Vice President of ICTCT, since 2004.

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CURRICULUM VITAE

Dago Antov

Sünniaeg ja koht:	25.07.1956 Tallinn, Eesti
Kodakondsus:	Eesti
Kontaktaadress:	Stratum OÜ
	Juhkentali 34, 10132 Tallinn
e-post:	dax@stratum.ee

Hariduskäik

1974	Tallinna 46.Keskkool
1979	Dipl.Eng Ehitusinsener Autoteede erialal, Tallinna Polütehniline Instituut, Ehitusteaduskond
1997	Advanced International Training Programme on Traffic Safety Management for Central and Eastern Europe. Swedish National Road and Transport Research Institute VTI, Linköping, Rootsi
1998	MSc, Geoinformaatika ja kartograafia, Tartu Ülikool, Bioloogia-Geograafiateaduskond, Geograafiainstituut
2002	Certificated Road Safety Auditor. Road Safety Audit training programme. TMS Consultancy, University of Warwick Science Park, Coventry, UK

Töökäik

1979–1988	Tallinna Polütehniline Instituut, Autoteede kateeder nooremteadur, teadur; Teede ja Liikluse TU labori juhataja
1988–2006	Inseneribüroo Stratum (Stratum OÜ). Juhatuse esimees, projektijuht

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Uurimistööde aruanded, mis on koostatud Inseneribüroos Stratum Dago Antovi juhtimisel:

19 Rapla maakonna liiklusohutusprogramm. Tallinn 2001.

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22 Tallinna liiklusõnnetuste kohtanalüüs. Tallinn 2002.

23 Fooriprogrammide ja -parameetrite mõju liiklusohutusele. Tallinn 2003

24 Liiklusohutusliku olukorra uuring: Eakad liikluses. Lõpparuanne. Tallinn 2003

25 Kooliõpilaste koolitee ohutustamine. Tallinn 2003

26 Liiklusõnnetuste asukoha määratlemise pilootprojekti laiendamine kogu Eestile. Tallinn 2003

27 Tallinna linna liikluskeskkonna ohutus ja selle võimalikud arengud. Tallinn 2003.

28 Liiklusohutuse audit Aardla – Soinaste – Raudtee tänavate ristmiku rekonstrueerimise eskiisprojektile. Tallinn 2003.

29 Abinõude valik jalakäijate ja jalgratturitega toimunud liiklusõnnetuste ning neis kannatanute arvu vähendamiseks: II etapp. Lõpparuanne. Tallinn 2004

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37 31 Liiklusõnnetuste arvu ja liiklusalaste õigusaktide seose analüüs. Tallinn 2004

32 Liiklusohutuse audit Tallinn – Tartu – Luhamaa maantee Tartu – Reola lõigul. Tallinn 2004

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