PEDESTRIANS' ROLE IN ROAD ACCIDENTS

Loreta Levulytė[1], David Baranyai[2], Edgar Sokolovskij[3], Ádám Török[4]

[1,3] *Vilnius Gediminas Technical University, J. Basanavičiaus g. 28, Vilnius, Lithuania*

[2,4] *Budapest University of Technology and Economics, Muegyetem rkp. 3, Budapest, Hungary*

Abstract: Nearly 1.3 million people die in road crashes each year, on average 3,287 deaths a day. In 2013 in European Union more than 22 % of all who died in road traffic crashes were pedestrians. The number of pedestrians killed on roads in the EU has decreased by only 11 %, compared to the total fatality decrease of 18 % from 2010 to 2013. Of all pedestrian fatalities, 69 % are killed inside urban areas. This paper reviews the literature concerning pedestrian-motor vehicle collision and road safety management according to pedestrian role in accident rise. Paper examine pedestrians safety in order to determine what kind of factors of transport infrastructure, vehicle technical parameters, pedestrian behaviour and road or street category have the influence on pedestrian and vehicle accidents and identify technical reasons of accidents rise. Pedestrians crossing, crossing selection, crossing design and waiting times present the pedestrian role in accident according to road situation. A review is conducted of information in the literature on the injury outcome of a pedestrian/vehicle collision for a given impact speed and the likely consequences of reducing the travelling speeds of vehicles in terms of the frequency and severity of pedestrian injuries. Technical information found gives the opportunity to improve accident reconstruction cases and technical parameters, also it let to identify road infrastructure problems and pedestrian behaviour in road.

Keywords: pedestrian safety, accident, forensic science, pedestrian crashes; road infrastructure, injuries.

1. Introduction: Background of Vehicle–Pedestrian Accidents

Road traffic accident analysis require to conduct in-depth collision analysis and identify the collision causation and contributing factors in different types of collisions, including the role of the driver(s), pedestrians, vehicle(s), roadway and the environment. Results from accident reconstructions are useful in developing recommendations for making roads safety, transport infrastructure improving safety aspects also on motor vehicle designs

improving. This paper is concentrated on pedestrian-vehicle collision in case to identify the pedestrian role in accident and technical reasons of accidents. A pedestrian, as defined for the purpose of this article, is any person on foot, walking, running, jogging, hiking, sitting or lying down who is involved in a motor vehicle traffic crash.

Walking transport modes where relatively unprotected road users interact with traffic of high speed and mass. This makes pedestrians vulnerable. They suffer the most severe consequences in collisions

---

[1] Corresponding author: loreta.levulyte@vgtu.lt

with other road users because they cannot protect themselves against the speed and mass of the other party (Piatkowski et al., 2015). Collisions between pedestrians and bicyclists or motor vehicles are a major problem in countries that are becoming motorized, and in which there are high rates of walking and bicycling (Haleem et al., 2015). Pedestrians are commonly referred to as vulnerable road users because in collisions with motor vehicles the lack of a protective structure and differences in mass height and make their injury susceptibility. Protecting them is a challenge, because road infrastructure typically have been built for motor vehicles, with little attention to those that moving on foot who may wish to travel on or alongside roads, or cross them, or change direction at intersections (Shinar, 2012).

2. Pedestrians Fatalities

In terms of fatality rate, the most commonly used way of comparing road safety levels among countries; the EU has now reached 51 dead per million inhabitants. Since 2010, the countries with the lowest fatality rates have had a slower than average decrease rate or even a stagnation of the number of road deaths (see Fig. 1).

According to the latest detailed numbers reported by European Commission (Transport and Mobility report, 2015) in 2013, 22 % of all who died in road traffic crashes were pedestrians. The number of pedestrians killed on roads in the EU has

decreased by only 11 %, compared to the total fatality decrease of 18 % from 2010 to 2013. Of all pedestrian fatalities, 69 % are killed inside urban areas.

The majority of these *vulnerable road users* accidents intentions can be influenced by several overarching categories: behavioural, legislative/enforcement, infrastructure/ engineering, and post-crash care/trauma, known as Haddon matrix for crash and injury prevention (Deljavan *et al.,* 2012).

From technical point of view in accident reconstruction, traumatic event pedestrian-vehicle impact is divided into three phases: pre-crash, crash, and post-crash. Simply stated, the pre-crash phase is the prevention phase. The crash phase is that portion of the traumatic event that involves the exchange of energy or the Kinematics (mechanics of energy). Lastly, the post-crash is the patient care phase.

A correct understanding of exposure of crashes and injury risks is needed to save and protect as many pedestrians as possible by using newest technologies and engineering solutions according to law regulations and suggestion for their improving.

Target crash type can be defined or viewed in number of ways. Much of the information from crash data analysis and from reviews of pedestrian safety literature highlight the associations between pedestrian's crash occurrence and transport infrastructure environment type (Havard *et al.,* 2012*)*.

FATALITY RATE PER MEMBER STATE FOR 2010 AND 2014
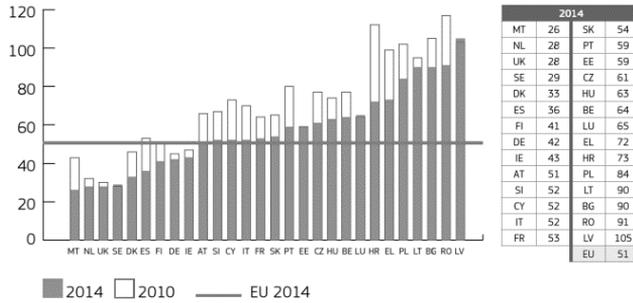
Fig. 1.
Fatality Rate per Member State for 2010 and 2014
Source: CARE (EU road accidents database)

3. Methodology

Nowadays transport and its infrastructure play a great role in people daily life and become a crucial component of modernity. Unfortunately, according to the crash statistics reports more and more pedestrians are involved in traffic accidents. Transportation is increasingly associated with the rise in road accidents and premature deaths, as well as physical and psychological handicaps. Equally significant are the rising costs in health services and the added burden on public finances. Scientist, police, investigators, road traffic accident reconstruction experts are trying to identify reasons of crashes involve pedestrians (Haleem *et al.*, 2015; Liu and Tung, 2014; Shinar, 2012).

Crossings are one of the most important aspects of street design as it is at this location that most interactions between pedestrians, cyclists and motor vehicles occur. Well designed and frequently provided crossings are critical to the balancing of movement priorities. The design of crossings, and the frequency at which they are provided, will have a significant impact on pedestrian/cyclist mobility and comfort and the flow of vehicular traffic (Lobjois *et al.*, 2013).

4. Pedestrian Crossings and Injuries

As it was mentioned, crossings are one of the most important aspects of street design as it is at this location that most interactions between pedestrians and motor vehicles occur.

Three pre-crash scenarios were identified for single-vehicle pedestrian crashes involving the front of the vehicle (Yanagisawa *et al.*, 2014; Kusano *et al.*, 2013):

1. Vehicle travelling straight with a pedestrian crossing;
2. Vehicle travelling straight with a pedestrian moving in-line with traffic;
3. Vehicle turning with a pedestrian crossing.

These three pre-crash scenarios contributed to 215,000 crashes and 12,124 fatalities in the 5-year span. These pre-crash scenarios had 28,000 (13%) crashes in which an object

obstructed the driver's view, resulting in 2,056 (16%) fatalities. Other key findings included the occurrence of 93,000 crashes in non-daylight conditions (9,320 fatalities), 25,000 crashes in inclement weather (1,239 fatalities), and 160,000 crashes on roads with posted speed limit less than 40 mph (4,446 fatalities). Moreover, 33,000 struck pedestrians were under 13 years old (633 fatalities). Finally, vehicle braking was reported in only 21,000 crashes (1,563 fatalities) (Yanagisawa *et al.,* 2014).

(Žuraulis, Sokolovskij, and Matijošius, 2013) investigated the braking and deceleration processes as the most used modes to avoid accident (pre crash phases). Levulytė *at al.,* (2014) found that road surface and it's condition correlate with the maximum allowable driving speed and its limiting, while the performance of the vehicle's stability and has influence on braking distance (Sokolovskij and Prentkovskis, 2013).

Road safety education (RSE) assumes that psychological determinants predict risk behaviour, and subsequently that risky road behaviour predicts crash involvement. Contributory factors to pedestrian impacts with vehicle are various. The 11 most frequent contributory factors for the 107 pedestrian accidents was analysed by Cuerden *et al.,* (2007). The results of analysis are presented in Table 1 and this shows that the main contributory factor to pedestrian impact is „Fail to look" – 21.5 % of case.

Table 1

Contributory Factors to Pedestrian Impacts

Contributory Factor	No. of case	% of case
Failed to look	23	21.5
Inattention	21	19.6
Carelessness, reckless or thoughtless	20	18.7
Cross from behind parked car	16	15.0
Ignored lights at crossing	10	9.3
Surroundings obscured by stationary or parked car	10	9.3
Failure to judge other by persons path or speed	8	7.5
Impairment through alcohol	7	6.5
In a hurry	7	6.5
Person hit wore dark or inconspicuous clothing	3	2.8
Lack of judgement of own path	3	2.8

A remarkable finding was that pedestrians focused on only one lane at a time, taking advantage of an adequate gap in each individual lane unlike the usual assumption that pedestrians wait for all lanes to clear before crossing. In contrast to (Yannis *et al.,* 2013) found that distance from the oncoming vehicle was a better determinant for gap acceptance, rather than the vehicle's speed. Other effects associated with the accepted gaps were found as presence of illegally parked vehicles, presence of other pedestrians, and oncoming vehicle's size (Zhang *et al.,* 2015).

Pedestrians' road crossing behaviour has been explained in terms of minimum gap acceptance value by using a rolling gap (pedestrian roll over the small vehicular gaps) Kadali *et al.,* (2013). It has also been

explained by the binary logit model with the help of vehicular gap size, frequency of attempt and rolling gap. The study concludes that the pedestrian behavioural characteristics like the rolling gap, driver yielding behaviour and frequency of attempt plays an important role in pedestrian uncontrolled road crossing. These inferences are helpful for pedestrian facility design and controlling pedestrian safety issues at uncontrolled crossings (Onelcin and Alver, 2014).

Vehicle speed has a great impact on pedestrian safety and there have been many calls for moderating vehicle speeds in areas with high pedestrian activity (Tefft, 2013; Havard *et al.,* 2012). Speed during the impact has a huge influence on pedestrian body motion after impact and on injuries. Fig. 2 illustrates that the probability a pedestrian will be fatally injured rises rapidly then speeds above 35 km/h, with death almost certain at impact speeds of around 55 km/h or higher (Anderson *et. al.,* 1997).
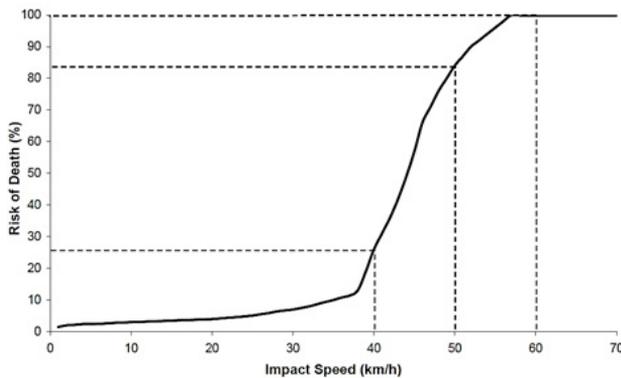
Fig. 2.
Risk of Pedestrian Death as a Function of Vehicle Impact Speed

The location of the initial pedestrian-vehicle contact and the pedestrian rest position deal with modelling of the relationship between throw distance and vehicle speed. Following impact pedestrian then is thrown forward from the vehicle and begins a flight phase. If during accident reconstruction it is possible to identify the point of first impact, from the pedestrian body thrown distance is possible to calculate vehicle speed before the impact (Nishimura *et al.,* 2015).

In order to reconstructed pedestrian's injury biomechanics of pedestrians in vehicle

impacts to compute the impact conditions and to asses injury risk a combination of multi-body simulation software are using. MADYMO software for the pedestrian kinematics and Finites Elements simulation for the Hybrid head impact against the windscreen can be used for conduction (Elliott *et al.,* 2012).

Some studies have also addressed pedestrian road crossing behaviour by considering the effectiveness of educational training programs (Dommes *et al.,* 2012). Studies had identified the importance of the

environmental characteristics, such as type of crossing facility, traffic volume and roadway geometry on road crossing behaviour. Studies have also explored the pedestrian moving road crossing behaviour before and after reconstruction of traffic facility (Havard and Wills 2012).

Accident pedestrian-vehicle collision reconstruction requires to determine the direction of pedestrian before accident also it is very important to know the pace of pedestrian according to his/her age. Usually, the pace of pedestrian is identified from statistical database (Zebala *et al.,* 2012).

The direction of pedestrian moving can be determine according to several evidence. This can be is determine from vehicle damages and pedestrian injuries mechanism, which is determined from complex of road accident reconstruction – medical expertise. This expertise lets identify the pedestrian injury abbreviation. Pedestrians' injuries and rest position after impact depends on vehicle frontal shape and speed before impact and impact speed (Richardson *et al.,* 2015) generalized different linear regression methods for pedestrian collision prediction model (CPM) and development studies on micro-level and macro-level related CPMs are summarized.

In addition, it has been determined that head injuries incurred by pedestrians in side impacts are mainly caused by impact with the road or ground rather than impact with the vehicle (Badea *et al.,* 2013), indicating the limitations of safety technology for this form of interaction between vehicles and vulnerable road users.

For the purpose to determine pedestrian injury patterns and risk on collisions in

Chine 109 real accident case were analysed and it was found sample criteria. The head and chest were the most often injured areas of the body in minibus/pedestrian collisions. The proportion of injuries in the head, extremities, and chest were 84.4%, 52.3%, and 50.5%, respectively. The proportion of head and chest injuries was approximately 1.2 and 1.7 times that of flat-front vehicle-pedestrian injuries reported by Zhao *et al.,* (2013).

5. Crossing and Waiting Time

Nowadays the view of streets by fixed cameras or CCTVs lets to identify pedestrian moving direction and oriental pane from cameras views (Behera *et al.,* 2015).

Very important object during pedestrian-vehicle collision is vehicle speed before impact and during impact. In addition, the speed during impact depends on vehicle moving mode; collision is during vehicle braking or without braking. In addition, vehicle speed depends personally on driver, but transport infrastructure also has influence on vehicle speed and on pedestrian manoeuvres across the road (Žuraulis *el al.,* 2013). There some cases accidents caused by rolling car van injured pedestrian very hard because of vehicle is without driver inside. Lee *et al.,* (2012) showed that when a parked car rolls down on a gentle slope, it can cause a pedestrian fatal accident.

The analysis of physical settings and factors, such as vehicle location, pedestrian location, roadway alignment, roadway profile, atmospheric and light conditions, and surface conditions aim to identify the efficiency of pedestrian crash avoidance/mitigation technology by addressing the most common pedestrian-vehicle crash situations. Both, General Estimates System

(GES) and Fatality Analysis Reporting System (FARS) contain useful information to determine the most frequent and fatal vehicle-pedestrian manoeuvres. Pedestrian crash data in Yanagisawa *et al.,* (2014) study is used as a supplement to the GES and FARS data to help identify pedestrian locations and directions. Prioritization of these pre-crash scenarios aided the development of objective test procedures for pedestrian crash avoidance/mitigation technology (PCAM) systems. The results of the crash analysis and objective tests helped to derive performance measures and predict the potential safety benefits for PCAM systems. Figure 3 shows the contributing factors of pedestrians in FARS fatalities. Approximately 90 percent of pedestrians were included in the categories of "improper crossing of roadway or intersection," "walk, etc., in the road," "dart/run into the road," "not visible," or "failure

to yield." These categories typically involve situations where the driver of the striking vehicle had little time to react. Consequently, more fatalities can occur if the driver does not apply the brakes and has higher impact-speed crashes with the pedestrian (Yanagisawa *et al.,* 2014; Zeng *et al.,* 2013).

A single logistic regression model of the fatalities or Abbreviated Injury Scale (AIS) 3+ injuries risks for pedestrian was developed in terms of vehicle impact speed. The corresponding risk function P(*v*) is (Nie *et al.,* 2012):

$$P(v) = \frac{1}{1+\exp(-a-bv)},\qquad(1)$$

where *v* is the impact speed, and the coefficients, *a* and *b* are estimated using the method of maximum likelihood.
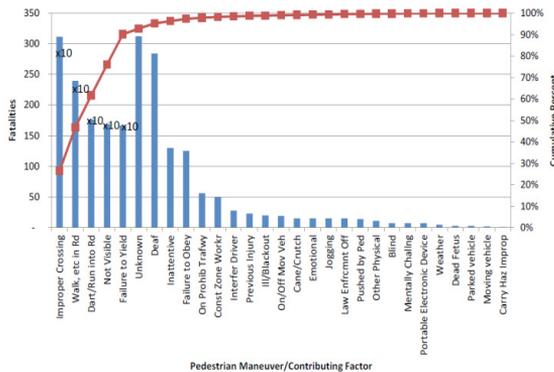
Fig. 3.
Pedestrian Manoeuvres/Contributing Factors Based on FARS (Yanagisawa et al., 2014)

The injury distribution of the pedestrian in the material can be seen in Fig. 4 (Nie *et al.,* 2012). In both AIS1+ (n = 1156), AIS2+ (n =464) and AIS3+ (n = 130) lower extremities are the most frequent injured body region. However, as injury severity increases the proportion of

head and thorax injuries increases too, while injuries on upper extremities decrease. Mobile-phone related injuries among pedestrians increased relative to total pedestrian injuries, and paralleled the increase in injuries for drivers (Nasar and Troyer, 2013).
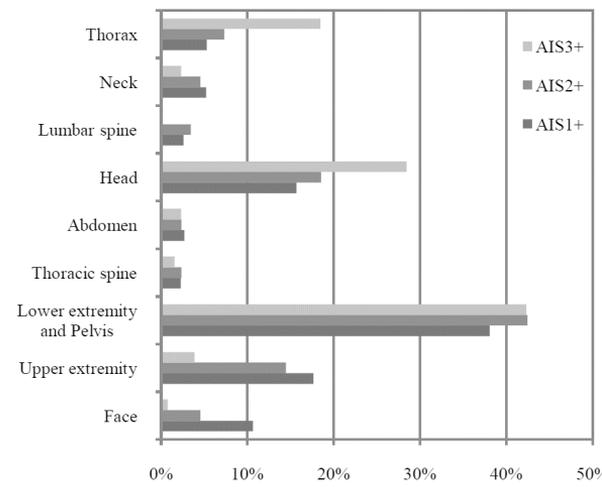
Fig. 4.
Injury Distribution on Body Regions of Pedestrians per AIS level, n = 1156

Each pedestrian intends to cross the road safely, but their perceptions about the chances of crossing the road safely are related to their individual characteristics, and also to the road traffic environments. One of the essential elements of expert opinions on road accidents in which a pedestrian is hit is to perform a time-distance analysis (Zebala *et al.,* 2012; Aziz *et al.,* 2012). This depends on pedestrians' acceleration at the onset of walking or running across a road after traffic lights change at a pedestrian crossing, or after vehicles on a road have gone by.

Pedestrians' unsafe crossing behaviour at different pedestrian crosswalks can be modelled by binary Logistic regression; pedestrian conflicts and crash count models also used to learn which exposure measures and roadway or roadside characteristics significantly influence pedestrian safety at road crossings (Islam *et al.,* 2014). The Poisson, negative binomial (NB), hurdle Poisson (HP), and hurdle negative binomial (HNB) models also let to develop and compare to model the number of pedestrian crashes (Hosseinpour *et al.,* 2013).

6. Infrastructure and Vehicle Technologies

In addition, vehicle safety technologies, such as passive and active in-vehicle safety, have an important role in reducing the number of pedestrian collisions. In the cases when collisions cannot be avoided, active in-vehicle technologies can reduce the severity of the impact and make the pedestrian-vehicle collision not so dangerous for pedestrian life.

All new car models are required to pass numerous tests related to occupant safety before they may be brought into circulation. These tests often differ in different regions of the world. In Europe, the corresponding procedures are laid down in the regulations of the UN Economic Commission for Europe (ECE). ECE R94, for example, describes the test procedure for frontal impact protection, while in ECE R95 the side impact test is defined.

In order to avoid or mitigate this kind of an imminent collision, Autonomous Emergency Breaking (AEB) systems, which variously use lasers, radar or video cameras, activate the brakes and automatically apply them when an imminent collision is detected. The most advanced systems can detect moving pedestrians and cyclists in the path or periphery of the vehicle. These systems can either warn the driver or apply AEB or do both. Intelligent Speed Assistance (ISA) systems also improve the safety of pedestrians and cyclists by increasing speed compliance, particularly in urban areas (Daniel and Lauffenburger, 2014).

There are plenty of analysis pedestrian and vehicle frontal impact simulation and real accident analysis comparison, thus let us better to understand vehicle frontal shape influence on pedestrian injuries and driver possibility to avoid danger situation. Some researchers are done on pedestrian protection and injury evaluation analysis by using correlation method between EuroNCAP pedestrian protection test result scores and injury outcomes in car-to-pedestrian injury collisions according to the frontal shape of vehicle (Strandroth *et al.,* 2014).

Infrastructure also have a substantial effect on pedestrian safety. Studies (Valero *et al.,* 2014) have shown that transportation infrastructure at intersection and non-intersection locations has the impact on pedestrian injury risk. The following factors are pointed out from previous studies. At small intersection along arterial roads where crossing collision accidents occur frequently, about 70% of VNS tend to neglect stopping in front of an intersection.

From a technical point of view, the danger situation for road safety becomes before the emergency situation. This means that during dangerous (pre-crash) situation driver and pedestrian must to do some action in case to avoid accident (braking, stop walking, etc.)

For drivers and pedestrians pre-crash behaviour evaluation is very important to evaluate the road environment. Ukkusuri *et al.,* (2012*)* investigated the link between the frequency of pedestrian–vehicle accidents classified by injury severe types and built environment variables, including land use patterns, demographics, transit characteristics and road network characteristics.

Another part of the scientific researchers work is dedicated for the definition of specifications towards to Human Body Detection (HBD) technologies (Marchal *et al.,* 2015). Therefore, the authors analysed the relationship between the visual field characteristic of both corners of an intersection, and number of accident. Drivers' safety confirmation behaviour was analysed by video survey at intersections with different visibility features. In previous research, the following points were clarified (Wang *et al.,* 2012). On intersections which have bad visibility at the left corner, compared with the right corner, crossing collision accidents occur at a high rate. The rate of safety confirmation of the accidents with motor vehicles driver to left side is about 20% lower than that of the right side.

In order to test the effects of road environment on the chances for pedestrians to enter the road, the following two indicators: (1) existence of right of way control devices, and (2) road location, are tested separately.

The data in Fig. 5 show that there are more chances for the cases to be found as

pedestrian on the road cases when there is traffic control device, clearly it will be arguable that the risk for the encounter is not the same when the pedestrian is on the road with the protection of the traffic control device or not. This means that no matter if there is traffic control device or not, having pedestrian on the road will always increase the risk for the driver; however, the absolute risk and the increased risk in these two scenarios are not comparable (Tian *et al.,* 2014).
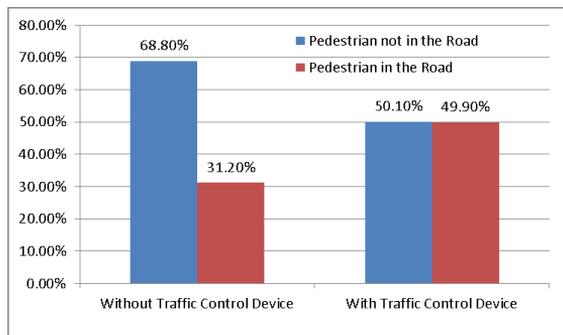
Fig. 5.

Percentages of Cases with Pedestrian on/not on the Road when there is/isn't Traffic Control Devices during the Encounter between Pedestrians and Drivers

Recent year's mostly in-depth analysis of accident reports and human and driver behaviour investigation were done. Very little was reported on HBD (Human Body Detection, ISA (Intelligent Speed Assistant), BAS (Break Assistant System) or AEB (Autonomous Emergency Breaking). According to literature review the graph in Fig. 6 was created to show separately, what is the shift of research fields from 2011 to 2015 is focus on pedestrian safety (see Fig. 6).
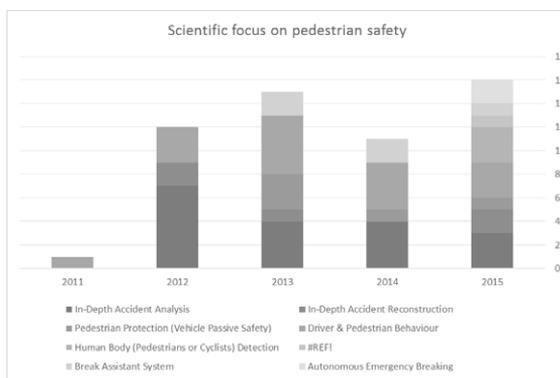
Fig. 6.

Shift in Research Fields: Scientific Focus on Pedestrian Safety

(Kajackas *et al.,* 2015) presents Vehicular Ad Hoc Network (VANET) system based on an analysis of the movement of a motorcade in an emergency situation. This analysis seeks to answer the question: when and under what conditions Emergency Message (EM) sent by Vehicle-to-Vehicle (V2V) system reaches the final target to help in preventing of serious accidents, such as multi-vehicle collisions. The model of calculation based on the key principles of vehicle braking enables finding the time to possible collision and the residual velocity of the vehicle. It is found what vehicle of the motorcade stops before the possible obstacle on emergency braking. Recent years mostly in-depth analysis of accident reports and human and driver behaviour investigation were done. As Fig. 7 illustrates in pedestrian safety very little scientific articles were reported on HBD (Human Body Detection, ISA (Intelligent Speed Assistant), BAS (Break Assistant System) or AEB (Autonomous Emergency Breaking) (see Fig.7).
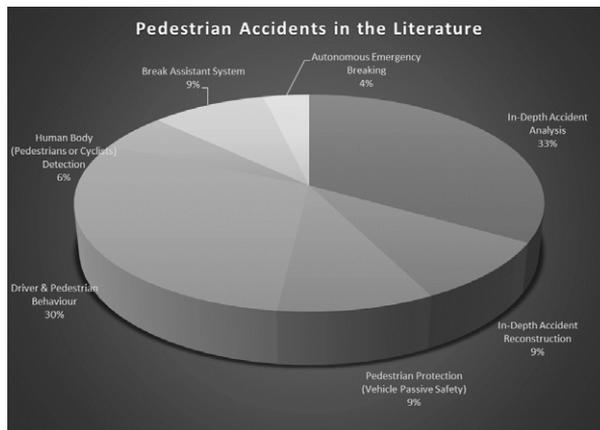
Fig. 7.
Distribution of Pedestrian Accident Research Fields

7. Conclusions

Many studies on vehicle-to-pedestrian collisions have been conducted and pedestrian protection has become an increasing concern in the world. This review of literature shows that there is not a single strategy how reduce pedestrian fatalities – it is a comprehensive approach employing engineering, education and enforcement with the focus on both driver and pedestrian. By review point was founded, that one of suggestion, for achieving traffic safety according to reduce the number of pedestrian fatalities in urban area, would be to use intelligent transport system for detecting pedestrians from imagine/video/ moving sensors with aim to alert drivers about pedestrian approach. In fact, vehicle frontal shape and smarter materials of vehicle body would reduce the severity of injuries and avoid fatalities, bur this depends on law database for vehicle manufactures. A lot of researches about pedestrian behaviour and crossing possibilities were analysed in reviewed articles and all of them are

related with system vehicle-infrastructure-pedestrian. Literature review let to realise that more accurate real-time traffic information changing between traffic involved persons may would let to avoid pedestrians participation in accidents. According this vehicular ad hoc networks (VANETs) offer a promising way to achieve pedestrian-vehicle goal to avoid accident by using a group of VENET's system: Vehicle-to-Vehicle (vehicles communicate either directly with other vehicles or through intermediary vehicles), Vehicle-to-Infrastructure (messages are transmitted between vehicles and road-side units located on nearby arterial road intersections or highway on-ramps), Vehicle-to-Pedestrian (messages are transmitted between vehicles and pedestrians who send and receive messages via their phones or other wireless devices). Based on the review it can be stated that from statistical analysis or surveying currently the research focus moved to ISA, BAS or AEB towards. These are the new research areas.

References

Aziz, H.A.; Ukkusuri, S.V.; Hasan, S. 2012. Exploring the determinants of pedestrian–vehicle crash severity in New York City, *Accident Analysis Prevention* 50: 1298-1309.

Badea-Romero, A.; Lenard, J. 2013. Source of head injury for pedestrians and pedal cyclists: striking vehicle or road, *Accident Analysis & Prevention* 50: 1140–1150.

Behera, R.K.; Gangadharan, J.; Kutty, K.; Nair, S.; Vaidya, V. 2015. A Novel Method for Day Time Pedestrian Detection, *SAE International Journal of Passenger Cars-Electronic and Electrical Systems* 8(2):406-412.

Brenac, T.; Perrin, C.; Canu, B.; Magnin, J.; Canu, A. 2015. Influence of Travelling Speed on the Risk of Injury Accident: a Matched Case-Control Study, *Periodica Polytechnica Transportation Engineering* 43(3):129-137.

Calvey, J.C.; Shackleton, J.P.; Taylor, M.D.; Llewellyn, R. 2015. Engineering Condition Assessment of Cycling Infrastructure: Cyclists' Perceptions of Satisfaction and Comfort, *Transportation Research Part A: Policy and Practice* 78: 134–143.

Cuerden, R.; Richards, D.; Hill, J. 2007. Pedestrians and Their Survivability at Different Impact Speeds. In *Proceedings of the 20th International Technical Conference on the Enhanced Safety of Vehicles* (Paper No. 07-0440). Lyon, France, June 18-21, 2007.

Deljavan, R.; Sadeghi-Bazargani, H.; Fouladi, N.; Arshi, S.; Mohammadi, R. 2012. Application of Haddon's matrix in qualitative research methodology: an experience in burns epidemiology, *International Journal of General Medicin*e 5: 621-7.

Dommes, A.; Cavallo, V.; Vienne, F.; Aillerie, I. 2012. Age-related differences in street-crossing safety before and after training of older pedestrians, *Accident Analysis & Prevention* 44(1): 42–47.

Elliott, J.R.; Lyons, M.; Kerrigan, J.; Wood, D.P.; Simms, C.K. 2012. Predictive capabilities of the MADYMO multibody pedestrian model: Three-dimensional head translation and rotation, head impact time and head impact velocity, *Proceedings of the Institution of Mechanical Engineers, Part K: Journal of Multi-body Dynamics*, 226(3): 266-277.

Haleem, K.; Alluri, P.; Gan, A. 2015. Analyzing Pedestrian Crash Injury Severity at Signalized and Non-Signalized Locations, *Accident Analysis & Prevention* 81: 14–23.

Havard, C.; Willis, A. 2012. Effects of installing a marked crosswalk on road crossing behaviour and perceptions of the environment, *Transportation Research Part F: Traffic Psychology and Behaviour* 15(3): 249–260.

Hosseinpour, M.; Prasetijo, J.; Yahaya, A.Sh.; Ghadiri, S.M.r. 2013. A Comparative Study of Count Models: Application to Pedestrian-Vehicle Crashes Along Malaysia Federal Roads, *Traffic Injury Prevention* 14(6): 630-638.

Islam, M.S.; Serhiyenko, V.; Ivan, J.N.; Ravishanker, N.; Garder, P.E. 2014. Explaining Pedestrian Safety Experience at Urban and Suburban Street Crossings Considering Observed Conflicts and Pedestrian Counts, *Journal of Transportation Safety & Security* 6(4): 335-355.

Kadali, B.R.; Vedagiri, P. 2013. Modelling pedestrian road crossing behaviour under mixed traffic condition. *European Transport* 55(3): 1-17.

Kajackas, A.; Žuraulis, V.; Sokolovskij, E. 2015. Influence of VANET system on movement of traffic flows in emergency situations, *PROMET – Traffic&Transportation* 27 (3): 237–246.

Kusano, K.D.; Gabler, H.C. 2013. Pre-Crash Scenarios for Determining Target Populations of Active Safety Systems. In *Proceedings of the 23rd International Technical Conference on Enhanced Safety of Vehicles (ESV)* (paper number 13-0078). Seoul, South Korea.

Liu, Y. C.; Tung, Y.C. 2014. Risk Analysis of Pedestrians' Road-Crossing Decisions: Effects of Age, Time Gap, Time of Day, and Vehicle Speed, *Safety Science*, 63: 77–82.

Lee, Y.; Sungji, P.; Seokhyun, Y.; Youngsu, K.; Jae-Mo, G. 2012. Pedestrian Accident Analysis With A Silicone Dummy Block, *Forensic Science International* 220(1–3): e13–e16.

Levulytė, L.; Žuraulis, V.; Sokolovskij, E. 2014. The research of dynamic characteristics of a vehicle driving over road roughness, *Eksploatacja i Niezawodnosc – Maintenance and Reliability* 16(4): 518–525.

Lobjois, R.; Benguigui, N.; Cavallo, V. 2013. The Effects of Age and Traffic Density on Street-Crossing Behavior, *Accident Analysis & Prevention* 53: 166–75.

Marchal, P.; Gavrila, D.M.; Letellier, L.; Meinecke, M.M.; Morris, R.;Töns, M. 2015. SAVE-U: An innovative sensor platform for Vulnerable Road User protection. *Intelligent Transport Systems and Services* 2:21-28.

Nasar, J.L.; Troyer, D. 2013. Pedestrian injuries due to mobile phone use in public places, *Accident Analysis Prevention* 57: 91-95.

Nishimura, N.; Simms, C.K.; Wood, D.P. 2015. Impact characteristics of a vehicle population in low speed front to rear collisions, *Accident Analysis & Prevention* 79: 1–12.

Jin, N., Guibing, L., Jikuang, Y., Xuenong, Z., Chao, Z., Xiaoping, Y., ... & Meichuan, W. (2012). A Study of Injury Risk of Bicyclist and Pedestrian in Traffic Accidents in Changsha of China. In Proc. of *5th International Conference on ESAR*.

Onelcin, P.; Alver, Y. 2014. Pedestrian Behaviour at Signalized Intersections in Izmir, Turkey, In *Proceedings of International Conference on Traffic and Transport Engineering - ICTTE2014,* November 27-28, Belgrade, Serbia, 801-806.

Piatkowski, D.P.; Krizek, K.J.; Handy, S.L. 2015. Accounting for the Short Term Substitution Effects of Walking and Cycling in Sustainable Transportation, *Travel Behaviour and Society* 2 (1): 32–41.

Richardson, S.; Moser, A.; Orton, T.L.; Zou, R. 2015. *Simulation of Vehicle Lateral Side Impacts with Poles to Estimate Crush and Impact Speed Characteristics*. SAE Technical Paper No. 2015-01-1428.

Shinar, D. 2012. Safety and Mobility of Vulnerable Road Users: Pedestrians, Bicyclists, and Motorcyclists, *Accident Analysis & Prevention* 44(1): 1-2.

Strandroth, J.; Rizzi, M.; Strenlund, S.; Lie, A.; Tingvall, C. 2011. The Correlation between Pedestrian Injury Severity in Real Life Crashes and Euro NCAP Pedestrian Test Results, *Traffic Injury Prevention* 12(6): 604-13.

Sokolovskij, E.; Prentkovskis, O. 2013. Investigating traffic accidents: the interaction between a motor vehicle and a pedestrian, *Transport* 28 (3): 302–312.

Tefft, B.C. 2013. Impact speed and a pedestrian's risk of severe injury or death, *Accident Analysis and Prevention* 50: 871–878.

Tian, R., Li, L., Yang, K., Chien, S., Chen, Y., & Sherony, R. (2014, June). Estimation of the vehicle-pedestrian encounter/conflict risk on the road based on TASI 110-car naturalistic driving data collection. In *Intelligent Vehicles Symposium Proceedings*, 2014 IEEE (pp. 623-629). IEEE.

Ukkusuri, S.V.; Miranda-Moreno L.F.; Ramadurai, G.; Isa-Tavarez, J. 2012. The role of built environment on pedestrian crash frequency, *Safety Science* 50: 1141–1151.

Wang, N.; Mitani, T.; Yamanaka, H. 2012. An analysis between driver's visual field and bicycle accidents or vehicle's behaviour at unsignalized small intersection on the arterial road, *Journal of Japan Society of Traffic Engineering* 32(33). (in Japanese).

Valero, C. F. F., & Puerta, C. P. (2014). Identification of the Main Risk Factors for Vulnerable Non-motorized Users in the City of Manizales and Its Relationship with the Quality of Road Infrastructure. *Procedia-Social and Behavioral Sciences*, 162, 359-367..

Yanagisawa, M.; Swanson, E.; Najm, W.G. 2014. Target crashes and safety benefits estimation methodology for pedestrian crash avoidance/mitigation systems. (Report No. DOT HS 811 998). Washington, DC: National Highway Traffic Safety Administration.

Zhang, Y.; Mamun, S.A.; Ivan, J.N.; Ravishanker, N.; Haque, K. 2015. Safety effects of exclusive and concurrent signal phasing for pedestrian crossing, *Accident Analysis and Prevention* 83: 26–36.

Zheng, J.; Wu, X. 2015. Prediction of Road Traffic Accidents Using a Combined Model Based on IOWGA Operator, *Periodica Polytechnica Transportation Engineering* 43(3): 146-153.

Zebala, J.; Ciępka, P.; Reza, A. 2012. Pedestrian acceleration and speeds, *Problems of Forensic Sciences* 91: 227–234.

Zhao, H.; Yang, G.Y.; Zhu, F. 2013. An investigation on the head injuries of adult pedestrians by passenger cars in China, *Traffic Injury Prevention* 14: 712–17.

Zeng, W.; Chen, P.; Nakamura, H.; Asano, M. 2013. Modeling Pedestrian Trajectory for Safety Assessment at Signalized Crosswalks, In *Proceedings of the 10th International Conference of the Eastern Asia Society for Transportation Studies*, Taipei, Taiwan.

Žuraulis, V.; Sokolovskij, E.; Matijošius, J. 2013. The opportunities for establishing the critical speed of the vehicle on research in its lateral dynamics, *Eksploatacja i Niezawodnosc – Maintenance and Reliability* 15(4): 312–318.

Žuraulis, V.; Levulytė, L.; Sokolovskij, E. 2014. The impact of road roughness on the duration of contact between a vehicle wheel and road surface, *Transport* 29(4): 431–439.

Yannis, G.; Papadimitriou, E.; Theofilatos, A. 2013. Pedestrian gap acceptance for mid-block street crossing, *Transportation planning and technology* 36(5): 450-462.