Protection of Pedestrians as the Key Action for Implementing Poland’s Vision Zero

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ABSTRACT

WHO reports show that pedestrians account for 10 to 70% of total road crash fatalities. In Poland, pedestrians also represent a significant road safety problem. For many years, pedestrian collisions have accounted for approx. 30% of total road crashes with more than 30% of pedestrians killed. Therefore, pedestrian safety has been one of Poland’s main objectives in its road safety programs implemented over the past 20 years.

The paper describes the implementation of Poland’s national road safety program GAMBIT 2005, which adopted the far-reaching Vision Zero. Despite the lack of a dedicated pedestrian safety program, pedestrians are key to the implementation of Vision Zero. Therefore, one of the program’s main objectives was the safety of pedestrians, cyclists and children.

Because pedestrian fatalities have not decreased, the implementation of Vision Zero requires a more focused approach to pedestrian safety. To manage pedestrian safety, a risk-based approach is used. The paper describes pedestrian safety management based on methods for estimating measures of strategic societal risk, tactical risk classification, and assessing the effectiveness of operational level actions. The paper also describes the effectiveness of pedestrian safety studies and their evaluation.
INTRODUCTION

After drivers and passengers of vehicles, pedestrians are the largest group of road crash victims. Pedestrians as victims of fatal road crashes represent from 10 to 70% of total road crash fatalities (1), and that share depends mainly on the level of socio-economic development of the country, population density, level of motorization, structure of the road network, etc. (2). The highest fatality rate in road crashes occurs in Asia and Africa with Europe boasting the lowest road crash fatality rate (1).

The strong pressures on fatality reduction, using, e.g. Vision Zero (3,4) as the main guideline for road safety programs, has made the EU Europe’s and the world’s safest region. The 4th European Road Safety Action Program sets out the goal to halve road fatalities by 2020 compared to 2010 and implement a European long-term policy known as the Vision Zero.

However, despite the considerable progress (a 40% fatality reduction between 2001 and 2010 in EU Member States), the individual risk in road transport, measured by the number of fatalities or seriously injured per 1 billion VTK is still 20-30 times greater than in air, maritime or rail transport. Vision Zero can be a catalyst for reducing the level of traffic risk in the Member States, just as in other modes of transport. Apart from a number of European countries, other countries have accepted this challenge as well, including states in the US (5,6).

While pedestrian safety has been covered at length, there is still a need for evaluation, research and experimental studies. The studies carried out in recent years have focused on the following issues:

• characteristics of pedestrian safety,
• methods of researching the behavior of pedestrians and drivers
• methods of modeling and prediction measures of pedestrian safety (2,7),
• assessment of the effectiveness of pedestrian protective measures (8),
• programs and strategies for the protection of pedestrians (1).

This work includes studies into the role of pedestrian safety measures as a way to achieve Vision Zero (9),

IMPLEMENTATION OF VISION ZERO IN POLAND AND PROSPECTS FOR THE FUTURE

In 2004 (the year of Poland’s accession to the EU), as part of the diagnosis for the National Road Safety Program GAMBIT 2005 (10), it was found that:

• Poland’s fatality rates were very high (5,640 deaths in 2003, demographic mortality rate – 149 fatalities/million population)
• groups exposed to a particularly high risk of death in Poland included: vulnerable road users (pedestrians, bicyclists), children and young drivers,
• the basic problems of road safety included dangerous behavior of road users, poor quality of road infrastructure, lack of an effective system of road safety management.
• the EU requires countries to achieve a significant reduction in road crash fatalities.

To respond to this, in 2005 Poland developed the GAMBIT program for the years 2005-2013 (11). The program stated that:
Poland’s long-term and ethically justified road safety vision will be **VISION ZERO**.

The Program’s main strategic goal was to reduce fatalities by 50% in ten years (compared to 2003), i.e. not more than 2,800 killed in 2013 (Figure 1).

The strategic goal was supported by 15 groups of priority actions and 144 tasks focused on five detailed objectives:

- build a basis for an effective and long-term road safety policy.
- develop safe behavior of road users.
- protect pedestrians, children and cyclists.
- build and maintain a safe road infrastructure.
- reduce crash severity.

In 2013 on Polish roads 3,357 people were killed, which means that the strategic objective was achieved in 81.5%. Instead of a 50% decrease in the number of fatalities, only 40.5% was achieved (i.e. a decrease similar to the EU average as a whole in the period from 2001 to 2010) ([12,13](#)).

In the first four years of program implementation, there were no significant fatality reductions. The years 2009 and 2010 proved to be groundbreaking, when:

- program-wide actions on national roads were intensified (a new network of freeways and highways, modernization of many existing roads to meet road safety standards, an integrated approach involving the 4E principle and collaboration between road authorities, police, rescue services and the media),
- actions were taken at the regional and local level using the systemic approach to road safety (integrated approach), which included the development of the road safety system and activities in the area of education, enforcement, engineering and rescue services,
- a speed camera system was implemented (collaboration between road administration and the police),
- a road infrastructure safety management process was commenced using methods based on the risk theory (hazard assessment, risk assessment, identification of high-risk spots, selecting effective actions, risk communication).

The integrated approach to reducing the risk of injury or death has produced a significant fatality reduction. It seemed that the GAMBIT 2005 strategic objective could be achieved earlier. Unfortunately, in 2011 the downward trend was interrupted when speed limits on freeways and highways were raised and the speed camera system was redefined (in 2011 it practically did not exist). As a result, the number of road fatalities in 2011 increased in comparison with the previous year by 7%, i.e. by 500 people. While in 2012 the downward trend was back and continues until today, it is not strong enough. The speed camera system was heavily criticized by some politicians, drivers and the media. The former Finance Minister also somewhat contributed to that situation by including speeding ticket proceeds in the state budget for 2013 and classifying these as income. Those were important reasons why Poland’s fatality reduction slowed down in recent years.
During the GAMBIT 2005 Program, a number of educational, preventive and infrastructural activities were undertaken at the national level. At the same time political and administrative decisions were taken which contradicted the policy of the program. While the program included a number of legislative, educational, preventive and infrastructure actions, only 84 out of 144 (58%) were completed. Some of them did not produce the desired results and others were poorly implemented. It is estimated that the program’s activities during 9 years of its implementation have produced these results:
41,100 people were killed on Polish roads and the costs of road crashes exceeded $90.0 billion,

- approx. 9,600 people were saved from being killed in road crashes and savings on the costs of road crashes were approx. $20.0 billion,
- if properly implemented, the program would have saved 7,700 people more and reduced the costs of road crashes by an additional $16.0 billion.

In the opinion of national (12) and foreign experts (14) Poland’s road crash casualties have been steadily decreasing. GAMBIT has helped to attract scientists, governmental and local institutions, road authorities, enforcement, emergency services, teachers and people of good will. However, road crashes are still not seen in Poland as an important issue or a political priority. The institutions remain ineffective because they refuse to accept a shared responsibility for road safety problems.

As we know from demographic and automotive predictions from 2011 to 2020 Poland’s population may decrease by 1-4%, the number of vehicles could rise by a further 15-25%, i.e. exceed 30 million vehicles, and population mobility (measured by vehicle miles travelled) may increase by 30-35%. Unless preventive actions are intensified, the downward fatality and crash trend could be interrupted. In this case, by 2020 over 40,000 people could die in road traffic crashes, and more than 0.5m people may be injured. The consequences could reach $72.5 billion. Therefore, it is necessary to take effective and efficient measures to protect road users.

In the light of the current situation, it can be concluded that Poland’s socio-economic trends and road fatalities over the past few years are best described by the scenario of a moderate demographic and socio-economic development. However, this scenario does not support the achievement of the 2020 strategic objective or Vision Zero in 2050 (standard intervention) (13). Therefore, three groups of additional interventions have been proposed:

- intervention group 1 - changes in road user behavior (driving with safe speed, non-alcohol, automatic enforcement, etc.),
- intervention group 2 - changes in the development of a safe road network (increase motorways and expressway density, higher standard of two lane roads),
- intervention group 3 - changes in the country’s operational systems (development of health care system, reduction of corruption degree).

The results (Figure 2) indicate that specific intervention groups could lead to a significant reduction in Poland’s road fatalities. In addition, the results suggest that:

- the 2020 strategic objective (not more than 2,000 deaths) can be achieved, if additional interventions are applied leading to a reduction in fatalities to 1,600,
- it will be more difficult to achieve Vision Zero in 2050; estimates suggest that deaths following the interventions could be above zero (30 to 150 fatalities).
It is estimated that by 2050 during the analyzed period (38 years) nearly 45,000 people may be killed on Polish roads if standard measures are applied only (standard intervention) and approx. 24,000 people could be saved if additional interventions are used.

Diagnostic analyses identify the three most important road safety problems in Poland:

- poor protection of pedestrians,
- speeding – many crashes are caused by excessive speed,
- underdeveloped system of road rescue and post-crash assistance.

Actions for reducing the effects of the problems described above have already been provided in the new National Road Safety Programme. It is strategic program for the year 2020, which is currently implemented (15).

**DESCRIPTION OF PEDESTRIAN SAFETY IN POLAND**

Pedestrians in Poland are extremely vulnerable, since pedestrians participate, usually as casualties, in every third road crash. From 2004 to 2013, there were 130,500 crashes involving pedestrians on Polish roads, in which 124,300 people were injured and 15,600 were killed. Pedestrians are the largest group among fatalities (34%), followed by car drivers (28%). In total, unprotected road users (pedestrians, cyclists, motorcyclists, moped riders) account for almost 50% of all deaths. This makes Poland the most dangerous and the least pedestrian friendly country among all EU Member States. The number of pedestrians killed in road crashes in Poland per 1 million inhabitants was 31.6 fatalities in 2010, while the same ratio in the Netherlands was nearly ten times lower (3.8 fatalities per 1m inhabitants). Some Member States of the European Union have made a major progress in pedestrian safety over
a period 20 years. Still, pedestrians represent a big part of all deaths (over 20% of all fatalities) in Portugal, the Czech Republic, Ireland, the UK, Hungary and Poland. In addition, Poland has the highest risk of having a road crash fatality in relation to the number of inhabitants.

In Poland from 1999 to 2013 (Figure 3) pedestrian crashes (crash involving vehicle and pedestrian based on accident report) went down significantly, but the number of fatalities and the share of crashes involving pedestrians in total crashes is still very considerable. The trend to reduce the number of crashes involving pedestrians is compatible with the trend of changes in the total number of crashes and victims of crashes. This is related to the gradual improvement of road safety. However, the share of pedestrians among the fatalities is still substantial.

We have seen a wide variety of risks which pedestrians face in individual voivodeships (region) and poviats (counties). The risk is higher in high-density poviats and lower in rural poviats (i.e. fewer inhabitants).

Pedestrian traffic is mainly concentrated in built-up areas, hence:
- more than 90% of crashes involving pedestrians take place in built-up areas, where approx. 65% of all pedestrian casualties are fatal,
- nearly 10% of crashes involving pedestrians take place outside built-up areas, where approx. 35% of all pedestrian casualties are fatal.

Most pedestrians are killed on straight sections of roads (60% of crashes involving pedestrians) but also on pedestrian crossings (30%), although they should guarantee a safe crossing of the road, at intersections and on sidewalks (4%). The most common causes included failure to give way to the pedestrian on the crossing and speeding. The autumn-winter period is particularly dangerous for pedestrians. The most dangerous time of the day for pedestrians is the time of limited visibility. At night-time, the risk of being a victim of a road crash is much higher than during the day (16). Despite many actions which promote the use of high-visibility devices by pedestrians, the share of crashes involving pedestrians in conditions of limited visibility has been steadily increasing and amounts to over 70% in the case of fatalities. This is particularly true for road sections located outside built-up areas, where there are more than 70% of crashes involving pedestrians, with as much as 90% of the fatalities in such crashes at night.

Road users aged over 70 are the largest group of victims injured (16% of all injured) and killed (23% of all fatalities) (17). The most common mistakes made by pedestrians include:
- entering the road directly in front of an oncoming vehicle,
- crossing the road in places not designed for crossing,
- entering the road from behind a vehicle or an obstacle,
- crossing the road on a red light,
- being invisible on the road after dark or in conditions of limited visibility.

Pedestrians under the influence of alcohol are an additional risk.
Crashes involving pedestrians usually occur in complex circumstances, due to the presence of a number of factors associated with road users, roadside and the vehicle. Mistakes made by road users in Poland are the cause of the majority of pedestrian crashes; other factors include planning and design errors and poorly maintained road infrastructure, the usual cause of inappropriate behavior of road users and road crashes. Factors conducive to crashes which involve pedestrians include the non-regulated priority of a pedestrian on the pavement, lack of pedestrian safety devices (pavements, refuge islands) and limited visibility of pedestrians at night.

Protection of pedestrians, cyclists and children was one of the five objectives of the GAMBIT Program 2005-2013. In order to evaluate this objective, two indicators have been applied:

- reduction in the risks to vulnerable road users in relation to the number of inhabitants from 68 to 22 fatalities per 1 million inhabitants (in the case of pedestrians, a reduction was anticipated from 49 to 16 victims per 1 million inhabitants, and 29.3% was obtained).

- reduction in the share of vulnerable road users in the total number of fatalities of road crash fatalities from 46 to 30% (in the case of pedestrians the anticipated reduction was from 33 to 21%, compared to the actual 33.7%).

To improve pedestrian safety, a number of priority actions were named, including the following:

- revision of the rules of priority for pedestrians in the crosswalks and sections without sidewalks.
• school education (proper pedestrian behavior in road traffic),
• widespread use of pedestrian protection measures (segregation pedestrians and other road users, refuge island with additional signing and marking, traffic calming measures).

Tasks undertaken so far have contributed to a decrease of more than 46% in pedestrian fatalities. Although this decline is too small to achieve 2013 objectives, the specific actions and tasks delivered under GAMBIT 2005 helped to save 4,100 people from being killed and 7,200 from severe disability.

This decline is without a doubt the result of lower vehicles speeds achieved through enforcement, better communications with the public (media campaigns and education) and numerous measures designed to improve pedestrian safety (footpaths outside the pavement, traffic calming, safe zebra crossings for pedestrians (21, 22)). However, the lack of national and local studies into the effectiveness of educational and engineering measures makes it impossible to identify which of these measures were the most effective.

The analyses conducted to date demonstrate that pedestrian protection still remains the key issue in creating road safety programs. The implementation of Vision Zero requires extraordinary measures aimed at protecting pedestrians.

PEDESTRIAN SAFETY MANAGEMENT SYSTEM

Pedestrian safety management, just like road safety management, consists of a formal and repetitive course of action which integrates the phases of risk assessment and risk response. The purpose of this method is to help those responsible for the road network with rational decisions regarding road safety, road infrastructure safety and elimination or reduction of the consequences suffered by road users. To manage the safety of pedestrians, a risk-based approach was used (13,17,18). This method differentiates three levels of management: strategic, tactical and operational management. The risk management method includes two phases: the risk assessment and risk response.

Levels of Risk Management

At the strategic level (national) represented by the political authorities of the country, the transport ministry or infrastructure ministry, authorities of the voivodeship (region) or poviat (county), the weight of decisions is the greatest (decisions have the greatest impact). Decisions are taken under conditions of uncertainty or risk arising from limited access to data, strong volatility of the phenomenon and absence of appropriate tools to facilitate decision making. At the tactical level (regional) represented by the voivodeship and poviat governments, road and transport authorities, the decisions weigh less, but the choice of the most effective and efficient actions is very important. There is a need for tools, procedures and methods to facilitate decision making under conditions of risk and uncertainty resulting, inter alia, from limited access to data. At the operational level (local), represented by design offices, road authorities, transport operators, road users, where specific measures are taken, in addition to a good access to data, there is a need for detailed methods of hazard analysis and risk assessment and methods for predicting the impact of a proposed action on risk reduction.
**Risk Management Method**

The risk management method is a repetitive way to ensure effective and efficient risk reduction in road traffic, with a particular focus on interventions and actions related to road infrastructure within reasonable limits. In the proposed risk management approach, there are two important phases \((13,17)\): risk assessment including risk valuation and analysis and risk response including: risk handling, risk monitoring and risk communication.

At each management level, methods of analysis and risk assessment of various precision should be used. With regard to pedestrian safety, these methods should be used, in particular by:

- central authorities (Parliament and government) to prepare and evaluate the impact of proposed legislation, safety standards, rules and recommendations concerning road users and operators, production and operation of vehicles and the construction and maintenance of roads and pedestrian facilities;
- central offices (transport minister, National Road Safety Council, National Police, General Directorate for National Roads and Motorways) to determine the strategic objectives in national programs for safety improvement, risk assessment in the road network, assessment of the impact of selected legal regulations and evaluation of the effectiveness and selection of strategic activities;
- regional and local authorities as well as regional and local road safety councils to prepare a safety ranking in selected areas, assessment of risk in the road network managed by the given local authority, to determine strategic objectives in local programs to improve security, selection of effective strategic and operational actions;
- road authorities (country, region, city) to assess the risks in the road network managed by the authority, select effective operational activities, perform road safety audits, evaluate the effectiveness and efficiency of the actions.

As regards pedestrian safety management, the individual risk (refers to the behavior of a single road user) and societal risk (refers to the behavior of entire social groups in the selected area or road network) are essential.

**TOOLS FOR MANAGING PEDESTRIAN SAFETY**

In order to ensure a smooth management process, the right tools should be used to facilitate risk estimation and assessment and decision making. Below is a proposal for the development of three such tools that require scientific support, namely the method for estimating measures of societal strategic risk (national), tactical risk (regional) classification method, and the method for assessing the effectiveness of actions at the operational level (local).

**Method for Estimating Measures of Social Risk at the Strategic (National) Level**

This method is designed to estimate the number of pedestrian fatalities. There are a number of PF (pedestrian fatalities) ratio modeling in the literature. The simple regression model \((2)\) or Kuznets model \((7)\) is applied. The choice of the particular form of the analytical approximating function depends on how well the function graph matches the empirical data and fulfills boundary conditions. In the proposed method, a multi-factor model for estimating pedestrian fatalities is applied, as described by formula \((1)\):
\[ PF = P \cdot RFR_b \cdot MF_c \cdot PFP_b \cdot MPF_c \] (1)

where:

- \( PF \) – number of pedestrian fatalities in the road network in the country (fatalities/country/year),
- \( P \) – population (M inhabitants/country/year),
- \( RFR_b \) – base road fatality rate (fatalities/1M inhabitants/year),
- \( MF_c \) – country modification factor,
- \( PFP_b \) – base percentage rate of the share of pedestrian fatalities in road crashes during the analyzed year (%),
- \( MPF_c \) – correcting factor for the percentage share of pedestrian fatalities in road crashes in the analyzed country and during the analyzed year.

\( RFR_b \) and \( MF_c \) ratios are estimated according to the models developed by the author and described in (13).

\( PFP_b \) and \( MPF_c \) ratios are estimated according to the models from formulas (2) and (3).

Using multiple available databases of Eurostat, FAO, IRF, IRTAD, OECD, TI, UN, WB, WHO and many other sources, empirical data were collected on the number of deaths and numerous parameters which describe selected countries in different years, such as demographic, geographic, economic, social, automotive, road and transport variables. The number of countries was narrowed down to those that have reliable pedestrian fatality statistics, and those without significant disruptions in the road fatality rate. Selected countries (among others: Australia, France, Japan, the Netherlands and Sweden) have a similar, model function graph of changes in the road fatality rate. Road safety and transport system databases were built for 39 countries, for 1990 to 2010, a collection of 321 country-years.

Based on the collected historical data describing selected countries, a model was developed for the base function of dependency of the demographic fatality \( RFR_b \) on the adopted independent variables. Initial analyses suggested the use of the exponential function, as the one that best approximates the data being analyzed. The resulting model is described with formula (2). The variables have a high degree of significance \((p < 0.05)\) and meet the Wald test at significance level of 5% which shows that the independent variables are significant in the non-linear models. The \( R^2 \) coefficient of determination was 0.92.

\[ PFP_b = \beta_0 \cdot \exp ( - \beta_1 \cdot GDPPC - \beta_2 \cdot CPI - \beta_3 \cdot VTKPC - \beta_4 \cdot DPR - \beta_5 \cdot DP - \beta_6 \cdot PM ) \] (2)

where:

- \( GDPPC \) – gross national product per capita (thousands ID/inhabitant/year), \( (PPP - \) Purchasing power parity, constant 2005, ID - International Dollar),
- \( VTKPC \) – average vehicle kilometers travelled per year per capita (km/population/year),
- \( CPI \) – dishonesty (corruption) perception index,
- \( DPR \) – density of paved roads depend of demography (km/1 M population),
- \( DP \) – density of population (population/ km2),
- \( PM \) – percentage density of motor vehicles (%),
- \( \beta_0, \beta_1, \ldots, \beta_{10} \) – equation coefficients.
A simple model of $RFR_b$ changes was derived on the basic parameters which describe the level of socio-economic development of the country ($GDPPC$), the degree of national organizational system development ($CPI$), the mobility of inhabitants ($VTKPC$), the structure of the road network ($DPR$), the density of population and the share of motor vehicles ($PM$). The model parameters were chosen using the STATISTICA package of statistical programs (17). Figure 4 shows the function graph of $PFP_b$ changes on the level of socio-economic development $GDPPC$ and the mobility of inhabitants $VTKPC$ (assuming the average values for the other independent variables).

The use of the base model developed for Poland demonstrated that the estimated numerical values $PFP_b$ deviate from the actual values, therefore a local coefficient was applied to adapt the base values to local conditions by using country modification factor $MPF_c$. $MPF_c$ was modeled on the exponential function generally described with one of the formulas, as presented in formula (3). The variables used have a high degree of significance ($p < 0.05$) and meet the Wald test at significance level of 5% which shows that the independent variables are significant in the non-linear models. The $R^2$ coefficient of determination was within 0.88 to 0.96.

**Figure 4** $PFP_b$ dependency graph of the level of socio-economic development $GDPPC$ and the and mobility of inhabitants $VTKPC$
\[ MPF_c = \exp(\gamma_1 \cdot GDPFC - \gamma_2 \cdot EDI - \gamma_3 \cdot DME + \gamma_4) \]  

where:

- \( MPF_c \) – correcting factor for the percentage share of pedestrian fatalities in road crashes in the analyzed country and during the analyzed year.
- \( EDI \) – level of education index,
- \( DME \) – density of highways and expressways of demography (km/1 M population),
- \( \gamma_1, \gamma_2, \ldots, \gamma_n \) – equation coefficients.

With the \( MPF_c \) applied, the mean squared error of adjustment of estimated \( PF \) values to the actual data decreased to 1.2%. As a result, this model could be used as a prediction model to estimate long-term changes in the number of Poland’s pedestrian fatalities.

**Method of Classification of Societal Risk at the Tactical (Regional) Level**

Based on past experience, a concept is proposed for identifying high-risk pedestrian locations using crash analysis (i.e. based on risk management), broken down to ranges and levels. The proposed concept includes the following elements: levels and scope of the analyses, period of analysis, proposed measures of risk and criteria for the selection of sections. Information collected at the tactical level is used for taking management (tactical) decisions by politicians and regional decision makers (Marshal Office, Provincial Road Safety Council, branches of the General Directorate for National Roads and Motorways, Provincial Road Authorities, Provincial Police Headquarters, Provincial Fire Brigade Headquaters, etc.), by regional media and individual road users (e.g. choosing a safer road in the region).

For the analyses conducted at the regional level (e.g. Provincial Secretariat of the Road Safety Council) it is interesting to assess the risk of pedestrian crashes occurring within the poviats (counties). As part of risk assessments carried out in the EuroRAP Program, a risk mapping process was conducted for the poviats. An example of a map, with a classification of pedestrian risks is shown in Figure 5. Such maps should be published annually by the Secretariat of the National Road Safety Council or Provincial Road Safety Councils.

At the tactical (regional) level, the analyses covered only national and voivodeship (regional) roads. The road network is divided into homogeneous sections, 2 (1) – 10 km long. The sections should have similar parameters: road class (S, GP, G, Z, L), number of lanes, area (urban, non-urban) and similar traffic volumes. The General Directorate for National Roads and Motorways uses this method for identifying hazardous sections. It includes a map which demonstrates the individual risk of being a fatal victim as a pedestrian for the analyzed road sections. As regards the provincial road network, there is a lack of a uniform classification of risk (the boundaries between classes of risk used for national roads cannot be used), therefore it is necessary to develop a methodology for risk assessment that comprises rules for calculating risk and a uniform risk classification.
These studies are conducted to a limited extent in Poland and effectiveness assessments are limited to global comparisons of changes in crashes, fatalities and injuries, without analyzing the underlying causes.

Due to the conditions which prevail in Poland, the main actions are focused on providing adequate road infrastructure for pedestrians, namely safe crosswalks and pedestrians paths, and traffic management that ensures lower speeds at safe levels. These tasks have been implemented in Poland mainly by:

- building sidewalks along non-urban roads and two lane streets,
• improving the visibility of crosswalks and implementing solutions which reduce
the speed of vehicles in conflict zones,
• applying a “attention-getting” system of crosswalk marking
• developing an enforcement system using speed cameras in high-risk places.

Below are selected results of studies into the effectiveness of road safety measures,
implemented in the course of road safety improvement programs. Research into the
effectiveness of Poland’s speed camera system has demonstrated a significant improvement
in road safety. When the system was launched in the national road network, fatalities
decreased by 13.3%, injuries by 8.8% and crashes by 38% (20). The use of various types of
pedestrian crossings demonstrates an improvement in road safety. Studies of pedestrian
crossings on national roads show a changes in fatal crashes on national roads depending on
the type of crossing (zebra crossing, refuge island, traffic lights or flashers (21)), which were
calculated based on accident rates ratios (Table 1),

Table 1 Accident rates ratios for various pedestrian crossings’ types in relation to zebra
crossings in and outside built-up areas

<table>
<thead>
<tr>
<th>Type of Accident</th>
<th>Type of Pedestrian Crossing</th>
<th>Within built-up areas</th>
<th>Outside built-up areas</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Zebra</td>
<td>Refuge Island</td>
<td>Traffic Signal</td>
</tr>
<tr>
<td>Total</td>
<td>1.0</td>
<td>1.033</td>
<td>1.118</td>
</tr>
<tr>
<td></td>
<td>(0.990 ; 1.080)</td>
<td>(1.039 ; 1.199)</td>
<td>(1.126 ; 1.276)</td>
</tr>
<tr>
<td>with a pedestrian</td>
<td>1.0</td>
<td>0.394</td>
<td>0.142</td>
</tr>
<tr>
<td></td>
<td>(0.359 ; 0.429)</td>
<td>(0.114 ; 0.170)</td>
<td>(0.232 ; 0.300)</td>
</tr>
<tr>
<td>fatalities with a pedestrian</td>
<td>1.0</td>
<td>0.299</td>
<td>0.052</td>
</tr>
<tr>
<td></td>
<td>(0.265 ; 0.332)</td>
<td>(0.03 ; 0.07)</td>
<td>(0.201 ; 0.266)</td>
</tr>
<tr>
<td></td>
<td>Zebra</td>
<td>Refuge Island</td>
<td>Traffic Signal</td>
</tr>
<tr>
<td>Total</td>
<td>1.0</td>
<td>1.038</td>
<td>2.758</td>
</tr>
<tr>
<td></td>
<td>(1.024 ; 1.053)</td>
<td>(2.715 ; 2.897)</td>
<td>(1.255 ; 1.305)</td>
</tr>
<tr>
<td>with a pedestrian</td>
<td>1.0</td>
<td>0.524</td>
<td>0.913</td>
</tr>
<tr>
<td></td>
<td>(0.454 ; 0.595)</td>
<td>(0.869 ; 0.957)</td>
<td>(0.400 ; 0.552)</td>
</tr>
<tr>
<td>fatalities with a pedestrian</td>
<td>1.0</td>
<td>0.182</td>
<td>0.606</td>
</tr>
<tr>
<td></td>
<td>(0.128 ; 0.236)</td>
<td>(0.530 ; 0.682)</td>
<td>(0.290 ; 0.437)</td>
</tr>
</tbody>
</table>

(…) – 95% confidence interval

Introduction of "attention-getting" marking and signing of crosswalks, on provincial
(regional) roads in Malopolska, near schools, helped to completely eliminate fatal crashes on
pedestrian crossing in the last 3 years.

Because of the difficulty with studying small samples, i.e. pedestrian crashes on
crosswalks in cities, and because drivers don’t have to give way to pedestrians (allowed by
law), a study was undertaken to understand how a change in driver behavior can improve
pedestrian safety, using the example of pedestrian crossings in Krakow. Vehicle speeds were
measured on approaches to crosswalks marked with fluorescent signs and zebra marks
against a red background compared with the standard marking. The results show lower
speeds of approaching vehicles of up to 10% compared to the standard crossing. Studies have
also shown that the speed is reduced by approx. 40% of the drivers, compared to standard
crossings (22).
The number of crashes on crosswalks in Krakow, where a differentiated marking of crosswalks was applied decreased by 16% from 2009 to 2013 (to 211 crashes/year), and the number of fatalities fell by 77% (3 fatalities).

CONCLUSIONS

Pedestrian safety is an important problem of Poland’s road safety. Therefore, efforts to improve pedestrian safety are critical for the implementation of Poland’s Vision Zero. Based on actions carried out to date within the road safety programs from 2005 to 2013, it is evident that:

- the problem of pedestrians is still one of the most important and unresolved problems of road safety in Poland.
- while GAMBIT 2005 actions led to a reduction in pedestrian fatalities, they were not as effective as intended; this is why pedestrians as a percentage of all fatalities and population are higher than assumed in the program,
- the effectiveness of the measures has not been properly understood, because there is no research on the behavior of pedestrians and drivers, no methods for identifying pedestrian risks, estimating and forecasting crashes involving pedestrians and pedestrian casualties or assessing the effectiveness of the interventions.

With only a partial implementation of GAMBIT 2005 in Poland, Vision Zero is going to require special attention and actions to improve pedestrian safety. Therefore it is necessary to:

- implement a system-wide management of pedestrian safety, based on system and behavioral theories,
- use pedestrian safety management based on risk management comprising the risk assessment and risk response phase at the national, regional and local level,
- develop useful tools to manage pedestrian safety with scientific support, namely methods for the identification of hazards to pedestrians, classification of pedestrian safety, estimating pedestrian safety measurements and selecting the most effective and cost-efficient interventions for the protection of pedestrians in road traffic,
- conduct systematic and multidisciplinary research into the effectiveness and economic effectiveness of pedestrian safety measures at all levels of the country’s road safety management system.

If dynamically implemented, these steps may bring us closer to the implementation of Vision Zero in accordance with the assumptions of the 4th European Road Safety Action Program, namely zero fatalities on Polish roads by 2050.

Research on the effectiveness of pedestrian safety measures, especially those involving infrastructure and traffic management, suggests that they are highly effective and lead to fewer pedestrian fatalities. Therefore it is necessary to apply a system-wide approach to pedestrian safety management, which includes integrated actions at all levels of management, including identification of pedestrian risks, choosing effective and economically efficient interventions and regular monitoring and communication of risks.
REFERENCES


