Vision Zero in Poland

Kazimierz Jamroz, Aleksandra Romanowska, Lech Michalski, and Joanna Żukowska

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Abstract

Poland's experience of road safety work is relatively short. In the early 1990s road deaths soared to a staggering 8000 a year. A diagnosis found that Poland's lack of systemic road safety action was to blame for those figures. In response, the state set up road safety bodies and commissioned road safety programs. In 2005, Poland followed the example of Sweden and adopted Vision Zero as a far-reaching concept of changes in road safety. The work that followed helped to improve the situation and reach less than 3000 fatalities in 2015. Despite that, for years Poland has been notorious for its road accident deaths, which are some

K. Jamroz (✉) · A. Romanowska · L. Michalski · J. Żukowska
Gdansk University of Technology, Faculty of Civil and Environmental Engineering, Gdansk, Poland
e-mail: kjamroz@pg.edu.pl

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of the highest in the EU. Poland has had its share of both successes and failures. The results of road safety policies are still below the expectations and many problems have not been solved. Road accidents are not considered a major problem. As a consequence, they are low on political agendas and the institutions remain ineffective due to a sense of collective responsibility for road safety problems. Achieving Vision Zero will require many changes, learning from past mistakes, taking advantage of the experience of the best performing countries, and, above all, taking effective and efficient actions with their systematic monitoring.

This chapter is a summary of the last 30 years of road safety work in Poland. It presents a diagnosis of Poland's problems, an assessment of the policies so far, and the likelihood of achieving the assumptions of Vision Zero in the future. Building on this, recommendations are given on the next steps Poland should take to improve its road safety.

Keywords

Road safety · Poland · Vision Zero · GAMBIT · Program · Strategy · Scenario · Forecast

Introduction

Between the late 1980s and early 1990s a political transformation of Poland was taking place. Just as many other Central and Eastern European countries, Poland was making a shift from socialist to capitalist economy. The period was marked by an astonishing increase in road accident fatalities. People wrongly assumed that this was inevitable simply because motorization was developing dynamically. State bodies with statutory responsibility for road safety could not agree more because it justified their lack of spending on better roads. After all, there were always other more important issues, or so it seemed at the time. There was no reaction from the public, either. After years of socialism, people were willing to pay the price for growing mobility even if it meant accidents and victims. It was not until a group of World Bank experts (Gerondeau 1993) published their report in 1992 that an honest and objective diagnosis of the Polish situation was made clear – the system failed to address the problems of growing motorization leading to the high number of victims. The report paved the way for tackling road safety problems in Poland head on. The first steps were taken and they were to appoint the National Road Safety Council and develop Poland's first ever road safety program known for short as GAMBIT 96 (Krystek et al. 1996).

Since 1991, which was a peak year with the highest number of fatalities in Poland, the situation has improved significantly. Road deaths have now fallen from the catastrophic 8000 in 1991 to less than 3000 in 2019. The reduction was achieved thanks to the new socioeconomic situation, which kept improving after the

transformation, road safety policies, change in road user behavior, and the delivery of national road safety programs.

An important milestone at the time was Poland's accession to the European Union (May 2004) and the development and implementation of the National Road Safety Program for the Years 2005–2007–2013, called GAMBIT 2005 (Jamroz et al. 2005). The program adopted Sweden's Vision Zero as an ethically justified vision of road safety (Jamroz et al. 2006). By adopting it Poland committed to strive for zero fatalities in road traffic. In order to achieve this, the following demands need to be met:

- Human life and health are put above mobility and other goals of the transport system.
- Both politicians, planners, road designers and builders, teachers, journalists, policemen, road carriers, rescue services and road users are jointly responsible for road accidents and eliminating their consequences.
- The road system and vehicles are designed, built, and operated in such a way as to minimize and compensate road users' errors.
- The traffic safety management system has procedures and tools to meet the challenges posed.

The moment of adopting Vision Zero as a far-reaching vision of road safety can be recognized as the start of systemic road safety action in Poland (Jamroz and Michalski 2005; Jamroz et al. 2017).

Poland's experience of road safety over the last three decades has had its ups and downs. For years Poland has been notorious for topping the EU's most dangerous country rankings. The risk of becoming a fatality in Poland was 50% higher than the EU average and double that of the United Kingdom, Sweden, the Netherlands, and Denmark. The results of road safety treatments are below the expectations. Many problems remain unsolved such as excessive speed or a high number of pedestrian fatalities. Road accidents are still not seen as a major problem in Poland or given political priority. In addition, the relevant institutions do not produce results because responsibility for road safety is collective (Krystek et al. 2013).

While the country has had successful road safety policies, more needs to be done (Wegman 2007; Jamroz et al. 2019). As it works its way toward Vision Zero, Poland will have to make many changes, learn from its mistakes, and take advantage of the experience other countries have with tackling road safety problems. This sets the context for Polish road safety research (Jamroz et al. 2006, 2016; Jamroz 2011, 2013; Krystek et al. 2013; Gaca and Kiec 2016). It aims to:

- Evaluate the approach to road safety programs in Poland
- Identify the conditions and efforts which have significantly improved road safety
- Identify barriers to the full implementation of measures
- Identify the challenges Poland will face in the years to come
- Understand how likely Poland is to achieve Vision Zero

This chapter is a summary of the last 30 years of road safety efforts in Poland.

State of Poland's Road Safety

Changes Between 1988 and 2019

Over the last 30 years Poland's road safety has improved significantly. Since 1991, which recorded the highest number of road deaths in history at 7900, fatalities have been reduced nearly threefold to 2900 people killed in 2019 (Table 1).

Compared to other EU countries, the changes have not been quick enough with Poland topping EU lists over the last 18 years several times. In 2018, Poland was number four among the EU's most dangerous countries (Fig. 1). The risk of becoming a fatality in Poland is still 50% higher than the EU average (which is 49 fatalities per one million population in 2018) and double the risk in the United Kingdom, Sweden, the Netherlands, and Denmark (Fig. 2). The total number of fatalities in Poland, Germany, France, and Italy represented half of the entire European Union's road deaths in 2018.

The Situation in 2018

Based on the police road safety database SEWIK, in 2018 there were 31,700 road accidents on Polish roads with 2865 people killed and 37,300 people injured of which 10,900 were seriously injured. The most frequent causes of serious accidents (involving pedestrians and serious injuries) included: hitting a pedestrian, side collisions, and head-on collisions; serious accidents happened most often on national roads, junctions, at nighttime, at pedestrian crossings and involved speed and hard roadsides (Fig. 3).

Road safety research in Poland (Jamroz et al. 2017, 2019) shows that:

1. Vulnerable road users: pedestrians, cyclists, and young drivers continue to be at high risk of death or serious injury.
2. Poland's basic road safety problems are still the same, i.e., poor quality of some of the road infrastructure, ineffective speed management, relatively poor road safety behavior.
3. Simple road safety measures are no longer working and soft measures are not enough; what is needed is an integrated and knowledge- and research-based approach with the right resources and funds.
4. The road safety management system is weak: there is no lead at the central or regional level, programs are poorly funded, access to accident databases is poor, and the scope of data is limited.

Table 1 Changes in Poland's road safety from 1988 to 2019 compared to socioeconomic changes

	Population	Number of vehicles	Vehicle travel distance	Gross domestic product per capita	Number of fatalities	Road fatality rate		
Year	P (m)	V (m)	VKT (b vkm)	GDPPC (thous. ID/year)	F (victims)	RFR_P (victims/ 1 m. inhab.)	RFR_M (victims/ 1 m. veh.)	RFR_T (victims/ 1 b. vkm)
1988	37.8	6.9		8.20	4851	128.3	703.0	
1991	38.2	8.6	94.6	7.57	7901	206.8	918.7	83.5
1997	38.6	12.3	127.4	10.22	7312	189.4	594.5	57.4
2001	38.2	14.7	148.4	11.96	5534	144.9	376.5	37.3
2007	38.1	19.5	220.8	15.66	5583	146.5	286.3	25.3
2015	38.0	27.4	315	21.77	2938	77.3	107.2	9.3
2019	38.3	29.5	335	25.72	2909	75.9	98.6	8.7

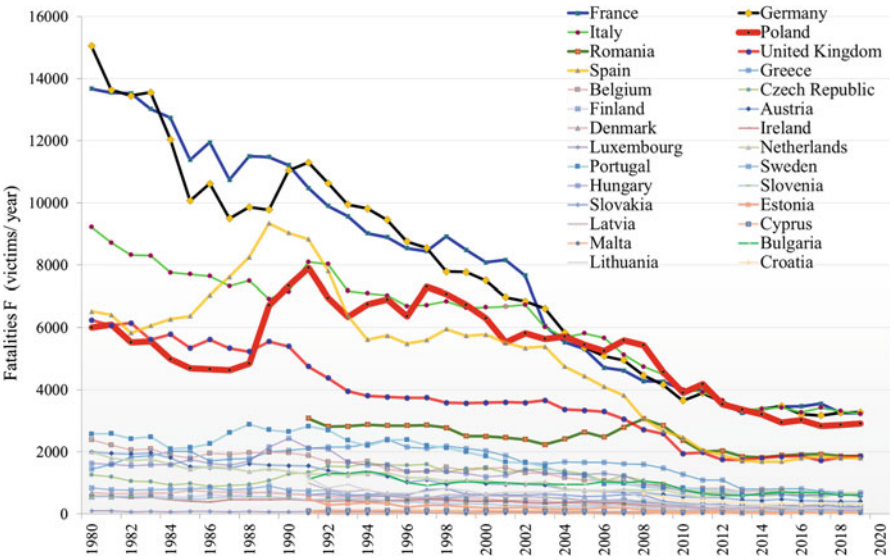


Fig. 1 Changes in fatalities in EU countries in the years 1990–2018

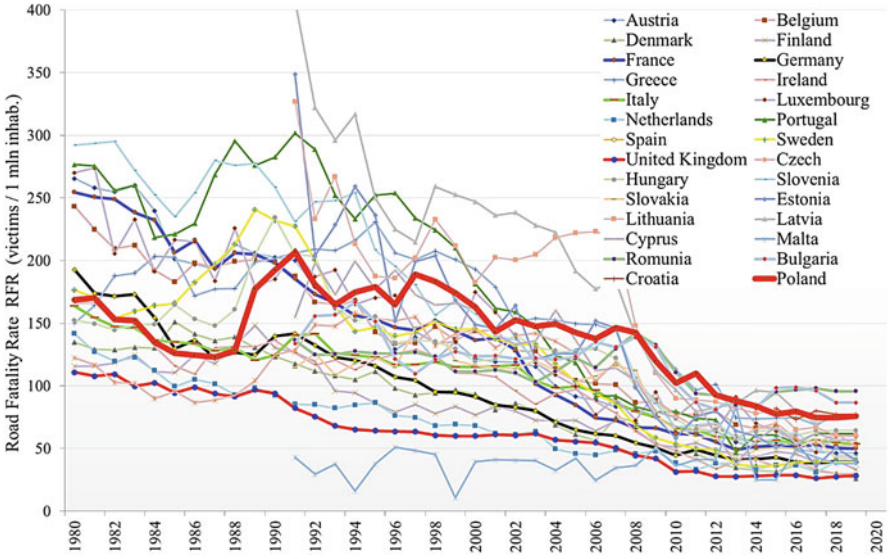


Fig. 2 Changes in road fatality rates in EU countries in the years 1990–2018

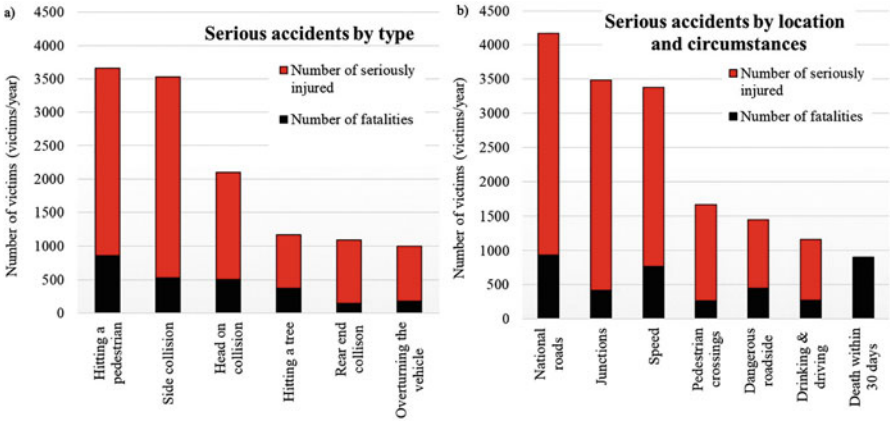


Fig. 3 Distribution of fatalities and serious injuries in Poland's serious accidents broken by type (**a**) and accident location and circumstances (**b**)

Key Road Safety Problems

An analysis of Poland's road safety data has helped to identify nine problems which generate a particularly high number of road accident deaths. The road accidents in question occur on national roads and involve pedestrians, speeding, nighttime, running-off-the-road and hitting a tree, high severity (death at the scene or within 30 days), drink-driving, and accidents at junctions and pedestrian crossings. Despite a significant drop in fatalities in the last 20 years (1999–2019) (Fig. 4), fatal accidents remain a serious risk.

Speed Excessive, dangerous, or not adequate for the driving conditions, speed is the risk factor of about 30% of fatal accidents. Between 1999 and 2019 fatalities in these accidents fell by 61%. This is mainly thanks to the speed camera system (CANARD) (Jamroz and Michalski 2005; Jamroz et al. 2005), building a network of safe roads and introducing traffic calming zones in urban areas (Gaca and Kiec 2016). Sadly, other decisions were also made which went against fatality reduction in speed-related accidents such as reducing the coverage of the speed camera system (2015) and increasing motorway speed limits from 130 km/h to 140 km/h (2010).

National Roads (managed by National Road Administration) carry more than 25% of overall traffic. Nineteen percent of all accidents happen on these roads with fatalities representing as much as 33% of all road deaths. The years 1999–2019 saw the introduction of a number of systemic policies such as the development and implementation of GAMBIT National Roads (Jamroz et al. 2008), construction of new motorways and expressways (between 2002 and 2019 nearly 3500 km of new sections were completed), and a steady improvement of safety standards. As a result, fatalities on national roads dropped by 65%. Certain problems, however, persist: too few good quality roads (motorways and expressways), lack of ring roads, roads with

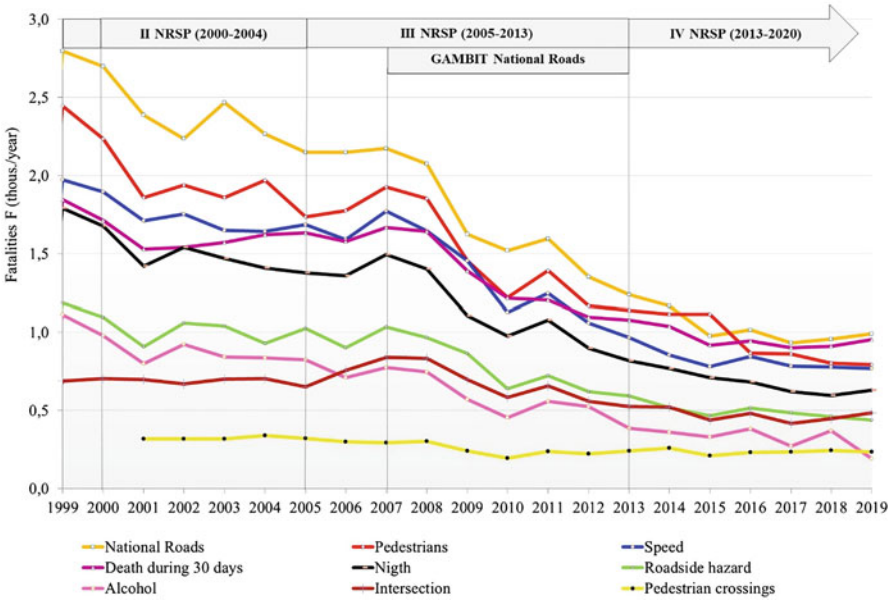


Fig. 4 Changes in the number of road fatalities in Poland in the years 1999–2019 and in the periods of National Road Safety Programs (NRSP), broken by selected road safety problems

wrong cross-sections, underdeveloped and unsafe roadsides, lack of protection for vulnerable road users, road safety standards not met during road improvement works, and poor progress on ITS delivery for road traffic management.

Pedestrians For many years Poland has been one of the European Union's most dangerous countries for this (31% of all fatalities) with the highest number of pedestrian fatalities among EU countries. Between 1999 and 2019, pedestrian fatalities fell by 68%. The reduction has been particularly strong since 2007. Eighty-five percent of pedestrians are killed in built-up areas and 15% in non-built-up areas. The following are sites of fatal pedestrian accidents:

- Built-up areas: 48% at pedestrian crossings, 42% on the road, and 3% on the pavement
- Non-built-up areas: 87% on the road, 8% at pedestrian crossings, and 2% on the roadside
- National roads: 11%, regional roads: 17%, municipal and county roads: 29%, and county capital streets: 43%.

The main problems regarding pedestrian safety include: unregulated pedestrian priority on the road (work is under way to change the law), lack of pedestrian safety devices (pavements, refuge islands, traffic control devices on multilane carriageways), pedestrians poorly visible during nighttime, and drivers' behavior (excessive

speed, not giving priority to pedestrians) (Jamroz et al. 2016, 2019). There are measures designed to improve pedestrian safety. These include: pedestrian and cycling paths being built along rural sections of national and regional roads and the Manual for organizing pedestrian traffic (Jamroz et al. 2014a), now the basis for improving standards of pedestrian infrastructure safety, especially at the local level. The aforementioned problems of pedestrian safety are also indicated in the new Polish guidelines for the design of pedestrian devices, which is under preparation.

Death Within 30 days Between 1999 and 2019 the number of people dying within 30 days from accident date fell by 48%. This is the result of elimination of hard obstacles in the roadside, using protective devices (i.e., road barriers), changing the car park (i.e., airbags as standard car equipment), and developing a rescue system. Nonetheless, high accident severity is still an important problem in Poland. The factors contributing to high accident severity (10 fatalities per 100 accidents) include: high vehicle speed on roads with unsegregated directions of traffic and hard roadsides, rescue system deficiencies, and problems of the health care system. Efforts must be taken to reduce accident severity by improving infrastructure, organization, and management, and implementing a better road rescue system and post-accident help for victims.

Nighttime Between 1999 and 2019 the number of fatalities in nighttime accidents fell by 65%. The factors contributing to nighttime fatalities include: higher speed during the night in built-up areas (60 km/h 24.00 to 6.00), limited perception of the road by road users on rural roads (pedestrians, drivers), vertical and horizontal markings not meeting reflectivity requirements, and poor lighting (in particular junctions, pedestrian crossings). It is common practice to switch off traffic lights at night. A contributing factor which is frequently underestimated, especially on motorways, expressways, and other transit roads is driver fatigue or driver drowsiness and a poor network of places where drivers can rest (Jamroz and Smolarek 2013a).

Dangerous (hard) Roadside About 25% of rural accidents and nearly 16% of all of Poland's fatalities involve vehicles running off the road which roll over or hit a roadside object. Between 1999 and 2019 the number of fatalities when a vehicle hit a hard roadside went down by only 63%. The main cause of the situation is that roadside design and maintenance are not adequately regulated. In addition, conflicts arise when roadside trees are to be cut down (another area without proper regulation). Steps are taken, however, to improve roadside safety such as tree felling when roads are built or improved, when new road sections are built running parallel to sections with protected tree lines, containment structures are used together with a new approach to safety barriers.

Drinking and Driving In the late 1990s, alcohol was one of Poland's main road safety problems. Between 1999 and 2019 the share of fatalities in drink-driving accidents dropped from 22% to 10% and fatalities in drink-driving accidents fell by

as much as 83%. Poland has one of the lowest share of drink-driving fatality accidents, a result of intense and systematic enforcement (Police, Road Transport Inspectorate), education, awareness raising, and a change of alcohol consumption culture in Poland.

Junctions The primary problem of junctions has to do with the road infrastructure and increasing traffic. With a high number of simple junctions giving priority to the main road traffic and a growing demand for entry from side streets, drivers force their way across the junction causing more and more serious side crashes and head-on collisions. If fatalities are to go down, safer junctions should be used (roundabouts, signalized junctions), with better visibility, clarity, and easier to cross. In 1999 the share of fatalities in accidents at junctions compared to all fatalities was about 10% to increase in 2018 to 14%. Fatalities within this period went down by 30%. More efforts must be taken, in particular building modern and safe junctions, to eliminate side crashes and head-on collisions. Equally, more needs to be done to improve enforcement (speed control and running the red light), compliance, and partnership among drivers).

Pedestrian crossings Crossing the road is one of the highest risk behaviors of road users in Poland. Pedestrian accidents usually happen on the road 60%, at pedestrian crossings 30%, and on pavements 4%. Crossing a road in Poland carries a lot of risk. The problems pedestrians face include a lack of pedestrian protection on high speed roads (lack of elevated refuge islands, ineffective protection at painted refuge islands, lack of cycle crossings, etc.) and extended pedestrian crossings, which are particularly dangerous when pedestrians have to cross four or six lanes that are not separated and sometimes even include tram tracks in the middle. The share of pedestrian fatalities in road accidents is 5–8% of all fatalities and has been at 250 annually over the years. If pedestrian fatalities at pedestrian crossings are to fall, the number, location, and type of pedestrian crossings must be verified; pedestrians should spend less time in vehicle conflict zones, conflicts between pedestrians and vehicles should be minimized and, once the conflict happens, the consequences should be minimized thanks to lower speeds in pedestrian zones.

Poland's Road Safety Programs

General Characteristics of Road Safety Programs

Poland's experience of road safety policies is relatively short. Following GAMBIT 96, there have been five national road safety programs (Table 2) of which the first four are called GAMBIT and were developed by teams headed by the Gdansk University of Technology.

Table 2 National road safety programs in Poland between 1996 and 2020

Program (years in force)	Acronym	Policy/ vision	Strategies	Actions	Responsible entity
Integrated road safety Program GAMBIT'96 (1996–1999)	I NRSP*	None	Main qualitative goal, overall fatality reduction	Grouped (integrated)	National Road Safety Council
Road Safety Program for Poland 2001–2010 GAMBIT 2000 (2000–2004)	II NRSP	None	Main target (4000 fatalities in 2010), 2 objectives	Two groups of tasks	National Road Safety Council
National Road Safety Program 2005–2007 – 2013 GAMBIT 2005 (2005–2013)	III NRSP	Vision zero	Main target (2800 fatalities in 2013), 5 strategic objectives, operational program	4E** and system development	Secretary of the National Road Safety Council
Road Safety Program 2007–2013 GAMBIT National Roads (2007–2013)	GAMBIT National Roads	Vision zero	Main target (500 fatalities on national roads in 2013); priorities, pilot program	3 eras, 4E	National Roads Administration
National Road Safety Program until 2020 (2013–2020)	IV NRSP	Vision zero	Main targets (2000 fatalities and 6900 serious injuries in 2020), 5 pillars	Safe system, 4E	Secretary of the National Road Safety Council

[a]NRSP – National Road Safety Program
[b]The 4 E's concept includes: Education, Engineering, Enforcement, Emergency

Detailed Characteristics of Road Safety Programs

Integrated Road Safety Program GAMBIT 1996 (I NRSP)

Commissioned by the Minister of Transport and Maritime Economy, Poland's first comprehensive Integrated Road Safety Program was developed between 1993 and 1996, known as GAMBIT 1996. Authored by a multidisciplinary team made up of scientists, engineers, teachers, police officers, fire fighters, and experts in many fields, the program was led by the Gdansk University of Technology (Krystek et al. 1996). Its biggest strength was that it brought together different sectors and

industries around a common goal. With multiple specialists forming a single multidisciplinary team, work on the program paved the way for long-term cooperation of the different communities and helped to build the foundations for Poland's systemic policies. GAMBIT'96 was Poland's first ever integration and coming together of the sectors of education, infrastructure, enforcement, and rescue. The knowledge and experience of many foreign experts (Muhlrad 1991; Laberge-Nadeau et al. 1992; Haegi 1993; Gunnarsson 1995) helped to develop the program.

A diagnosis helped to identify the biggest problems: lack of road safety bodies, dangerous road infrastructure, high share of old vehicles in vehicle streams, and ineffective enforcement. In 1995, road accidents on Polish roads claimed the lives of 6900 people. The program did not set a target and instead gave a general goal of reducing road accident fatalities in Poland.

While GAMBIT 1996 was commissioned by central authorities, central government did practically nothing to implement the Program and seemed satisfied with just having a program and carrying out the odd ad hoc measure completely unrelated to the Program's methodology. Building on the national program, several regional programs were also developed (Gdansk, Elbląg, Katowice, Suwałki) and systematically implemented. The regional level became involved in improving road safety (Michalski et al. 1998).

Unfortunately, following the country's administrative reform (the number of regions went down from 49 to 16 and a four tier structure was established), regional efforts came to a halt in 1999.

The program's scientific outcome was the first International Road Safety Seminar GAMBIT (GAMBIT 1996), which brought together scientists, practitioners, administration, and NGOs. Since then the Gdansk University of Technology has been hosting biennial meetings of scientists from institutes and universities, engineers, producers of road safety devices, teachers, police officers, road rescue staff, doctors, and lawyers interested in protecting road users from the risk of injury or death (Fig. 5). They exchange experience, set new directions, and put pressure on central, regional, and local authorities.

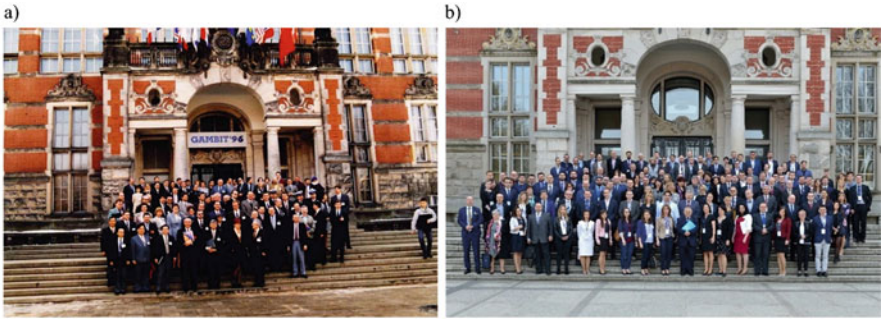


Fig. 5 Participants of the Road Safety Seminar GAMBIT in front of the Gdańsk University of Technology main building: (**a**) GAMBIT'96, (**b**) GAMBIT 2018

Poland's Road Safety Program for the Years 2001–2010 GAMBIT 2000 (II NRSP)

In 1999, a new administrative structure emerged with four tiers of governance: central, regional, county, and municipal. As a consequence, Poland's road network structure changed as well and the transport minister commissioned a new road safety program, which was called GAMBIT 2000 (Krystek et al. 2001).

In 2000, road accidents on Polish roads killed 6294 people. A diagnosis was carried out and identified the main problems: excessive speed, vulnerable road users, accident severity, transit roads passing through small towns, and high risk sites.

Taking advantage of international experience (OECD 1994; Andersson and Nilsson 1997; Broughton et al. 2000; Kroj 2001; Oppe 2001) and based on analyses of socioeconomic forecasts, GAMBIT 2000 adopted strategic goals. The main goal was to reduce road accident fatalities to 4000 in 2010 (i.e., to reduce fatalities by 36% compared to 2000). There were three objectives:

1. Implement road safety measures in seven problem areas
2. Create a basis for an effective and long-term road safety policy
3. Gain public support for road safety

The program also identified two groups of tasks:

1. Systemic action (group A) to include safety management, building databases and knowledge, safety audit, and staff training. This was designed to make road safety management more efficient following a review of the laws and adding new regulations to help with an effective delivery of the program.
2. Action to include the main problems and threats (group B) such as excessive speed, vulnerable road users, accident severity, transit roads passing through small towns, high risk sites to an extent compatible with the diagnosis and availability of funding. The program had its first short-term and long-term targets.

GAMBIT 2000 was formally adopted by the government in May 2001 as the National Road Safety Program until 2010. It was designed as the government's road safety program using direct or indirect means to change road user behavior and road safety management by the regions, counties, and municipalities. The Program was to help local authorities to create better conditions for effective road safety policies. The Program's funds were to be spent on building or improving road infrastructure. The work was considered a pilot to promote "good practice" in the area of road safety treatments (Krystek et al. 2001).

In the initial period of GAMBIT 2000 (a period of 2.5 years), fatalities compared to 2000 dropped by 10.4%. While work on delivering goal 1 (specific measures) and goal 2 (systemic measures) progressed, goal three, i.e., to gain public support for road safety never took off.

Despite the short period, GAMBIT 2000 helped to:

- Increase activity at the regional and local level (training for road safety staff, developing regional and local road safety programs, increase in using effective road safety measures)
- Build and implement systems for monitoring selected road user behaviors (speed, seatbelts) in all regions
- Prepare road safety training for central and regional staff
- Support financially central (national roads, police, rescue) and regional work (regional and county roads)
- Raise public awareness of road traffic risks
- Involve nongovernmental organizations in road safety efforts

The possible reasons why GAMBIT 2000 goals were not achieved in their entirety might be that the program did not really have a clear leader to run it and be accountable for it. Poor cooperation between central and local government was also to blame (especially between different tiers of road authorities). There was too little engagement from central bodies because decision-makers just did not think road safety was a strong enough priority. Shortage of staff and lack of scientific and technical support for road safety professionals also contributed to the poor performance. On the practical side, there were no operational programs to translate the plans into tasks and projects with specific targets, monitoring indicators, costs of delivery and contractors, all of which may have significantly boosted planning and availability of funding. With Poland lagging behind the safety standards required by the European Union in the run-up to becoming a member, a new approach to road safety was definitely called for (GAMBIT 2002).

National Road Safety Program for the Years 2005–2007–2013 GAMBIT 2005 (III NRSP)

When Poland joined the European Union in 2004, the country was required to adapt its national road safety program to the new conditions under the EU's transport policy, its strategy set out in the White Paper and the third EU Road Safety Action Program. The program aimed to halve the number of road deaths between 2000 and 2010 (European Commision 2000). The National Program GAMBIT 2005 was planned for the years 2005–2013, fitting in with Poland's first financial support period from the European Union (Jamroz et al. 2005).

In 2003, stage one of GAMBIT 2000 ended providing a baseline for GAMBIT 2005. Poland's basic road safety indicators were: 5740 people killed, 147 people killed per one million population. The rates were at a 1970s level of Sweden, the Netherlands, and England and were almost double the rates recorded in those countries at that time. Poland's basic road safety problems included: dangerous road user behavior; insufficient protection of pedestrians, children, and cyclists; poor quality of road infrastructure; and ineffective system of road safety.

While the authors analyzed the visions of a number of countries (12 original visions) (OECD 2002), the one they felt strongest about was Vision Zero delivered in Sweden (Tingvall 1998; Tingvall and Haworth 1999), and also in Norway (Siegrist 2010), Iceland (Sigţórsson et al. 2013), Australia (Wadhwa 2001), and Switzerland (Siegrist 2010).

The new program set its strategic target at halving fatalities by 2013 compared to 2003 numbers, which meant not more than 2800 people killed in road accidents in 2013 (Fig. 6a). The program defined three time perspectives:

1. A far-reaching vision of road safety based on Vision Zero
2. A road safety strategy until 2013 (approved by the Polish government in 2005) and a strategic goal for the next period 2014–2020
3. An operational program for the years 2005–2007 (approved by Poland's new government in 2006, sadly without earmarked funding)

To achieve the quantitative goals, five strategic goals were formulated:

1. Prepare a basis for effective and long-term road safety action
2. Shape safe road user behavior
3. Protect pedestrians, children, and cyclists
4. Ensure a safe road and roadside infrastructure
5. Reduce accident severity and accident consequences

Each strategic goal set out strategic actions and tasks. There were 144 tasks in 16 strategic actions. The program adopted an extended 4E principle. It aimed to build a road safety system and improve the organizational structures, education, enforcement, road infrastructure, and road rescue (GAMBIT 2006). The five areas were to be integrated at three tiers: national (ministries, administration, and central institutions), regional (regions), and local (county, city) (Fig. 6b).

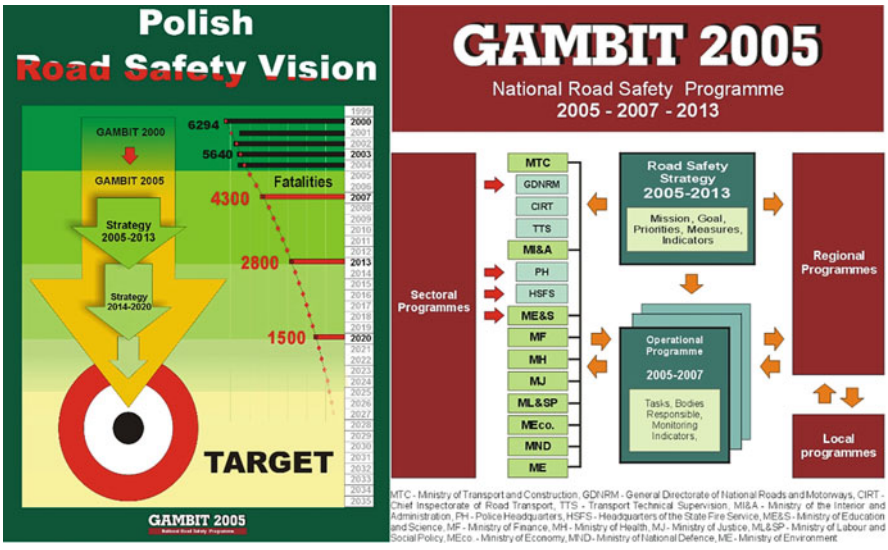


Fig. 6 National Road Safety Program for the Years 2005–2007–2013

GAMBIT 2005: (**a**) Polish Vision Zero, (**b**) the program's delivery structure.

As part of GAMBIT 2005 implementation, there were a number of national level activities in areas such as education, prevention, and infrastructure providing a great fit with the overall program directions. Despite that, a number of political and administrative decisions were taken which went against the program. Quite a lot was done in the area of legislation, education, prevention, and infrastructure. In the first 5 years into the Program, 84 of 144 tasks (58%) were launched. While some did not bring the expected results or were poorly performed, others worked well and helped to improve road safety. They included:

- Regional and county road safety programs were developed and implemented covering a dozen regions, cities, and counties
- Sectoral road safety programs were developed and implemented (for national roads, police programs)
- Work began on building the Polish Road Safety Observatory and two regional observatories
- Driver training and exams were changed
- An enforcement system was implemented and developed (speed control, driver working time control)
- Cycling was regulated
- A network of expressways and motorways was extended, safe junctions and traffic calming measures were built
- Road safety audit was made compulsory for some projects
- Rescue and post-accident protection systems were modernized

Unfortunately, many of the Program's important steps were never taken such as:

- GAMBIT 2005 did not have a clear leader.
- The structures of road safety bodies were not improved or made more efficient, especially the National Road Safety Council.
- No local institutions were appointed (inspectors, officers, leaders).
- No system of sustainable road safety funding was introduced.
- No monitoring system was built to keep track of strategy progress.
- Effective road safety measures were not promoted.

Evaluation of the first short-time operational program was conducted in 2007. It concluded that (Wegman 2007):

1. The road safety strategy and action plans under GAMBIT 2005 were well prepared.
2. Road safety staff were trained, increasing the number of road safety professionals at different levels of governance. Polish experts benefitted from training available abroad (the Netherlands, France, and Sweden) and are well-informed participants of the international road safety community.

3. The actions set out in GAMBIT 2005 were not delivered fully or evaluated for their effectiveness. Funding was limited. As a result, the impacts were limited, too.
4. While regional GAMBIT programs were quite abundant and well prepared, delivery was poor and ineffective with no support from the central level, lack of solid accident databases, or a systematic evaluation of the programs.
5. The lead agencies within government structures (leaders) with responsibility for road safety did not emphasize a strong enough political will to improve road safety (lack of a political or operational leader and agencies not happy to work together).

The analyses show that Poland's approach to the problem was far from the standards normally applied in the European Union. It was clear that when the next national program is formed, the institutional setup would have to be given top priority to ensure that the program can be delivered effectively.

Road Safety Program for the Years 2007–2013 – GAMBIT National Roads

In 2007, a sectoral program was developed to address the network of national roads, called GAMBIT National Roads (Jamroz et al. 2008). For the first time the National Roads Administration acknowledged the role of partners (teachers, journalists, police officers, and fire fighters) in delivering a joint road safety vision. This was the basis for an integrated effort in a 4E approach. The program's mission followed a slogan used by many countries: **Safe roads save lives**. The program was a delivery mechanism for the National GAMBIT 2005 Program and its national roads infrastructure section. With a fairly high amount of EU funding available for road infrastructure, the main goal was defined very ambitiously, i.e., to reduce road deaths between 2006 and 2013 on national roads managed by the General Directorate for National Roads and Motorways by 75%, i.e., 500 fatalities in 2013 (Fig. 7).

Six special goals were set to reduce fatalities which are the result of: hitting a pedestrian, head-on collisions, side and rear crashes, running off the road, to reduce nighttime fatalities, and fatalities caused by excessive speed. The tasks were organized into three groups following the 3Eras concept (infrastructure measures, safety

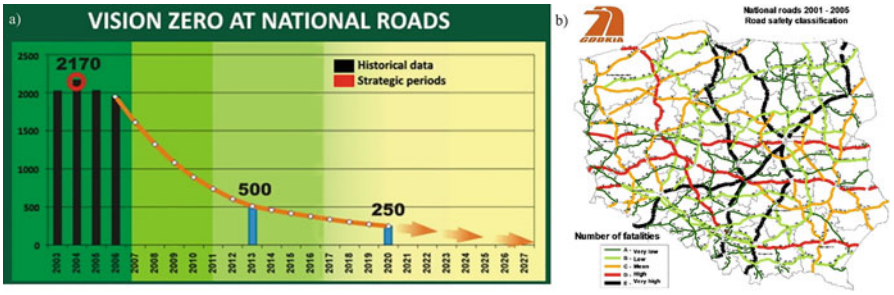


Fig. 7 GAMBIT National Roads: a) Vision Zero on national roads, b) Classification of road safety on Poland's national roads 2001–2005

management, and development of safety culture). Designed to ensure effectiveness and efficiency, the selection procedure consisted of the following steps (GAMBIT 2008):

1. Select sections with the highest risk of serious accidents
2. Identify hazards on high or very high risk sections (based on road safety inspection or audit)
3. Select the most effective action

The procedure made a difference in that it focused on comprehensive actions to include the following pillars: engineering, enforcement (speed cameras), emergency, education (campaigns in schools in close proximity to the roads), and the media (cooperation with national, regional, and local media) within the corridor of national road no. 8 (Fig. 8). When the road was modernized, fatalities on that road dropped by

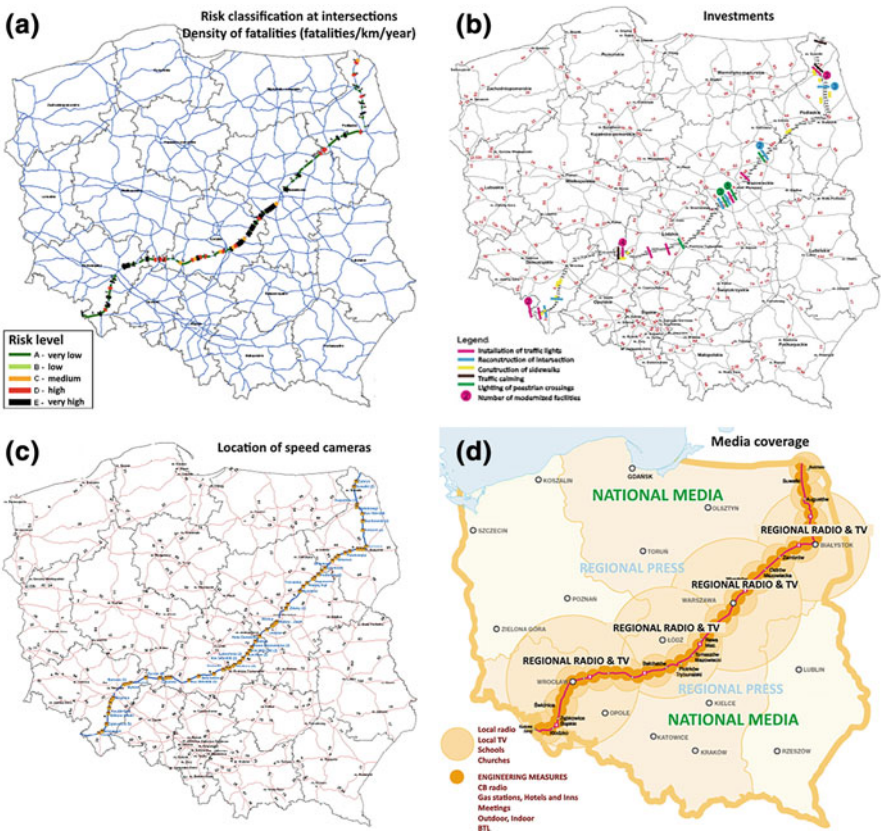


Fig. 8 Pilot project 8 + 8 + 88, national road no. 8: (**a**) risk classification on road sections, (**b**) location of proposed engineering treatments, (**c**) location of speed cameras, (**d**) coverage of regional and local media which cooperated in the pilot project

about 30%. The best solutions were implemented on another set of eight roads and then rolled out on 88 national roads; this time, however, only engineering measures were applied. Unfortunately, despite the positive outcomes of the pilot project the strategic goal was not achieved because in 2013 more than 1200 people were killed (against the goal of 500 fatalities in 2013 – Fig. 7a) on national roads which means that the assumptions were overly optimistic. More work followed in the next period. Mainly designed to build motorways and expressways, the actions helped to reduce fatalities on national roads below 1000 road deaths, but they also helped to reduce fatalities on non-national roads (secondary roads). This was possible thanks to traffic shifting from lower standard roads to better standard roads.

National Road Safety Program until 2020 – NRSP 2020 (IV NRSP)

In 2012 (a year before the previous program ended) work began on drafting a new program called the National Road Safety Program 2013–2020 (National Road Safety Council 2013). Detailed analyses showed that the main factors contributing to accidents in Poland are still the same:

- The State's organizational and functional system (lack of political will, lack of a road safety body)
- Dangerous road user behavior (excessive speed, willingness to take risks, drivers not treating pedestrians and cyclists properly)
- Too few devices for pedestrian and cyclist safety
- The road safety management system (lack of a speed management system, lack of tools for managing road infrastructure safety)
- Quantity and quality of road infrastructure (lack of a network of high safety standard roads, few safe junctions)
- Deficiencies in the operation of the rescue and post-accident help systems

The Program builds on the assumptions of Vision Zero adopted in the previous road safety programs. It has two main strategic goals: to halve fatalities on Polish roads, i.e., to reach 2000 and to reduce serious injuries by 40%, i.e., down to 6900 in 2020 compared to 2010. Developed on the basis of the Safe System (OECD 2008; Larsson et al. 2010; Groeger 2011; Mooren et al. 2011), the Program has five pillars of action: safe people, safe roads, safe speed, safe vehicles, medical rescue and post-accident care (in accordance with the suggestions of the UN Decade). Each pillar sets out priority actions which represent Poland's basic road safety problems and how they should be tackled. Each priority is a set of measures in the areas of engineering – understood as technical measures, enforcement – understood as enforcement and control, education – understood as raising road safety awareness by understanding the risks. In addition, the Program included a section on rescue measures (4E's). While the program received the endorsement of the National Road Safety Council, it did not win the approval of the Polish government leaving it without any political or financial support. The Program is delivered by the Secretariat of the National Road Safety Council which prepares annual implementation programs made up of measures that can be delivered by central bodies using their own resources (road

administration, police, fire service) and national measures such as training, studying road user behavior, media campaigns, development of road safety device design, and examples of good practice. The effects, however, are not satisfactory with cheap road safety measures no longer achieving much improvement or effect.

Role of Research

One of the main pillars of Vision Zero is facts and research in place of myths and just scratching the surface of the problem. As work on developing and implementing national and regional road safety programs began, it was clear that there is a lack of knowledge about the factors that affect road safety and a lack of tools. The available science did not include:

- An understanding of dangerous road behavior
- An understanding of the most relevant human, technical, and organizational factors and how much they affect the risks of road accidents on Poland's roads
- Methods to classify road sections for their safety
- Methods for long-term forecasts of fatalities nationally and regionally
- Methods for assessing the effectiveness and methods for selecting effective road safety treatments
- Methods for monitoring progress of treatments

Research was an important part of the implementation of the individual road safety programs. Some of it was conducted by university and research institute staff and some under national and international research grants (Jamroz et al. 2010; Jamroz 2011; Bergel-Hayat and Żukowska 2015; Gaca and Kiec 2016).

One of the first research areas was a nationwide study of road behavior carried out between 2002 and 2007 (Jamroz et al. 2016; Gaca and Kiec 2016) and continued in the periods that followed (Jamroz 2013). The first results were shocking:

- Nearly 50% of drivers drove over the speed limit with as much as 90% of drivers speeding on transit roads passing through villages and towns.
- Forty percent of drivers and front seat passengers and 60% of back seat passengers did not use seatbelts.

The results helped to intensify information and training campaigns and enforcement, including the start of building an automatic speed camera system called CANARD (Jamroz et al. 2005).

An important issue was building a Road Safety Observatory and developing a method for estimating road accident costs. Thanks to the method, it was possible to estimate Poland's annual costs of road accidents reaching more than 10 billion euro.

The next research area designed to support road safety was a study of risk-based methods for estimating fatalities and classifying road sections for accident risk (Jamroz 2011). This work helped to develop a concept of how Poland's road safety

will change as a result of treatments (Jamroz et al. 2010; Jamroz and Smolarek 2013b; Wachnicka 2018). According to this concept, a country's level of road safety depends primarily on its level of socioeconomic development and population mobility. If we consider that the road fatality rate (RFR) is a normalized measure of the country's road mortality, the level of road safety changes nonlinearly depending on changes in socioeconomic development (Fig. 9).

Within the range of low and very low socioeconomic development, as people's incomes grow, so does their mobility as well as motorization and density of paved roads. Because road and vehicle standards are low, road accident fatalities increase quickly.

As gross domestic product GDP continues to grow, the rate of increase in fatalities levels off and the RFR reaches a breakpoint. This is the result of a shock when people realize the death toll of road accidents and start to think twice as drivers and pedestrians leading them to slowly change their behavior as road users (a decreasing appetite for risk: driving slower, commonly using seatbelts, no drinking and driving). National and local institutions and organizations take steps to reduce the pace of growing motorization, a safety system becomes operational (developing a system of legislation, education, appointing a leader), safety management methods are used (a more developed enforcement system, safety programs).

Once the increase in fatalities reaches its breakpoint, accident mortality drops rapidly, a situation caused by a more stable level of motorization, density of paved roads and population mobility, and more better quality roads, i.e., expressways and motorways. Key to this is also the development of state and democratic institutions leading to less corruption, a better health care system, safety culture (use of seat belts, lower alcohol consumption).

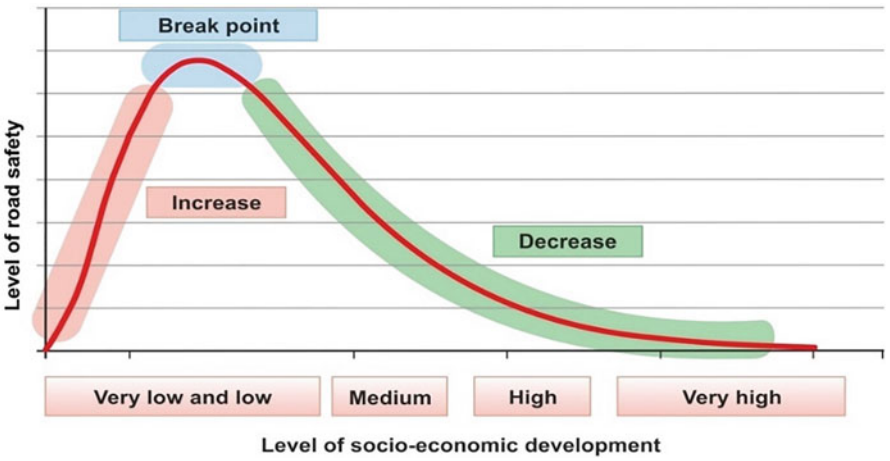


Fig. 9 Concept of a model of road safety changes in a country depending on its level of socioeconomic development

With a growing GDP and a very high level of socioeconomic development, the fatality rate should aim asymptotically to zero. This is helped by the fact that societies increase their wealth and have more respect for each other's lives including those of road users. Adopting this concept and explaining it to those who care about road safety was very helpful with understanding the mechanisms of how a road safety system operates. The concept was used to formulate the vision and strategies in the new road safety programs (Figs. 6a and 7a) and in the proposed method for forecasting fatalities (Jamroz and Smolarek 2013b).

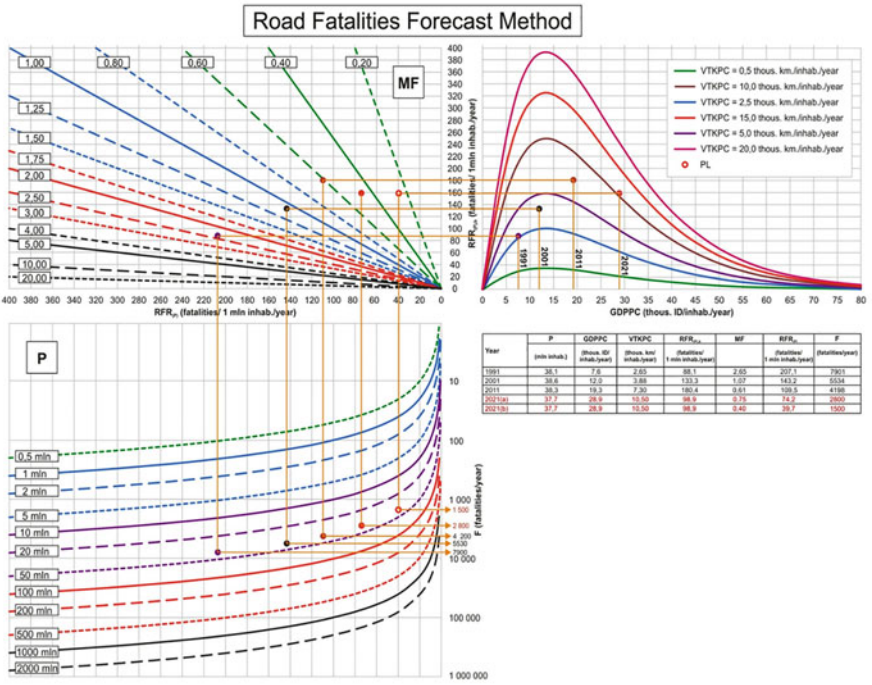
Poland did not have methods for forecasting road accident fatalities at the national or regional level. Attempts were made to use available methods and models (Smeed 1949) or the work of external experts (Oppe 2001). Simplified methods were also used. But because they were international methods, they did not account for Polish conditions or left out many important factors just as the simplified methods. As a result, the fatality forecasts were far from reality. Efforts were taken to develop Poland' own methods for forecasting road accident fatalities depending on demographic and economic factors at the national (Jamroz 2011) and regional levels (Wachnicka 2018).

To assess safety at the national level (strategic), the risk-based approach was applied which takes account of road traffic behavior of entire social groups in an area (country, region). Estimates are made of the consequences of road accidents (number of fatalities, accident costs) within a specific time period (usually over a year), which may occur as a result of dangerous incidents caused by a malfunctioning road transport system. Key to the level of the strategic risk are the country's economic development, level of motorization, social change, better education, etc.

The most commonly used measures of strategic risk are: number of fatalities F as a general measure and the road fatality rate dependent on demography RFR as a normalized measure for comparing countries for their safety levels.

A group of mathematical models was elaborated to estimate road accident fatalities F depending on gross domestic product per capita GDPPC, average number of kilometers traveled by car per capita VTKPC, number of population P, and a set of modifying factors MF (including: level of health care, level of education, level of corruption, density of road network, seat belt usage, alcohol consumption, etc.). The models were then used to develop a simplified and easy to use (by decision-makers, students, journalists) method for estimating measures of societal risk (RFR and F) shown in Fig. 10 (Jamroz and Smolarek 2013b).

A good example of how research can serve to solve road safety problems was a research program called Development of Road Innovation (RID) delivered between 2015 and 2019 by the National Centre for Research and Development and the General Directorate for National Roads and Motorways. Of the total of 15 research projects seven were dedicated to road safety problems such as: design and maintenance of safety barriers, 2 + 1 roads, the effect of advertising on road safety, speed management, the effect of ITS methods on road safety on motorways, and use of nonstandard road marking. The results of these projects are being incorporated into design practice (Gaca et al. 2018; Jamroz et al. 2018a; Oskarbski et al. 2018).



Year	P (mln inhab.)	GDPPC (thous. ID/inhab./year)	VTKPC (thous. km/inhab./year)		MF		F (fatalities/year)
1991	38,1	7,6	2,65	88,1	2,65	207,1	7901
2001	38,6	12,0	3,88	133,3	1,07	143,2	5534
2011	38,3	19,3	7,30	180,4	0,61	109,5	4198
2021(a)	37,7	28,9	10,50	98,9	0,75	74,2	2800
2021(b)	37,7	28,9	10,50	98,9	0,40	39,7	1500

Fig. 10 Simplified method for estimating road accident fatalities F in the analyzed country

These are just some of the research projects that have helped to get a better understanding of the factors contributing to safety, develop methods for estimating accidents and casualties, and prepare tools for designing elements of roads and selecting effective and efficient solutions (GAMBIT 2016, 2018).

Role of International Cooperation

Following the development and implementation of national, regional, and local road safety programs, and III NRSP (GAMBIT 2005), in particular, Poland has seen a systematic drop in road accident casualties. Polish experts have established a stronger international presence; substantial efforts have been made to improve road safety using tried and tested solutions from other countries. There was help from many experts (the Netherlands, Sweden, Germany, and Switzerland) with training for Polish experts, road authorities, road police, etc. As a result, Poland reached the breakpoint earlier than other countries marking the start of a downward trend in fatalities thanks to lessons learned from more advanced countries (Fig. 11). By using the experience of developed countries, developing countries respond to unfavorable trends earlier and take steps to improve their road safety management

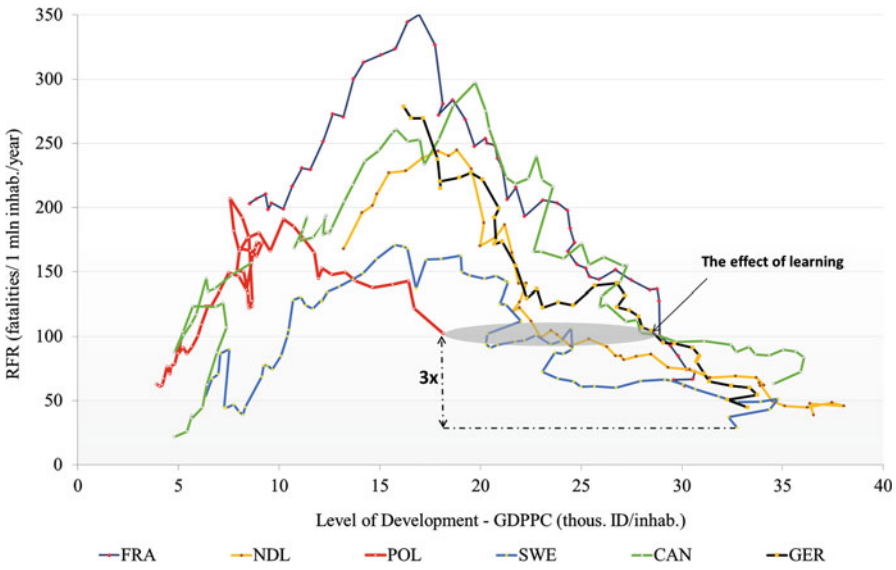


Fig. 11 Concept of a model of how experience (effect of learning) influences a country's level of safety

systems, spend more on improving road safety, implement new solutions and regulations, and are able to reduce road transport fatality rates.

Poland has benefited greatly from EU accession in 2004. The effect has been positive because (Jamroz et al. 2018b):

(a) Polish road safety strategies and programs have had to adapt to EU transport strategies and road safety programs and their requirements.
(b) Rigorous norms and standards, including those for road infrastructure safety (European Parliament and the Council 2008) have been made part of Poland's legislation and design and maintenance practice for national roads and some of local roads.
(c) With access to EU funds, Poland was able to develop a safe and modern road infrastructure such as motorways and expressways, numerous ring roads, and new links.
(d) Road safety scientists and researchers have better access to international programs and research projects, research infrastructure, and modern technologies; they are part of international teams, research projects, and conferences.
(e) Member states put pressure through their annual rankings and reports on the progress they make in achieving the strategic goals set out in road safety programs.

Poland's road safety benefitted greatly when the country joined EuroRAP's risk assessment program in 2006 (EuroRAP 2018). Using methods developed by

EuroRAP, an assessment was conducted of the risk on national roads (Fig. 7b) and compared to the level of risk in other countries. With poor results, the road authorities felt motivated to improve road safety. EuroRAP's methodology was used as a basis for developing Poland's own methods for assessing and classifying risk on national and regional roads and on street networks in major cities (Jamroz 2019).

Evaluation of the Effectiveness of Poland's Road Safety Programs

As the programs were ongoing, it was clear that road safety had improved significantly (Table 3). During GAMBIT96 the drop in fatalities was small at a mere 2.5%. During the subsequent programs, however, the effects were substantial; between 2000 and 2019 (GAMBIT 2000, GAMBIT 2005, NRSP 2020) the number of fatalities almost halved. The biggest reduction in fatalities was achieved during GAMBIT 2005; in that period (2005–2012) fatalities fell by nearly 40%.

Below are the characteristics of the most important efforts supported by the programs. Figure 11 shows how the efforts were positioned relative to the changes in fatalities in Poland between 1986 and 2018.

Period Before Road Safety Programs (1986–1995) Under planned economy (until 1989) the people of Poland had poor access to cars and fuel which was rationed (up to 30 liters per car per month toward the end of the period). As a result, population mobility was much lower and people prevalently used public transport to travel. The constraints meant that there were very few fatalities. The problem began when the political system changed (from socialism to democracy) and the economy went through a transformation (from planned to capitalist economy), which was in the second half of 1989. With the introduction of the free enterprise act, Polish citizens were able to buy cars freely (mostly second-hand cars bought abroad) causing a rapid increase in cars on Polish roads. Young drivers with very little experience of driving more powerful and dynamic cars and practically no police on the roads (change of structure, staff, and forms of operation) produced an "explosive mix" with tragic consequences and an increase in fatalities at 3050 in 2 years (from 4851 in 1998 to 7901 killed in 1991), i.e., by 63%. This came as a real shock to both government and society.

In 1992, the World Bank experts were employed to study the situation. Their report identified Poland's main road safety problems such as lack of an organization with responsibility for road safety and a very high risk to road users in Poland (Gerondeau 1993). A combination of a shocked public, refusal to accept the high road traffic risk, pressure from the media, and fast economic growth helped to overcome the trend. Following the critical peak of 1991 and the World Bank report results, Poland took steps to develop its road safety program. In 1995 there were 6900 fatalities on Polish roads (i.e., a reduction of 1000 compared to 1991) (Fig. 12).

Table 3 Changes in people killed during individual road safety programs in Poland between 1996 and 2019

National road safety program	Program period	Population P (m)	No. of fatalities F (victims)	Change in killed DF (victims)	Rate of change in killed TF (victims/ year)	Percentage drop in killed PF (%)	Road fatality rate RFR (victims/1 m pop.)
–	1995	38.6	6900	–	–	–	178.8
I NRSP	1996–1999	38.7	6730	−170	−43	−2.5	173.9
II NRSP	2000–2004	38.2	5712	−1018	−204	−15.1	149.5
III NRSP	2005–2012	38.1	3540	−2172	−272	−38.0	92.9
IV NRSP	2012–2019[a]	38.3	2909	−631	−90	−17.8	76.0

[a]currently in force

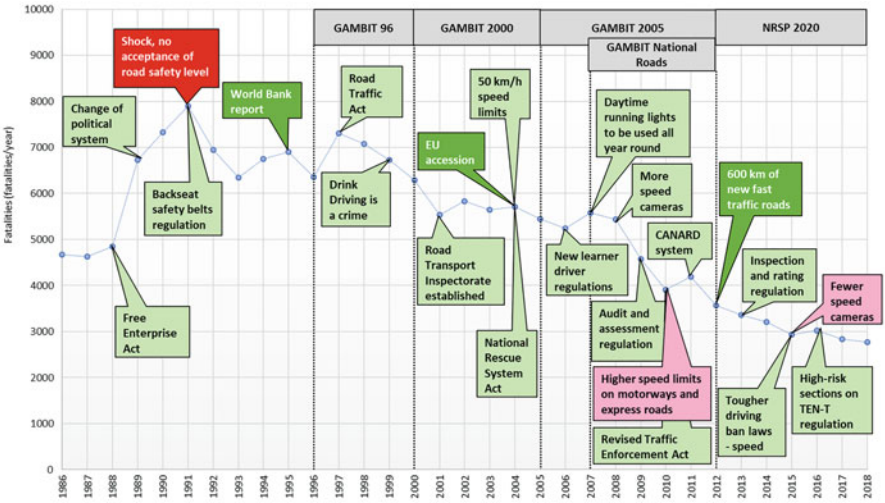


Fig. 12 Fatalities in Poland against road safety milestones

1996–1999 A time of strong variations in the fatality trends between 1993 and 1997 as the central government made other issues its priority. Despite that, fatalities dropped significantly after 1997, a trend which continued until 2001. Because the program only lasted for a short time, it achieved a mere 2.5% drop in fatalities at 6730 victims (i.e., 170 victims less compared to 1995). With the adoption of the Road Traffic Act (1997), road traffic and enforcement were better regulated and improved. In 1999, the Act was amended to add a drinking and driving regulation making a BAC above 0.05% a crime as opposed to a misdemeanor which it was before. That was a very good start to more measures designed to reduce accidents caused by drunk drivers.

2000–2004 During GAMBIT 2000 (II NRSP) the reduction in fatalities reached 15% at 5712 (i.e., 1018 victims less compared to 1999). At the time the Road Transport Inspectorate was established with responsibility for controlling vehicles and transport companies just as the police. Despite numerous efforts, there were no quick results; however, over time a cumulative effect could be seen with a reduction in fatalities in the years that followed. One of the contributing factors was Poland's accession to the European Union, which led to more regulation and bringing Polish laws to the level of countries boasting much better safety.

2005–2012 During GAMBIT 2005 (III NRSP) the national level saw a number of legislative, educational, preventive, and infrastructural efforts. However, only 84 of 144 tasks (58%) were completed. Some did not bring the expected results or were poorly performed and a number of political and administrative decisions were taken which went against the program. Many of the measures had a positive effect on Poland's road safety. They were: new regional and county road safety programs

covering about a dozen regions, cities, and counties; new sectoral road safety programs (for national roads, police); start of building the Polish Road Safety Observatory and setting up two regional observatories, new driver training, and examination rules; implementation and development of an enforcement system (speed control, control of driver working time); normalizing cycling on roads; intensive construction of expressways and motorways; construction of safe junctions, pavements, and pedestrian devices (especially on rural roads); traffic calming measures; introduction of road safety audits for some projects; and modernization and development of the rescue system and post-accident care.

The effects of the III NRSP were clear especially between 2007 and 2010, when more measures were introduced such as compulsory use of daytime running lights all year round, new speed cameras making enforcement more intense, introduction of some of the tools recommended in EU Directive of 2008 on road infrastructure safety management (audit of design documentation and assessment of newly designed roads for their safety impacts on other networks). The first sectoral program was implemented, GAMBIT National Roads, mainly focusing on infrastructure and the operational program "Roads of Trust", which involved media campaigns to inform the public about road safety problems and warned against road risks. We could see the effects of EU recommended road safety principles and standards and more funding for building safe roads in Poland. The length of safe roads increased significantly during that period (in the record year of 2012 more than 600 km of motorways and expressways were completed). Thanks to the new investments and an improved enforcement system on national roads, serious accidents (involving fatalities and serious injuries) decreased and the level of risk on the roads was clearly changing (Figs. 13 and 14). New tools suggested in the Directive on road

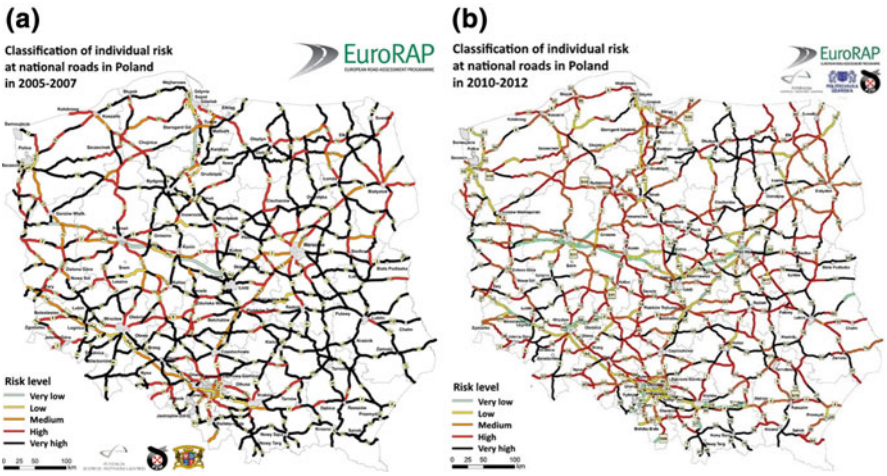


Fig. 13 Map of individual risk on the network of Polish national roads; (**a**) between 2005 and 2007, (**b**) between 2010 and 2012

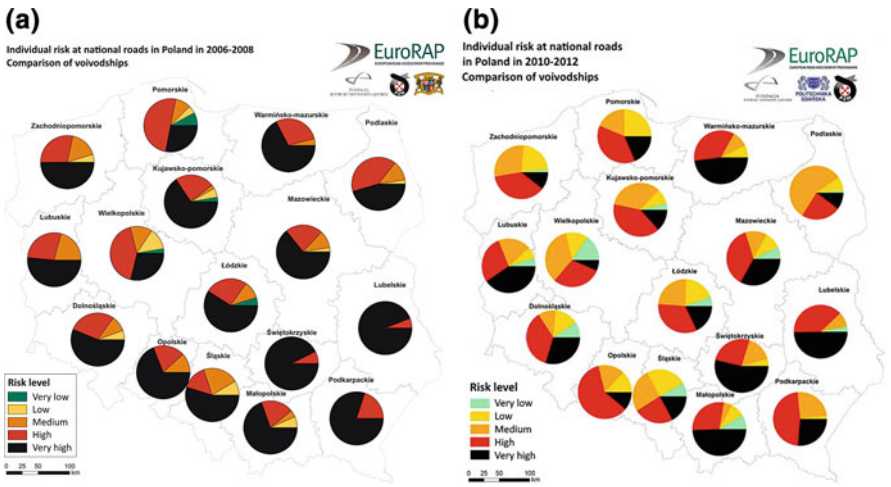


Fig. 14 Map of individual risk on the network of Polish national roads by the regions; (**a**) between 2006 and 2008, (**b**) between 2010 and 2012

infrastructure safety management were implemented (European Parliament and the Council 2008), i.e., inspecting existing road infrastructure and classification of hazardous sections. The speed limit in built-up areas was reduced to 50 km/h (sadly the nighttime speed limit was left at 60 km/h, work is under way to change this regulation in 2020) and driving tests were amended. It is estimated that thanks to the program within 8 years fatalities dropped by 38% to 3540 (i.e., fatalities went down by 2172 compared to 2004), about 6000 people were saved from death in a road accident and about PLN 34.5 billion was saved.

Road accidents, however, were still not seen as a major problem in Poland. They did not become a political priority and the institutions proved ineffective because responsibility for road safety was shared (collective). Unfortunately, many of the key actions set out in the program were never launched. No one was appointed to a lead role regarding GAMBIT 2005 delivery, the country's road safety bodies were not improved, in particular the National Road Safety Council, no appointments were made at the local level (inspectors, officers, leaders), funding for road safety was not secured, the strategy was not monitored for its progress, and good road safety practice was not promoted. Another setback came in 2010, when the motorway speed limit was raised to 140 km/h and the expressway speed limit went up to 120 km/h. In 2011 the automatic speed camera system underwent restructuring (it was moved from the Police to the Motor Transport Inspectorate) leading to an increase in fatalities by 350 within a year. Analyses showed that Poland's road safety standards are far from the standards applied in the European Union. These imperfections became challenges when the next national road safety program was being formulated.

2013–2020 In the first 5 years of IV NRSP fatalities fell by 20% reaching 2831 (i.e., 709 fatalities less compared to 2012). Since 2016 fatalities and serious injuries

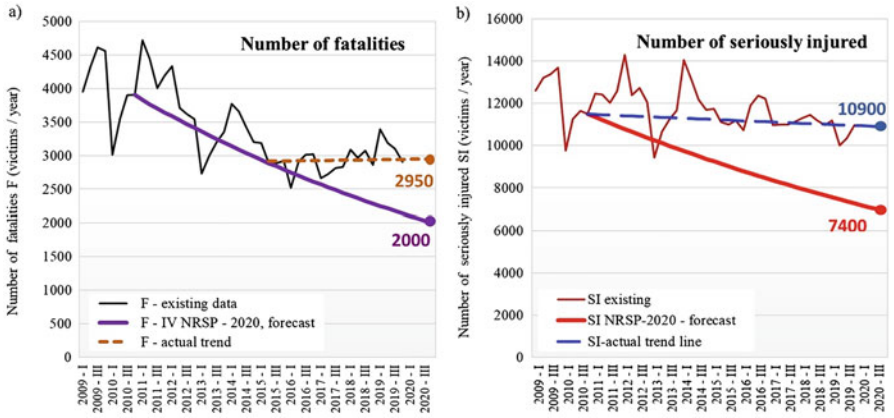


Fig. 15 Barometer of casualty change: (**a**) deaths F, (**b**) serious injuries SI in road accidents during the IV NRSP 2020

have leveled off (Fig. 15). There are some real downsides to the Program: the automatic speed camera system has a more limited coverage (2015) following the shutdown of speed cameras on local authority roads, which led to an increase in fatalities by 150 in the first year of the new smaller system and selected sectoral actions (mainly soft actions) are delivered by central bodies (Secretariat of the National Road Safety Council, Police, Road Transport Inspectorate, Fire Service). The Program's main targets are at risk with a 15–20% fall in fatalities in 2020 rather than the expected 50% and serious injuries may only fall by 3–5% in 2020 instead of the expected 40% (Fig. 15).

Prospects for Poland's Vision Zero

Possible Scenarios

Following a series of research projects, studies, analyses, and assessments of the previous four National Road Safety Programs in Poland, steps were taken to analyze and assess the potential for delivering the Polish Vision Zero. Some recommendations were also developed regarding new road safety programs in Poland until 2050. The analysis was made using the scenario method (Stipdonk and Wesemann 2007; Koornstra 2007; EC-DGTM 2011; Zmud et al. 2013; Jamroz et al. 2019). Four scenarios were developed (shown in Table 4) setting out key strategic actions and two groups of factors: level of socioeconomic development measured with an increase in the GDPPC and level of transport policy effectiveness regarding road safety.

Using the authors' own method for long-term forecasts of fatalities described in the works of Jamroz et al. (Jamroz 2011, 2012; Jamroz and Smolarek 2013b; Jamroz et al. 2014b, 2016), a fatality forecast was made for four road safety scenarios until 2050 listed in Table 5. The baseline year is 2017 with fatalities on Polish roads at

Table 4 Potential road safety scenarios of Vision Zero in Poland

The impact of transport policy on road safety improvements	Level of socioeconomic development (GDP growth rate)			
	Very high	High	Low	Very low
Very strong	S.1 Optimistic scenario			
Strong		S.2 Moderate scenario		
Weak			S.3 Stagnation scenario	
Very weak				S.4 Pessimistic scenario

Table 5 Expected number of fatalities F, by scenario and period

	Expected number of fatalities F (fatalities/year)				Expected RFR (victims/1 m inhab./year)				Summary number of people until 2050 PF (thous. Inhab./ 34 years)	
Scenario	2020	2030	2040	2050	2020	2030	2040	2050	killed	saved
S1	1850	630	180	40	49	19	6	2	24.1	39.5
S2	2240	1120	480	180	59	30	14	6	36.1	27.5
S3	2860	1650	750	300	75	45	22	9	49.6	14.0
S4	3020	2120	1300	750	108	57	38	21	63.6	–

F = 2831 people and the road fatality rate at RFR = 75 fatalities/one million population.

In addition, the particular scenarios assume that parameters may change until 2030 and that a similar pace of change may continue until 2050 (GAMBIT 2018).

Optimistic scenario S1 is characterized by a very high rate of socioeconomic development and a very strong effect of transport policy on road safety action.

Very high level of socioeconomic development includes a quick rate of the country's economic growth (increase in GDP more than 5% annually) and GDPPC at nearly 74,000 ID per capita in 2050. This will help to increase expenditures on the development of a network of modern and safe roads and a wide-ranging modernization of existing local roads, expenditure on health and rescue services on roads, transport education in schools, a safety management system, etc. The scenario assumes that population numbers will fall fairly quickly (29,600,000 in 2050 as a result of low birth rate) and that trips by car will fall (to 346 billion vkm/year in 2050).

A strong transport policy in relation to road safety action will primarily be designed to: strengthen the role of leader and that of road safety bodies, maintain a high degree of construction of motorways and expressways (up to 8000 km) and

other roads of a high road safety standard, implement a wide range of activities in the area of road infrastructure safety management, reduce the role of the car and change how cities are planned, develop an automatic road traffic enforcement system (more speed cameras and sections with automatic speed enforcement, $FV_1 > 1300$), implement new systems for road traffic management (ITS, speed management), implement new technologies (autonomous and automatic vehicles), develop a system of road rescue, gain strong political support from the central level, and develop a strong safety culture of road authorities and among road users.

Moderate scenario S2 is characterized by a high pace of socioeconomic development and a strong effect of transport policy on road safety action.

High level of socioeconomic development includes a fairly quick rate of the country's economic growth (increase in GDP more than 4% annually) and GDPPC at 63,000 ID per capita in 2050. This will help to allocate substantial funds to the development of a network of modern and safe roads and a wide-ranging modernization of existing local authority roads, expenditure on health and rescue services on roads, transport education in schools, a safety management system, etc. The scenario assumes that population numbers will fall moderately to 33 million in 2050 (modern birth rate) and that trips by car will fall (to 389 billion vkm/year in 2050).

A strong and responsible transport policy in relation to road safety action will be designed to strengthen the role of leader and that of road safety bodies, maintain a high degree of construction of expressways (to 7200 km) and other roads of a high road safety standard, implement activities in the area of road infrastructure safety management, develop an automatic road traffic enforcement system (slightly more speed cameras and sections with automatic speed enforcement, $FV_2 < 1000$). The scenario is a continuation of effective and efficient actions already started under III NRSP. It shows what fatality reductions can be achieved and the consequences if the trend is abandoned.

Stagnation scenario S3 is characterized by a low pace of socioeconomic development and a weak effect of transport policy on road safety action.

Low level of socioeconomic development includes a slower pace of the country's socioeconomic development (increase in GDP below 3% annually) and GDPPC at 51,000 ID per capita in 2050. With a limited pool of funding less money will be spent on building a network of safe roads and modernizing the network of existing local authority roads, there will be less spending on health care and road rescue, transport education in schools, a safety management system, etc. The scenario assumes an average pace of population decrease to 33 million people in 2050 (moderate birth rate) and that trips by car will fall (to 389 billion vkm/year in 2050).

A weak transport policy in relation to road safety means lack of a leader and a limited role of road safety bodies, slower pace of building expressways (to 6500 km) and other roads of high road safety standards, slow or limited implementation of safe road infrastructure management, a limited road traffic enforcement system (including a limited number of speed cameras and sections with automatic speed enforcement, $FV_3 < 750$).

Pessimistic scenario S4 is characterized by a very low rate of socioeconomic development and a very weak effect of transport policy on road safety action.

Very low level of socioeconomic development means a slow pace of the country's economic growth (increase in GDP below 2% annually) and GDPPC at 51,000 ID per capita in 2050. With a limited pool of funding, less money will be spent on building a network of safe roads, there will be less spending on health care and road rescue, etc. The scenario assumes an average pace of population decrease to 36.6 million people in 2050 and that trips by car will not fall (436 billion vkm/year in 2050).

A very weak transport policy in relation to road safety means lack of a leader and a limited role of road safety bodies, slower pace of building expressways (to 6500 km) and other roads of high road safety standards, no implementation of safe road infrastructure management, a limited road traffic enforcement system (including a limited number of speed cameras and sections with automatic speed enforcement, $FV_4 < 500$).

Estimating the Expected Effects of the Scenarios, if Delivered

The assumptions and scenarios of the country's socioeconomic development and road safety-related transport policies were estimated for the reductions in road accident fatalities they can achieve. The results are shown in Table 5 and Fig. 16.

If road safety efforts were to follow **optimistic scenario S1** which represents the effect of a broader set of road safety actions, the pace of change would be likely to stay strong, i.e., about 170 fatalities annually in the next decade. The reduction in fatalities could amount to 66% over the 10 years of the Program V NRSP (between

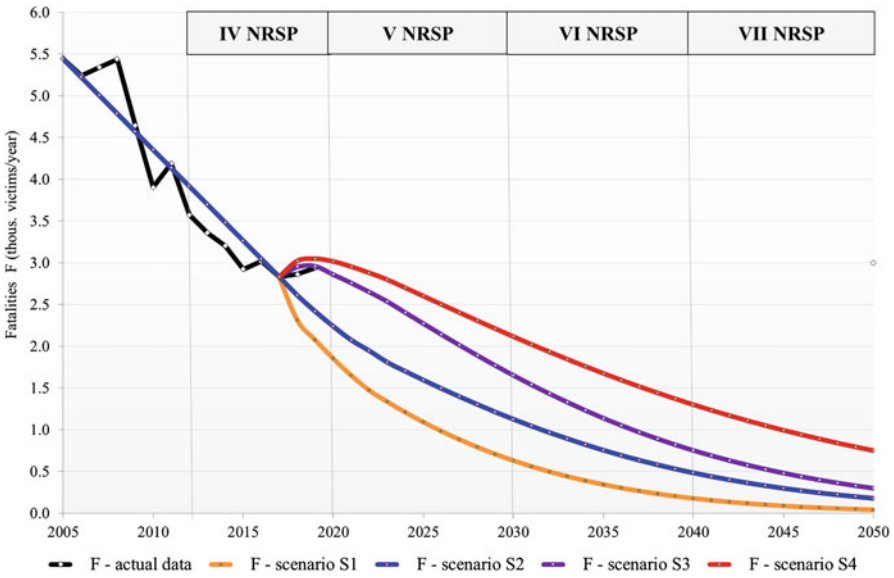


Fig. 16 Forecast of road accident fatalities until 2050 in Poland for different road safety scenarios

2021 and 2030). This would make RFR = 17 fatalities per one million population in 2030, close to the rate forecasted in that period in Sweden, the Netherlands, and the United Kingdom. The scenario shows that it was highly likely that Poland's fatalities could be close to zero in 2050 with about 40,000 more lives saved from road death than in the worst-case scenario (S4). Given the setbacks Poland's road safety system has suffered in the last few years, the fact that low-cost road safety treatments have been almost used up and that other conditions have put the brakes on positive road safety developments, the scenario is not very likely to happen.

If road safety efforts could follow **moderate scenario S2** which represents the effect of a fairly broad set of road safety actions, the pace of change would be likely to stay fairly strong, i.e., about 130 fatalities annually in the next decade. The reduction in fatalities could amount to 50% over the 10 years of the Program V NRSP (between 2021 and 2030). This would make the rate RFR = 30 fatalities per one million population in 2030 close to the rate as it is today in Sweden, the Netherlands and the United Kingdom. The scenario shows that it was fairly likely that Poland's fatalities could be close to zero in 2050 with about 27,500 more lives saved from road death than in the worst-case scenario (S4). Given the setbacks Poland's road safety system has suffered in the last few years, the scenario is not very likely to happen.

The setbacks in delivering road safety efforts and the resulting stagnation in fatalities at the level of 2016–2017 and seriously injured at the level of 2010 suggest that the number of fatalities is likely to change according to **stagnation scenario S3.** The scenario is a warning against doing less for road safety.With a limited scope of actions, the rate of decline in fatalities will slow down. It can be expected that over the 10 years of the Program V NRSP (between 2021 and 2030), the reduction in victims could be by 42%. This would make the rate RFR = 45 fatalities per one million population in 2030 higher than expected. This, however, is not enough to achieve V NRSP targets and deliver Vision Zero in 2050.

Pessimistic scenario S4 provides a stark warning against stopping or reducing road safety efforts because the average rate of fatality reduction will be about 45 fatalities annually until 2030 and the reduction in fatalities expected over the 10 years of the Program (2020–2030) could be a mere 29%. This is definitely not enough to achieve Program targets and deliver Vision Zero in 2050.

Given the history of previous road safety efforts, stagnation scenario S3 seems most likely. Unfortunately, this scenario will not ensure the achievement of the EU's strategic goal by 2030 (reduction in the number of fatalities), so additional measures will be necessary such as moderate scenario S2.

Guidelines and Recommendations for New Road Safety Programs

Three programming periods are envisaged on the way to achieving Vision Zero in 2050 (Fig. 16).

1. V NRSP – to be delivered in the years 2021–2030 – requires a new approach, a lot of organizational and financial effort, a change in road user behavior, road user

control reinforcement, implementation of a fleet of modern vehicles equipped with new technologies, development of safe infrastructure (completion of a planned motorway and expressway network, implementation of new traffic control technologies), and changes in mobility management. Depending on the scenario, in 2030 fatality reduction F could be in the range of 3020–1850 and the RFR in the range of 110–50 fatalities per one million population.

2. VI NRSP – to be delivered in the years 2031–2040 – requires a continuation of the approach from the previous period, a further development of road safety management system, broader changes in road user behavior, development of a fleet of modern vehicles, increasing the share of public transport and alternative means of transport in modal split, development of safe road infrastructure by adapting existing roads to new standards, common use of new traffic control technologies, and development of sustainable urban mobility management. Depending on the scenario, in 2040 fatality reduction F could be in the range of 2120–630 and the RFR in the range of 60–20 fatalities per one million population.
3. VII NRSP – to be delivered in the years 2041–2050 – requires a continuation of the approach from the previous periods, improving the development of road safety management system, significant changes in road user behavior and its control, development of a fleet of modern vehicles, a significant share of public transport and alternative means of transport in modal split, development of safe road infrastructure by adapting existing roads to the newest standards (increasing requirements), common use of new traffic control technologies, and development of sustainable urban mobility management (e.g., eco-city, techno-city). Depending on the scenario, in 2050 fatality reduction F could be in the range of 750–40 and the RFR in the range of 20–2 fatalities per one million population.

Analyses have shown that an intensified effort in the initial period of V NRSP could be followed by scenario **S2** actions. This, however, requires a wide spectrum of strategic, management, and operational activities designed to develop a system of road safety, change road user behavior, develop modern vehicles, build a modern and safe road infrastructure, and strengthen the road rescue system (Wadhwa 2001; NR2C 2018).

Actions to develop a road safety system are mainly to: adapt legal regulations to new challenges, develop and implement a new national road safety program and new urban and regional road safety programs, involve nongovernmental organizations and voluntary movements.

Actions to change road user behavior are mainly to: use an automatic lock to prevent drunk drivers from starting the engine (alcolock), develop automatic enforcement and speed management (speed cameras, systems of adaptive speed management (Intelligent Speed Adaptation ISA)), pedestrian and cyclist safety devices and new systems of driver training.

Actions to develop modern vehicles are mainly to: ensure a common use of winter tires, develop devices to aid drivers (maintaining a set speed and distance, detecting conflicts), develop and implement autonomous vehicles, electric and hybrid

vehicles, car co-sharing, vehicles communicating with external devices (with another vehicle (V2V), with road infrastructure (V2X), with a traffic control system (V2C)).

Actions to develop a modern and safe road infrastructure are mainly to: eliminate head-on collisions by separating carriageways (a more common use of 2 + 1, 2x2 cross-sections), eliminate side crashes by using safe junctions (roundabouts, signalized junctions), use new and safer types of interchanges, use safety devices (barriers, terminals, fencing) and devices for vulnerable road users (pavements, cycle roads, pedestrian crossings), develop autonomous and electric vehicle friendly infrastructure, take advantage of Intelligent Transport Systems. To achieve this, it is necessary to:

(a) Improve the regulations and guidelines for safe road design
(b) Develop new technologies and use adequate and durable construction materials and long life and low maintenance structural elements which guarantee a high level of safety and efficiency (object life cycle)
(c) Develop new materials, technologies, and structural parts to ensure a higher level safety for road users

Actions to develop mobility management are mainly to: implement traffic zoning, promote shared space, eliminate cars from central parts of cities (charges, public transport, cycling, ring roads), use new forms of urbanization (techno city, eco city).

Moreover, in addition to infrastructure measures and the development of road safety management tools, efforts should be undertaken and strengthened to develop the road safety culture. Actions should be aimed at changing the safety culture of individual road users by changing behavior, choosing less risky routes or means of transport, requiring and supporting actions to improve road safety. It is also important to change the approach of politicians, managers, road management employees, project offices, and media, so that road safety issues are included in everyday activities.

Summary

The moment of adopting Vision Zero can be perceived as the beginning of systemic work for road safety in Poland. Since the III NRSP was developed and approved by the then government, Vision Zero has become not only a political slogan, but also a practical tool for the functioning of the road safety system. The vision has been included in national strategies and adopted by many cities and regions in their road safety strategies. Poland's approach to road safety has become holistic; it has started to be perceived as an important social problem and given a higher priority. In combination with the requirements of the European Union and its technical and financial support, the road safety activities undertaken in Poland brought significant effects. The problem of road safety has also gained more attention of researchers – the results of road safety analyses, Polish case studies, and evaluation of road safety measures were presented at numerous conferences and published in research journals.

Local government officials, educators, journalists, policemen, paramedics, road designers, engineers, and administrators are interested and more aware of the issue of road safety. With more experience and interest in road safety, Polish institutions (i.e., national road administration), universities, and technical associations have started international cooperation, learning from better performing countries and passing on the experience of applying a systemic approach to road safety to countries with lower level of road safety (Egypt, Jordan, Lebanon, Uzbekistan, Albania, etc.).

However, the results of road safety policies are still below the expectations and many problems have not been solved. Road accidents are still not considered a major problem. As a consequence, they are low on political agendas and the institutions remain ineffective due to a sense of collective responsibility for road safety problems. Achieving Vision Zero will require many changes, learning from past mistakes, taking advantage of the experience of the best performing countries, and, above all, taking effective and efficient actions with their systematic monitoring.

Studies and analyses designed to evaluate Poland's road safety programs between 1996 and 2019 show that:

1. Ethical road user behavior, facts, research, and shared responsibility are the main pillars of Vision Zero and achieving it requires new ideas, technologies, and management systems to take account of human behavior as road users, modern vehicles, safe road infrastructure, mobility management, and development of the road safety management system.
2. A country's socioeconomic development is clearly a factor contributing to its road safety level and the main contributing factors are gross domestic product, population mobility, level of the organizational system (level of education, level of the health care system, level of corruption), level of the development of safe road infrastructure (network of safe roads), and change in road user behavior (speed, seatbelts, alcohol).
3. The goals, priorities, strategic actions, and objectives of new programs in Poland and in other countries should be based on a model for changing a country's road safety depending on its socioeconomic development and a method for estimating fatalities.
4. The effectiveness of road safety action depends on a number of factors. The current state of science and experience of countries that have a high level of safety show that it is possible to reach a maximum effect by adopting an ambitious vision and a systemic approach to achieving goals and strategies. Key to this is having a clearly defined and science-based philosophy of action rather than myths and popular opinion.
5. Analyses show that support and advanced efforts can help to reduce fatalities in the subsequent programming periods and achieve Vision Zero in a few decades.
6. Poland's experience shows that political and systemic change can have a significant effect on positive change in socioeconomic development, which is also beneficial for road safety. In the case of Poland, it was accession to the European Community that contributed to the significant drop in road accident fatalities.

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