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Road safety information system in Poland – supporting tools and their development

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ABSTRACT

As a signatory to the UN Declaration on road safety and member of the EU, Poland has an obligation to comply with relevant EU policies and in particular to halve the overall number of road deaths by 2020. To monitor the progress in reaching the targets, the road safety situation must be evaluated and its processes understood. For this purpose regional and national road safety observatories were launched in Poland, which triggered the need to develop special methods and tools to assess trends and how different factors affect risk, particularly in the short and mid-term perspective. One of these tools can be structural time-series models to explain how trends change and forecast realistic scenarios of change. We can also use models to simulate the effects of sources of risk on selected road accident consequences on sections of Poland's road network.

Keywords: road safety management and modeling, safety information system, safety management tools

1. Introduction

The complexity of how road accidents happen means that the effectiveness of road safety measures can only be ensured if the actions are comprehensive, organized and coordinated using a consistent set of methods and the right technical and organizational means. This suggests that each level of administration must have a road safety management system in place which ensures a long-term operation and systematic adjustments and improvements so that no opportunity to improve safety is missed.

Countries with impressive road safety track records owe their success to methodical and systematic improvements that have helped them halve road deaths in the last three decades, whilst road traffic in the same period increased several times. What this means is that societies that understand the risks involved in motorization have been able to stop the negative trends and reduce the risk. An important step in this process was the understanding that road accidents do not have to happen (it is not fate that decides, accidents can actually be predicted), but when they do, it is the result of faulty transport system design and operation. And so improving the system is part of the state's remit just as health care and the environment [1].

2. The development of Poland's safety information system

As a signatory to the UN Declaration on road safety and member of the EU, Poland has an obligation to comply with relevant EU policies and in particular to halve the overall number of road deaths by 2020. In an effort to advance road safety in Poland, the importance of a comprehensive understanding of safety problems has been identified as a critical element of any road safety management system. To achieve this requires a crash data collection and a management and analysis process that provides the necessary in-depth understanding. This should be the core activity of a comprehensive Road Safety Information System in Poland managed by a road safety Lead Agency, which could ensure a very strong link between data analysis (understanding the problem) and developing policies and programs for reducing death and injury on the roads [2].

Poland's arrangements for collecting, processing and disseminating road accident data were diagnosed by the World Bank in March 2013 in its review of the country's road safety management capacity. It identified the main and systemic reasons why Poland's road safety continues to be in such a poor state. The report emphasizes the importance of a system for collecting and analyzing road accident data and disseminating the information placing it as the key to the success of road safety improvement. Data accessibility is a pre-requisite for a results-oriented road safety management approach. As stated in the World Bank report, Poland does not have a coordinated road safety data collection system [3].

If Poland's road safety management system is to be created, the priority should be to build a consistent system for collecting and disseminating road safety data giving a reliable picture of the existing situation and changes and their trends in the past. To that end, it is also important to have all the necessary tools and analytical and research methods. If we are to prevent negative trends in the future and apply the right corrective measures, we must first understand the causes of the changes.

Launched in 2014, the Polish Road Safety Observatory (POBR[1]) is situated at the Motor Transport Institute in Warsaw. The Warminsko-Mazurskie Road Safety Observatory (at the Regional Road Traffic Centre in Olsztyn) was set up a few years before. These observatories along with the Pomorskie Observatory (at the Gdansk University of Technology) are Poland's first organizations to take on the task of collecting and disseminating road safety information, each at their different administrative level [4]. They may become the future foundations of an integrated road safety information system. How effective they are and will be, will primarily depend on how they will be organized and what powers they will have. But equally this will depend on the availability of reliable data (not only about road accidents but also road user behavior, traffic volumes, etc.) and the tools and methods for analyzing, concluding and forecasting how road safety will change. Such tools must be identified and continually improved.

3. Outline of the safety information system

The common understanding, which is also proposed to member states in the EU, is that an observatory is a unit which systematically monitors, analyses and studies road safety and, depending on its competencies and level of operation (European, national, regional), formulates draft guidelines and recommendations for lawmakers or those responsible for implementing road safety strategies, programs and preventive measures [5]. An observatory is different from other organizations of this type (research centers, statistical offices, etc.) in that it puts the emphasis on formulating and disseminating the knowledge collected in a way that is easy to use and understand not only by a small group of specialists but first of all by all users who are not necessarily knowledgeable in the meanders of specialist definitions, circumstances and principles of how road accidents are studied and analyzed.

Road safety observatories, as tools supporting the process of road safety management should meet two key roles. They should:

- facilitate (improve) the work of institutions and organizations involved in road safety efforts,
- act as a communications platform on topics related to road safety and provide access to a number of users to reliable knowledge, analyses, contacts, etc.

Depending on the administrative level (national or regional observatory), the objectives and tasks of observatories should meet the needs of the institutions which will be the key recipients of the observatories' knowledge and information, and the specific needs of other users. As an example, regional road safety observatories should be set up specifically to collect and disseminate road safety data with a special focus on the regional characteristics. The national observatory, on the other hand, should aim to collect centralized data to provide information about road safety levels compared to Europe and about how specific regions perform compared to the rest of the country. Knowledge about traffic safety should cover all aspects and suggest treatment and measures that have been tried and tested in Poland and abroad. The tasks of the national and regional observatories must be coordinated to ensure that they do not operate in isolation from one another (like islands), but instead support one another and form a network. They should use their mutual links to collect and verify key road safety information.

To ensure that the system for collecting and analyzing safety data if effective, it is important to investigate the causes and mechanisms that affect safety levels. We can only gain insight into how specific types of accidents occur through research. This will help to eliminate the causes. Unfortunately, such research in Poland barely exists. There is hardly any systematic monitoring or routine "before and after" assessments, which are key to understanding the quantitative effects of road safety interventions. Neither do we learn about the costs and benefits of interventions, which is a standard procedure in other countries before embarking on a project. This is helpful with effectiveness evaluations of road safety programs, setting the hierarchy of particular actions and changing them, if necessary [3].

4. Data and tools supporting safety information system

Road accident data provide the basic information needed to make an assessment which should then be followed by identifying more effective methods of improving road safety. This is why each organization involved in road and safety management, whether central, regional or local, must have access to reliable and complete safety data.

In Poland that access is still incomplete with some self-government bodies having difficulty in obtaining data of a sufficient level of detail needed to understand and solve traffic hazards. What is more

[1] POBR - Polish Road Safety Observatory (Polskie Obserwatorium Bezpieczeństwa Ruchu)

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accident data are not verified systematically, which makes analysis and use of the information more difficult.

Poland's existing road accident databases do not operate in a system. The only common element they have is the source of data, i.e. the police database called SEWIK. The databases are built for the particular organizations (institutions, agencies) and in the majority of cases, there is no mutual use of the data they collect. This leads to a lot of overlap and data are not used by other organizations simply because they do not know the data exist or have technical problems using them.

Although quite different, the problem of accessing road user data (speed, use of seatbelts, driving under the influence of alcohol and other similar substances) is equally important. If collected systematically, this information provides critical research material, and should also be used for routine analyses to monitor the state of road safety. Recently, the Secretariat of the National Road Safety Council has made an important contribution to data collection and dissemination by commissioning large-scale surveys of: speed, use of seatbelts, child seats and helmets [6].

The process of road safety management includes two groups of methods:

- retrospective methods based on analyses of past road accidents and
- prospective methods that support decisions to improve the road network thanks to a systematic identification and assessment of risk on the roads.

Prospective methods are more effective and efficient because they help to identify the consequences of particular hazards. But before these methods can be used, detailed knowledge is needed about roads and roadsides. This can be sourced from road safety inspections.

As part of analyses and research, we must identify and understand the relationships between sources of road traffic hazard and the consequences of road accidents. The relationships can be described with mathematical models at the macro and micro analytical level and then used as tools of road safety management. As an example, for the purpose of macro scale analysis we use time-series models to search for the relations between an observed level of risk and socio-economic changes. Micro scale analysis can be done using models that simulate the effects of changeability of a selected set of hazard sources on the consequences of road accidents on specific road sections. With no tools for effective road safety management, Poland has not been able to objectively assess road hazards. This is now a requirement under the EU's Directive on Road Safety Infrastructure Management [7]. Safety management on an existing road network is one of the tools proposed in the Directive. It also fits in with transport safety management in the broad sense as a tool supporting the operation of the system. It is a procedure for improving safety on an existing network comprising several stages. Its objective is to:

- assess safety and identify the most hazardous sections,
- conduct a road safety inspection of the most hazardous sections,
- select the most effective and efficient treatment consistent with the available funds,
- communicate the hazards to road users and partners (local authorities, police, businesses),
- monitor the level of safety following the delivery of measures and evaluate the effectiveness.

Developed for the General Directorate for National Roads and Motorways in 2013, the "Instructions for Classifying and Inspecting Road Safety on National Roads" support Poland's implementation of the EU Directive on road safety management.

5. Examples of tools supporting safety information systems

5.1. Socio-economic influences' modeling

The structural time series analysis methods [9], [10] have been used more and more for modeling the aggregate number of fatalities at national level in Europe [11] and therefore may be a very good tool for road safety modeling and forecasting in Poland.

A structural model of periodic (monthly) discrete time serie s consists of three basic components: the seasonal component, the trend and irregular interference. It can then be extended according to the needs of the situation: e.g. explanatory variables and interventions can be added in order to determine the effect selected factors have on the number of fatalities in Poland over the analyzed period. Among the potential socio-economic factors which are known to impact the number of fatalities, those analyzed by the author [12] include the industry production and the unemployment rate. Also the weather and road safety measures (or countermeasures) influence is accounted when the possible interventions of the model are analyzed (factors or specific events which impact the road safety level).

The general formulation used for modeling the monthly number of fatalities with the so-called structural model is the following one:

$$\begin{aligned} LogF_t &= \mu_t + \gamma_t + \beta\, x_t + \sum_{k=1}^{K} \lambda_k w_{kt} + \varepsilon_t && \varepsilon_t = N(0,\sigma_\varepsilon^2) \\ \mu_t &= \mu_{t-1} + \sum_{l=1}^{L} \lambda_l w_{lt} + \eta_t && \eta_t = N(0,\sigma_\eta^2) \\ b_t &= b_{t-1} + \zeta_t && \zeta_t = N(0,\sigma_\zeta^2) \\ \gamma_t &= -\sum_{j=1}^{s-1} \gamma_{t-j} + \omega_t && \omega_t = N(0,\sigma_\omega^2) \end{aligned} \quad (1)$$

where:

F_t is the monthly number of fatalities,

x_t is the variable measuring the economic factor in the month, with coefficient β,

w_{kt}, 1,..,K, and w_{lt}, *1,..,L*, are *K+L* intervention variables, with coefficients λ_k and λ_l,

μ_t and b_t are the level and slope of the local linear trend,

γ_t is the seasonal component written under a dummy form,

ε_t, η_t, ζ_t and ω_{it}, *i=1,..,I*, are error terms, with variances σ_ε^2, σ_η^2, σ_ζ^2 and $\sigma_{\omega_{it}}^2$ which are not mutually correlated, for *t*=1,...,*n*.

Depending on the risk factor, it is assumed in that formulation that the relation of the number of fatalities to a measure x of that risk factor is either multiplicative or semi-multiplicative, at the level of the month. Thus, $LogF_t$ will in all cases be the dependent variable whereas x_t or $Logx_t$ will be used as independent one.

The results of the analysis performed for Poland [12], [13] confirm that a structural times series model with explanatory and intervention variables is an appropriate tool for explaining the changes in the monthly number of fatalities in Poland for the period 1998-2012, in relation to economic factors such as the industrial production index and/or the unemployment rate. Thus the model is an appropriate tool to be used by any road safety monitoring body (e.g. an observatory).

5.2. Tools to inspect safety on existing road networks

Ranking of hazardous sections. The main objective of the ranking is to select sections where the risk of being involved in a fatal accident is the highest. It is also to select road sections with the highest potential for improving safety and reducing accidents costs as a result of road authority efforts.

Ranking of sections for their accident concentration is based on the notion of individual risk (number of accidents and their victims vs. miles travelled on that section). Individual risk relates to the behavior of an individual road user on a road (junction, section in between interchanges). It is defined as the likelihood of being a casualty (being involved in a fatal accident) during one trip or within a specific time interval when the user is at risk caused by the road infrastructure and other road users [14].

Because urban and rural accidents differ in severity, two measures are used:

- concentration of fatal accidents (KWZ) which takes account of, in particular, the consequences and severity of rural road accidents,
- concentration of accident costs (KKW) which takes account of, in particular, the consequences and costs of urban road accidents.

As a measure, concentration of fatal accidents (KWZ) includes and emphasizes in particular the consequences and severity of accidents occurring on rural roads where speeds are higher. The concentration of fatal accidents on an analyzed road section is calculated for types of fatal accidents and the period under analysis using the following formula (2):

$$\mathrm{KWZ_{i,j}} = \frac{\mathrm{LWZ_{i,j}}}{\mathrm{PP_i}} \qquad \textbf{(2)}$$

where:

$KWZ_{i,j}$ - concentration of fatal accidents of *j* type on a road section (fatal accidents/1 billion vkm /3 years) during *i* calculation period,
i – number of calculation period, *i = 1* for calculation period 2010 – 2012,
j= w – overall fatal accidents,
j= p,r – fatal accidents involving pedestrians and cyclists,
j= m – fatal accidents involving motorcyclists,
$LWZ_{i,j}$ – number of fatal accidents of *j* type on a road section (fatal accidents/3 years), during *i* calculation period,
PP_i – miles travelled on a road section (billion vkm /3 years), during *i* calculation period.

Safety ranking is based on a method used in the EuroRAP program [15]. Six classes of fatal accident concentrations on road sections are proposed as an intermediate solution (A, B, C, D, E1 and E2). The boundaries of classes A-D correspond to the boundaries of relevant classes adopted for this measure in EuroRAP. Class E is divided into two sub-classes: (E1) very high accident concentration and class (E2): catastrophic accident concentration which covers about 10% of the most hazardous sections of roads under analysis. Table 1 shows the proposed safety ranking based on fatal accident concentration.

Table 1. Safety ranking of road sections based on concentration of fatal accidents (individual risk – KWZo; KWZp,r; KWZm) [own study]

Risk class	Concentration of fatal accid.	Overall		Pedestrians and cyclists		Motorcyclists	
		KWZ (accid./1 billion vkm)		KWZ (accid./1 billion vkm)		KWZ (accid./1 billion vkm)	
		from	up to	from	up to	from	up to
A	Very low	0.0	2.4	0.0	0.8	0.0	0.5
B	Low	2.4	9.7	0.8	3.1	0.5	2.0
C	Medium	9.7	16.7	3.1	5.4	2.0	3.5
D	High	16.7	28.4	5.4	9.3	3.5	6.0
E1	Very high	28.4	41.4	9.3	13.6	6.0	8.8
E2	The highest	>41.4		>13.6		>8.8	

Concentration of fatal accidents has three categories of road users: all road users, vulnerable road users (pedestrians and cyclists) and motorcyclists.

Ranking of road sections for network safety is based on societal risk (number of accidents and victims vs. length of the section). Societal risk refers to behavior of groups of road users on a road (junction, section in between interchanges). It is defined as the sum of consequences of specific severity suffered over an analyzed period and on a specific road. In order to differentiate between road sections where accident costs are the highest and sections that have the biggest potential for reducing accident costs, two measures are used:

- density of road accident costs (GKW) which takes account of total costs of road accidents on road sections,
- potential for reducing accident costs (PRKW) which takes account of road safety actions.

Road safety inspection on a road network. A road safety inspection is an element of the road safety management system and part of preventive measures taken by road authorities. The objective of road inspection is to identify hazards and sources of hazards on a road network in order to implement effective steps to improve the safety of road users and the standards of the road network [16].

Road network inspections are divided into three types: general, specific and special. General inspection (OK) is conducted in the daytime and is designed to inspect the condition of elements along the road and assess their impact on road safety. General inspection is a systematic activity conducted at least once a year focusing on hazard identification. The aim is to ensure that maintenance work is effective and efficient and infrastructure work is planned well ahead.

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Specific inspection (SK) is conducted in the daytime and is designed to inspect specific sites which were identified as accident concentration sites or sections during the ranking or as a result of general inspections which identified hazards that can potentially cause serious accidents (fatality and serious injury accidents).

Nigh-time road inspection (NK) is designed to analyze how the road and its equipment are perceived with no natural light. The purpose of the inspection is to understand the quality of lighting on hazardous sections such as junctions and pedestrian crossings. It is also designed to assess the night-time visibility of signage and the possibility of drivers being dazzled by oncoming vehicles and roadside elements (e.g. advertising).

Road works inspections (RDK) is designed to check whether road works in progress are properly organized and secured for safety reasons.

The results of the inspection may be used for updating technical conditions and design guidelines and supporting decision-making when selecting corrective measures.

As an example, when a hazard is identified during an Inspection involving trees growing along the edge of the carriageway, the solution could be to remove all the trees on that section. A modification of the situation would mean removing trees that are the biggest hazard and protection would involve putting up safety barriers.

Once identified, the defects should be assessed and classified into one of four classes of hazard: Class A – low, Class B – medium, Class C – high, Class D – very high. Risk classes are assigned to the different defects: high - unacceptable – defect class D, medium – conditionally acceptable (acceptable on the condition that it is treated) – defect classes B and C, low – acceptable, defect class A. The risk classes require specific action: immediate, spread over time – when transitional measures are used, postponed. The classification will depend on how inspectors will assess it (using their knowledge and experience), but it will primarily depend on objective measures of hazard.

5. Conclusion

Research is on-going to deliver tools for road authorities and road safety observatories to help with making an objective assessment of hazards, classifying the defects and finally selecting appropriate corrective measures. Today inspectors can only rely on their knowledge and experience without any support in the form of objective measures of risk.

Detailed models will have to be built to describe the relations between safety measures and elements of the road and roadside which potentially pose a risk to road users. The models will be based on traffic volumes and actual speeds. These will be the two basic determining factors of risk assessment. The work covers different areas: rural, periphery of urban areas, sections of transit roads passing through small towns and central parts of cities. Fast traffic roads will also be included. The work will come as a continuation of previous work of the authors.

While the methods address national roads with all their specificity, local roads, especially regional and county roads, require a similar set of methods. There is hardly any safety inspection on local roads. Better road safety cannot be confined to national roads only, and more must be done to cover the entire road network in Poland.

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