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Traffic Police Effectiveness and Efficiency Evaluations, an Overview of Methodological Considerations

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Abstract

Context: Every government implements various policies to mitigate road traffic injuries (RTIs). Many of these interventions are performed by traffic police. To evaluate effectiveness and efficiency of police enforcement, numerous studies have been conducted. Potential capabilities of epidemiology could get opportunity to improve these studies. The aim of this study was to extract and discuss some related methodological points of traffic police effectiveness and efficiency from related studies, in view of epidemiology discipline.

Evidence Acquisition: Related articles were searched with “traffic police”, “effectiveness”, “efficiency” and “road safety” keywords in ScienceDirect, PubMed and Safetylit databases. Related papers were selected and read carefully to summarize and discuss the epidemiological points with aims of giving clues to improve quality of studies.

Results: From a total of 797 articles, 20 were eligible which among them 17 articles were about effectiveness and 3 of them were about efficiency evaluations. Discussed points were the method of study, taking a holistic view to all positive and negative side effects, desired inputs and outputs, relation pattern between police enforcement and outcome and potential confounders.

Conclusions: Better understanding of the effectiveness and efficiency mechanism and having valid evaluation required considering specific theories and points in this field. Applying a dynamic approach with considering epidemiological concepts and sophisticated statistical models could improve quality of studies in this field.

Keywords: Police, Epidemiology, Effectiveness, Efficiency

1. Context

Studying distributions and determinants of health- related states and events could help to treat them. Knowledge of disease control improves by applying methodological principles of epidemiology. Evaluation of public health programs is one of them (1).

Road traffic injuries (RTIs), as the 9th leading cause of burden of disease (DALYs) and death in the world (2), have imposed governments to invest funds and implement different programs. For instance, a road traffic accident (RTA) rate in an urban area of Kashan county was measured 2.3% in a year (3) or direct cost of treatment among fatal traumatic brain injuries (caused by RTAs) during five years in Shiraz imposed 511,000 USD in Iran (4). Director of the main programs is police administrations that evaluating their effectiveness and efficiency is necessary. Effectiveness is defined as “the extent to which a particular health technology (medical, device, drug, procedure, health program or health service, including intervention) does what it is intended to do (i.e. leads to a beneficial health outcome or result) when it is provided under clinical practice conditions or in the field” (5). Also, efficiency is defined as "the relationship between resources (capital and labor) and health outcome” (6).

As numerous studies have been conducted on the effectiveness and efficiency of traffic police enforcement, review of related epidemiological points could augment their quality (7-16).

The aim of this study was to extract some methodological aspects of traffic police’s effectiveness and efficiency in view of epidemiology discipline.

2. Evidence Acquisition

Every original article about a direct effect of police enforcements on RTAs, RTIs and driving behaviors with keywords of "traffic police", "effectiveness", "traffic police", "efficiency" and "road safety performance" was searched in ScienceDirect, PubMed and Safetylit databases without any time restrictions. Other road safety interventions were excluded (e.g. speed humps, speed camera and law legislations).

According to the titles and abstracts, interested articles were selected based on the aims of the studies about effectiveness and efficiency evaluation of direct police activity, without any restriction in the time of study, duration, outcome and method of the study. Then related articles were reviewed carefully and summarized in a table and mentioned methodological and theoretical specific points in them were extracted, without any appraising the quality of studies. The extracted points were presented in a paper, while considering epidemiological principles. They were discussed to attain conclusions and prepare a summarized paper to improve quality of studies in this field.

3. Results

From a total of 797 obtained articles, 20 were eligible (three ones about police efficiency and seventeen about effectiveness), which had been published from 1982 to 2014.

All of the efficiency studies had ecological designs. The input variables were the number of detected violations during road traffic controls, motor vehicles/1000 inhabitants, etc. The output variables were the number of alcohol examination, temporary confiscation of driving license, and road accident involving minor, serious injury and fatal crashes.

Designs of the effectiveness studies were community trials (11), ecological studies (5) and quasi-experience (1) with the period of the study from four weeks to nine years. Different input variables were used, such as comparison between methods of performing law enforcement and their intensities, police activity report sheets and frequency of patrolling, etc. The output variables were driving speeds and other violations such as not using seat belts, etc. Other details are presented in Table 1.

4. Disccusion

4.1. Type of the Study

Control of traffic violations is one of the main outcomes of traffic police enforcement. In a theoretical view that should be considered as the social activity and treated in social context (17, 18). Measuring the social context as an individual characteristic is not meaningful and required global measurement as one of the three measurement levels of ecological study (19).

Other reason that confirms adopting ecological studies or community trials refers to the consequence of police activity on population. Ross issued to it as a general deterrence effect of introduced punishment on other potential violators (20).

Applying other study methods require enough variability of favored variable(s) (e.g. rule compliance, RTAs, police apprehension levels) between individuals, regions or periods for distinguishing intervention effects. In some cases, because of high homogeneity in a society, it is not possible to find enough variability. For example in Norway with helmet use of 99%, because of high homogeneity, finding enough evidence about a desired effect of police intervention may not be attainable (21).

In efficiency studies similar to effectiveness evaluations, it is not possible neither to assign inputs (police enforcement) to drivers nor isolate confounding factors, such as road infrastructures from them. Therefore, it requires ecological studies or community trials to meet the study goals.

4.2. Taking a Holistic View to All Positive and Negative Side Effects

In general, reduction of traffic violations, RTAs and RTIs are the result of traffic police enforcement. However, alongside those favored outcomes there are other side effects which may occur. Therefore, to have a universal effectiveness and efficiency evaluation, considering them is necessary. For instance, reducing speed limits may increase travel times, therefore considering it is necessary for prioritizing various interventions. In this issue, Elvik called them as the marginal benefits, which could be assessed in terms of current official monetary valuations. Some of them listed as travel time, vehicle operating costs, road accidents, traffic noises and air pollutions. For more details see Elvik, 2003 (21).

4.3. Selecting Inputs and Outcomes

Evaluation of effectiveness and efficiency of traffic police performance required one or more sensitive variables.

Traffic safety like other cases have its specific indicators that true selection of them is necessary for valid evaluation. Road traffic accidents have been recognized as the final outcomes of traffic safety which express with injury, death and vehicle damage.

These indicators have their limitations such as the effect of motorization levels and population size on their values, low sensitivity to changes in restricted area and area

with rare events, taking different values by using different denominators (i.e. population, registered vehicles, licensed driver numbers, etc), changing the area safety rank and the effects of random fluctuations on the injury and death rate without meaningful interpretation to show declining or rising trends of risk. Moreover, injury and death indicators are affected by road infrastructures, medical emergency and culture of society.

Therefore, indicators with ability of crash and injury count and explanation of accident process while considering other affecting factors are required. Using these indicators in comparison of different regions and countries could give insight about specific clues to modify the traffic policies and performance in effectiveness and efficiency studies (22, 23).

In this issue, there have been conducted a series of consecutive studies, called SUNflower aimed to determine a benchmark country among the clusters of similar European countries. Applied indicators were determined by a collaborative team of experts with ability of detecting the best effective measures. Furthermore, it could rank countries while considering the contributing factors. Those comprehensive comparisons introduced realistic targets for the weaker countries, by learning from more successful country. The rationale of selected indicators was based on the comprehensive understanding of traffic safety and causality chain. For more details refer to Wegman et al. 2009 (23).

Furthermore, in other studies different indicators with local and national applications have been used (8, 13, 23-35). Look at the Table 2 that was designed based on the structure of Shen's table (14).

When a set of indicators as the inputs or outputs is used to determine the order of the region's safety score or determine the ratio of outputs to inputs in efficiency studies, its value may be changed according to the used indicators. To avoid this problem and have a holistic view to road safety, it is better to use a composed index with a cluster of different indicators. To combine different indicators, it is necessary to assign weight to them. To do this there have been proposed different methods such as factor analysis, analytic hierarchy process, budget allocation, data envelopment analysis and equal weighting (24). There is a methodological guideline to construct composite indicators and make an index (36).

In addition, proper interpretation of any evaluations requires considering some aspects such as enforcement duration, relative enforcement changes compared to the baseline level and campaign education.

4.4. Pattern of Police Enforcement and Outcomes Relation

There is an S-shape relation between police presence levels and RTAs (37). When there is no enforcement, RTAs are at a highest level. After police recruitment, until attaining to a perceived level of police presence by drivers, RTAs do not change. Then increasing the police presence has an effect on its reduction until it reaches to a level that is not induced by driver violations. In this phase police increasing presence will not be effective. In Elvik's meta-analysis, it was mentioned as the marked threshold (38). He concluded negative nonlinear relation between police enforcement and traffic violations (Figure 1) (39). Therefore, it seems that there is an optimum level. For resource management in efficiency evaluations, recognition of this level as the best productive zone is useful. In addition, understanding this relation is necessary for applying suitable statistical models.

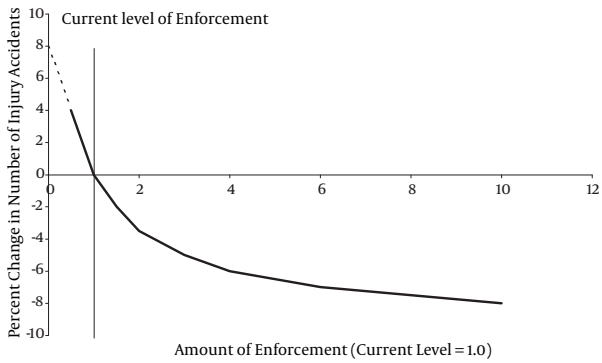

Figure 1. Relation Between the Amount of Enforcement and Percentage Change in the Number of Injury Accidents, Adopted from Elik, 2001 (39)

Stability of this relation over time is another issue. According to the game theory, abiding traffic law is not just a consequence of driver's judgment about tradeoff between violation utility and police punishment as a one-way effect of police enforcement. Instead, the driver and the police jointly and dependently interacts each other's decision (40). For instance when people drive over the speed level (a risk factor of RTAs) police reacts to this increasing violation by performing different ways such as increasing manpower along the roadside, more intercepting offender drivers and penalizing or seizing them or by increasing penalty fees. Police decision is the consequence of driver behaviors. This reaction of police causes decision of drivers by more abiding speed limit through apprehension of police punishment that decreases police's offence detections. Then police reduce its enforcement and again because of lowering apprehension level, speed violation increase (41,

42). These input and output fluctuations affect the effectiveness and efficiency score, over time. Figure 2 shows those relations.

Risk compensation is another factor affecting the relation between police intervention and driving behaviors. Drivers adjust their behaviors according to a perceived risk. When they perceived more risk (e.g. driving in adverse weather) they are more careful. In contrast when they protect themselves, for instance using a helmet, fastening a seat belt or driving by anti-lock brakes cars they may take more dangerous behaviors (43-45). When police persuades or enforces using a seat belt or helmet, this phenomenon may decline the effectiveness and efficiency value because of increasing other dangerous behaviors. Elvik pointed out to this as the road-user behavioral adaptation. In occasions, the road safety measures modify some risk factors but because of an offsetting effect of behavioral adaptation some other risky behaviors may increase (46). These relations are depicted in Figure 3.

4.5. Approach of Survey

To study accidents there are three approaches including sequential modeling, epidemiological models and system models (47). These approaches are compared by Delorme and Lassarre, 2014 (48).

They pointed out that in sequential modeling the accident is a result of related events, which ordered sequentially and are useful for detailed investigations.

In an epidemiological approach, accident is the consequence of causal relation between different factors. Combined relations determine frequency and severity of an accident. In this approach, a holistic interaction between different factors does not consider. This shortcoming is treated with system models.

To conduct the system models, instead of causal mechanism between separate factors in an epidemiological approach we could find interrelations and dynamic effects of causal factors. This approach was used in a study about evaluating policies for traffic violations (49). Considering to aforementioned theories and properties of relations between various factors over time, it seems adopting a dynamic approach is better.

4.6. Considering Potential Confounders in Adopted Studies

In occasions we do not access to the native or local findings. Therefore, we use results of other settings. In these cases some factors including driver behaviors, culture, road infrastructure and vehicle characteristics have affected the findings. In fact, every country has its specific complex that can have a significant effect on the effectiveness and efficiency findings.

In summary, relations between factors affecting the police activity could be depicted as below:

Other limitations refer to variation in study design, quality of data in different studies, study duration and target groups.

Even using internal evaluations requires considering probable bias. Regression to mean is one of them that occur following intervention in a high risk area. This causes over estimation of intervention effects, whilst because of regressed risk, some of attributed results have been occurred spontaneously. Therefore, expecting achievement of other study results in areas with less risk may not be corrected.

Against regression to mean bias, spillover phenomenon induces underestimation of police effectiveness and efficiency in comparing two adjacent areas or consecutive periods. Activity of police in a region can have a significant effect on driving behaviors in adjacent areas or periods, named the hallo effect. In a study about photo-radar effect on speed and number of collisions, moreover reduction in number of collisions in enforcement segments ($14 \pm 11\%$), in near area there were $19 \pm 10\%$ reduction rate, too (50).

Autocorrelation is another issue that emerges in comparing RTAs between nearby regions. Due to other unknown or unmeasured factors these regions are more similar (19). These low variability causes underestimation of effectiveness and efficiency in nearby regions.

In this paper some of the important methodological points of traffic police effectiveness and efficiency were discussed. Lack of a specific framework to conduct the effectiveness and efficiency study does not get enough assurance about covering all related aspects. Therefore, one of the limitations of this study may be neglecting some points. The next limitation refers to restricted search in three databases, instead of all databases and since the aim of the study was reviewing the methodological points and was not meta-analysis or systematic review, it does not a matter.

Footnotes

Authors' Contribution: Habibollah Rahimi determined and conducted search strategy and reviewed articles. He also participated in drafting of the manuscript. Hamid Soori, Seyed Saeed Hashemi Nazari, and Seyed Abbas Motevalian contributed to discussing and appraising the context of the manuscript and in drafting. Eskandar Momeni and Adel Azar contributed to discussing about some of theoretical concepts.

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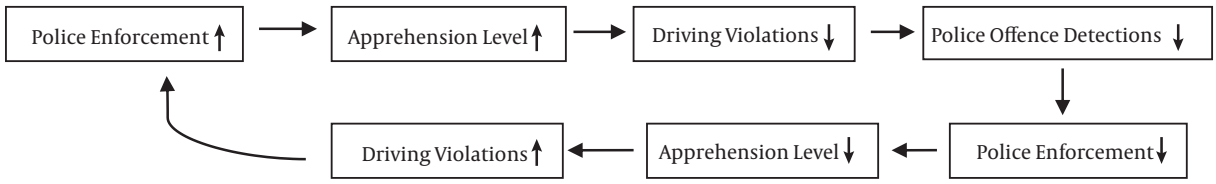

Figure 2. Schematic Diagram of the Game Theory

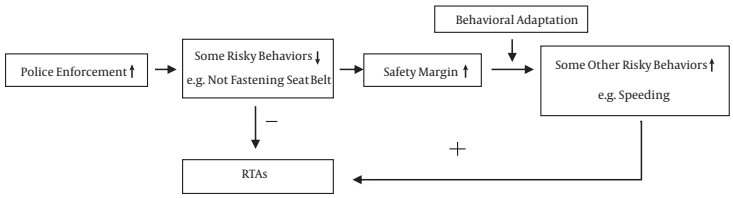

Figure 3. Schematic Diagram of the Risk Compensation Theory

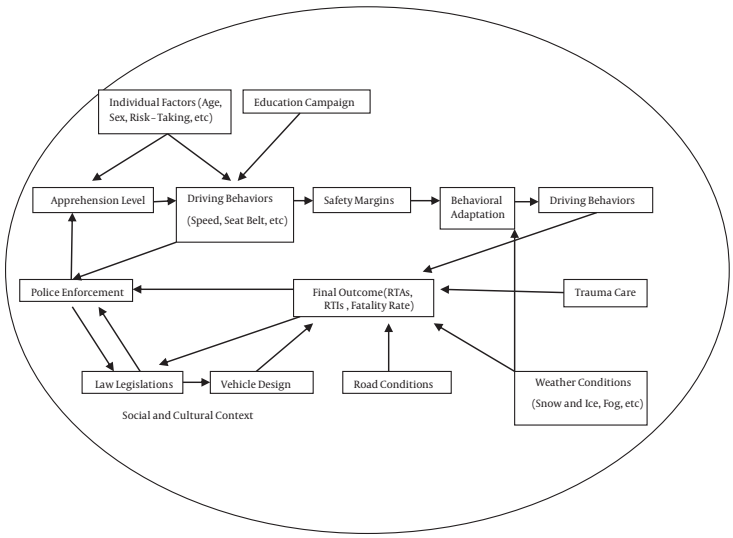

Figure 4. Schematic Diagram of Factors Affecting the Police Activity

of epidemiology in Shahid Beheshti University of Medical Sciences. The authors declared there were no funds to support this study.

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Table 1. List of Reviewed Studies

Reference	Location	Study Goals	Study Design	Duration/Time	Inputs	Outputs	Method of Analysis
(51)	Slovenia	Relative efficiency of police stations	Ecologic study	2010	Number of occupied employment posts, work stations and police vehicle radio stations, and road accidents	Number of road accidents involving minor and serious injury	Data envelopment analysis (DEA)
(16)	Slovenia	Measuring relative efficiency of police directories	Ecologic study	2005 and 2010	Number of violations detected during road traffic controls, number of motor vehicles/1000 inhabitants[a], length of public roads (2008)/km2	Number of alcohol examination, temporary confiscation of driving license	DEA
(13)	USA	Analyzing and comparing the road safety performance of U.S. states	Ecologic study	2002 - 2008	Highway safety expenditures, registered vehicles, licensed drivers, vehicle-miles traveled, total road length, overall road condition, safety belt usage	Fatal crashes	DEA-based Malmquist index model
(52)	China	Evaluating the introduction of the interventions to road safety improvements in the two cities (Suzhou and Dalian)	Community trial	9 months and 100 days	General awareness raising campaigns on the risks of drink- driving and speeding, a 100 day social marketing campaign related to drink driving accompanied with increased police enforcement activities	Knowledge, attitude and perceptions (KAP) about drink driving, prevalence of drink- driving, trends in speeding, crashes and injuries	Percentage difference
(53)	Australia	Exploring the relationship between monthly random breath testing (RBT) rates (per 1000 licensed drivers) and alcohol-related traffic crash (ARTC) rates over time	Ecologic study	5 years	Random breath testing (RBT)	Alcohol-related traffic crashes	Join point regression analysis, linear-log OLS regression
(8)	UK	Measuring effects of increased enforcement and publicity on driving behaviors	Community trial	4 weeks	Count of police vehicles passing each observation site, police vehicles recorded on CCTV passing one junction and activity sheets completed by the police officers involved in operation radar	Vehicle speed, use of seatbelts and mobile phones	Not mentioned

(54)	Greece	Quantification of the effect of speed and alcohol enforcement on both road accidents and fatalities and their regional variations	Ecologic study	5 years	The number of alcohol controls and speed infringements	The number of road accidents with casualties and the related fatalities	Multilevel modeling technique, poisson multilevel modeling.
(55)	UK	The impacts on crash and casualty numbers corresponding to the introduction of mobile speed camera initiative in the rural county	Ecologic study	4 years	Mobile speed cameras	Crashes involving fatalities or serious injuries	Linear Regression, percent difference
(56)	USA	Whether the levels of driving under influence (DUI) arrests, at the rates they are typically engaged in, have any meaningful impact on DUI crashes	Ecologic study	2 years (2001 and 2003)	Proactive DUI arrest rate	DUI-related crashes rate	Pearson product moment correlation
(12)	Greece	Quantification of the national and regional effect of police enforcement on road safety	Ecologic study	1998-2002	The number of alcohol controls and speed violations	The number of road accidents with casualties as well as socioeconomic parameters	A multilevel modeling technique
(57)	Australia	Re-evaluate the anti-drink driving and anti-speeding enforcement and publicity campaigns by examining their combined effects on the total number of serious crashes involving young male drivers	Community trial	6 years	The number of random breath tests, traffic infringement notices (speeding tickets), ad stock for anti-drink driving television advertising and the ad stock for anti-speeding publicity campaign	the total number of serious crashes involving young male drivers	Time-series model, poisson model
(9)	Netherlands	Evaluation of the speed and safety effects of mobile inconspicuous speed cameras on rural roads, along with publicity and communication about the project	community trial	5 years	Speed enforcement with mobile radar from an inconspicuous police car with additional instruments in latter years	Mean speed and the percentage speed limit violators, the number of injury and serious accidents	Repeated measures ANOVA
(58)	Israel	Investigating both the qualitative and quantitative effects of traffic policing on road safety	Ecologic study	2 years	The number of police reports issued for driving offences	Accidents	Poisson fixed effect, poisson random effect, negative binomial fixed effect, negative binomial random effect, Tobit regression
(11)	Israel	Monitoring of everyday police operations on driver's behavior, attitudes and the accident changes	Community trial	One year	11% - 14% increase in staff and vehicle fleet and a 15% supplement of enforcement tools	Severe accidents, all injury accidents, severe casualties and drivers' attitudes	A statistical model , combining the odds ratio and longitudinal methods, generalized linear model

(10)	Australia	Measuring the crash effects of the random road watch program	Quasi experimental	9 years	Program coverage, offences detected, hours enforced	Crash changes	Log-linear regression, Poisson regression, multiple linear regression, trend analysis
(59)	Germany	The effectiveness of police tests in finding driving while intoxicated	Community trial	6 months	Random breath test versus ordinary breath test (testing suspected intoxicated drivers)	Detection rate of intoxicated drivers	Comparison of detection rate
(60)	Norway	Reducing speeding behavior on a stretch of road by an increase in police enforcement	Community trial	16 weeks	Increase police enforcement	Average speed and the percentage of speeding drivers	Multiple linear regression
(61)	UK	Examining the effect of road safety campaigns and enforcement on behavior of people breaking the speed limits and intentions to speed	community trial	13 weeks	Police presence, warning signs	Vehicular speeds, intentions to speed in the future	Two-way ANOVA, 4-way ANOVA
(7)	Netherlands	Dose effect evaluation of police enforcement with different methods of enforcement	Community trial	4 and 12 weeks	Three different objective levels of apprehension for detected speeding drivers, on-view stopping offenders compared with mailing of fines with and without delay	Driving speed, driver opinion about speeding and speed enforcement	ANOVA
(62)	Canada	Obtain evidence on the effect of speed law enforcement on the speed choice make by drivers with considering “distance” and “time halo” effects	Community trial	Five weeks	police cruiser presence in “upstream”, “enforcement” and “downstream”	Vehicular speeds near enforcement symbol, upstream and downstream	Speed percentile comparison

[a] Some of inputs were not discretionary.

Table 2. List of Hierarchical Structure of Ever Used Road Safety Indicators

	Indicator		Description
An overall Road Safety Index	Final Outcome Indicators	Personal Safety	Fatalities per Million Inhabitants
		Traffic safety	Fatalities per million passenger cars, per 10,000 vehicles
			per 10 billion passenger-km travelled
		Traffic injury and accident	Injury accidents per fatality, the number of serious injuries per million inhabitants, slight injuries per million inhabitants, crashes per million inhabitants, accidents per 10,000 vehicles, accidents per 100,000 people and accidents per 100 km
		Vulnerable road users	Share of pedestrian fatalities out of the total fatalities
			Share of bicyclist fatalities out of the total fatalities
			Share of motorcyclist fatalities out of the total fatalities
	Safety performance Indicators	Speed	Median speed, average speeds, median absolute deviation, % drivers > legal limit, % drivers more than 10 km/h > limit
		Daytime running lights (DRL)	% usage of DRL per road and vehicle type, legislation on DRL
		Alcohol	% drivers impaired by alcohol (> legal limit), % drivers impaired by drugs, proportion of fatalities from crashes involving at least 1 impaired road user
		Protective systems	Daytime wearing rates of seat belts in the front seats, daytime wearing rates of seat belts in the rear seats, child restrain rate, helmet by cyclists, helmet by moped riders, helmet by motorcyclists
		Human	Drivers' training and licensing, driving license less than 3 years, fatigue driving rate, traffic violation, laws broken by pedestrian at intersection, number of driving license delivered per vehicles
		Vehicles	Average EuroNCAP score of the passenger car fleet, median age of the passenger car fleet, distribution of vehicle age (% > 15 years, …), percentage of vehicles of maximum five years old, median age of the passenger car fleet, average percentage occupant protection score for new cars sold, average percentage score of pedestrian protection for new cars sold, renewal rate of passenger cars, the implementation of seat belt reminders in new cars, composition of vehicle fleet (% cars, …), share of motorcycles in the vehicle fleet, share of heavy goods vehicles in the vehicle fleet

		Police performance	Counting monthly detected seatbelt offences, random breath tests, total officer hours on the road using moving radars and laser speed detectors, enforcement hours, the number of patrol hours per mile per year, passing police cars and motorcycles and daily activity sheet have been proposed, roadside police alcohol tests per 1000 population
	Policy performance indicators		The availability and ambition of national safety targets, selection of interventions, economic evaluation, monitoring the program's performance, program's stakeholder, legislation on DRL, responsibility system of road traffic safety, publicity and education of road traffic safety, PIN/Dacota common questions (comprised 18 basic questions on road safety management)
	Structure and culture indicators	Road condition	Number of passenger cars per 1000 inhabitants, population per km2 of country's territory, total road length, overall road condition, % intersection types (e.g. roundabout), % road length with barriers, intersection density, road density (km/km^2), percentage of motorways/ freeways in total road length, proportion of not lighting section at night, proportion of channelized intersection, proportion of signalized intersection, percentage of undivided roads, proportion of the radius of the circular curve under ordinary value, percentage of longitudinal grade above the maximum, percentage of sections at a heavy hill area, degree of saturation, percentage of large vehicles, perfect rate of traffic sign, service ability rate of traffic marking, stopping sight distance, over loading rate of heavy truck, number of days of adverse weather
		Socioeconomic	Popularizing rate of traffic laws and traffic safety common sense, gross domestic production (GDP) per capita, the level of motorization, percentage of urban population, percentage of illiteracy population (over 15 years unable to read), life expectancy, highway safety expenditures
	Trauma care		Medical staff /inhabitant, number of road accident emergency calls/ inhabitant, average response time, health expenditure as GDP %
	Scientific analysis of road traffic safety status and trend		RTAs death rate per hundred million GDP, the equivalent accident death rate per ten thousand vehicles, RTAs death rate per 100, 000 resident population, national and provincial highway mortality rate per hundred million vehicle kilometer, city RTAs death rate per hundred miles, country RTAs death rate per hundred miles, risk analysis of road traffic, decreased percentage of death number of RTAs, effectiveness of traffic law