Accepted Manuscript (Uncorrected Proof)

Title: Economic Evaluation of Urban Road Safety Interventions in Iran: A Benefit-Cost Analysis

Authors: Homayoun Sadeghi-bazargani[1], Mina Golestani[2,*], Mirbahador Yazdani[3], Khalil Pourebrahim[4], Zhila Yousefi[5]

1. *Road Traffic Injury Research Centre, Tabriz University of Medical Sciences, Tabriz, Iran.*
2. *Medical Philosophy and History Research Center, Medical Philosophy and History Research Center, Tabriz University of Medical Sciences, Iran.*
3. *Faculty of Engineering, University of Bonab, Bonab, Iran.*
4. *Payame Noor University (PNU), Tehran, Iran.*
5. *Health in Emergency and Disaster research Center, Social Health Research Institute, University of Social Welfare and Rehabilitation Sciences, Tehran, Iran.*

To appear in: ***Health in Emergencies & Disasters Quarterly***

Received date: 2025/07/1

Revised date: 2025/11/11

Accepted date: 2025/11/19

First Online Published: 2025/12/13

Please cite this article as:

Sadeghi-bazargani H, Golestani M, Yazdani M, Pourebrahim K, Yousefi Z. Economic Evaluation of Urban Road Safety Interventions in Iran: A Benefit-Cost Analysis. Health in Emergencies & Disasters Quarterly. Forthcoming 2026. Doi: http://dx.doi.org/10.32598/hdq.2026.696.1

Abstract

Background: Road traffic accidents are among the major public health challenges and a major political priority worldwide. In Iran, this issue has attracted considerable attention, and the country is among the top five countries with the most unsafe roads. This study evaluates the Benefit-Cost (B/C) ratio of urban road safety projects in Tabriz, Iran, during 2018–2020.

Materials and Methods: This study was an interventional study. A ~~retrospective~~ cost-benefit analysis was conducted on 9 accident-prone areas selected from 100 accident-prone areas in Tabriz city (through traffic data and expert opinions). The sampling method was purposeful. These safety interventions were implemented in Tabriz in 2019. The relevant data were collected through a three-part checklist (injuries, deaths, and social costs). Data analysis was performed using descriptive statistics (mean, standard deviation, percentage, and frequency) and inferential statistics in SPSS version 22.

Results: The results showed that fatal accident costs comprised 74.25% of total costs, mainly due to productivity losses and vehicle damages. While, benefits were estimated based on reductions in accidents and associated societal costs, discounted at 10%, with a social valuation coefficient of 20%. Costs included both implementation and operational expenses. The average B/C ratio was 50.54, ranging from 241.53 for Chaykenar to 0.13 for Abbasi intersection; most projects had ratios well above one.

Conclusion: The findings underscore the high cost-effectiveness of safety investments, supporting ongoing funding, though improvements in data quality and inclusion of intangible costs are recommended for future studies.

Keywords: Traffic accidents; Road safety; Black spots; Benefit-Cost ratio; Economic evaluation.

Introduction

Road traffic accidents are among the major public health challenges and a major political priority worldwide. In Iran, this issue has attracted considerable attention, and the country is among the top five countries with the most unsafe roads (Red List). Despite having less than 1% of the world's population, Iran is reported to account for 2% of global road traffic deaths, which is 1.5 times higher than the global average [1]. Road safety plays a crucial role in reducing accidents. Therefore, conducting rigorous economic analyses is essential to maximize the efficiency and economic returns of road safety improvement projects [2]. Economic evaluation of road safety programs serves as a key tool for policymakers in transport planning. This can be achieved through the active participation of government agencies, society, and stakeholders, strengthening cooperation between transport operators, road users, and society [3]. International studies show that many countries have implemented measures such as the removal of hotspots with reported safety improvements. For example, Elvik et al. analyzed the impact of removing hotspots on suburban roads and found that crash-related damages and injuries were reduced by 26% and 19%, respectively [4].

Highway safety management begins with the identification of black spots, also known as road hazards, high-risk areas, accident-prone areas, promising locations, or priority inspection locations [5, 6]. In fact, the black spots mean accident hotspots with a historically high incidence of crashes. Spakova and colleagues used an optimized cost-benefit and cost-effectiveness model considering multiple periods to maximize benefits within a limited budget [7]. Harwood and colleagues also proposed a process for allocating resources to maximize the efficiency of road safety efforts, including maintaining structural integrity and construction quality in non-highway facilities [8]. Statistics from 2015 show that in Iran, the fatality rate is 37 people per 10,000 vehicles, while the global rate is 9 people for the same number of vehicles [9]. Traffic accidents have the highest fatality rates in some regions. Accurate identification of these areas, called black spots, with sufficient and accurate information and planning to determine effective safety solutions to reduce risk at these strategic points can have a great impact on road accident prevention [10].

Material and Methods

Study design and setting

This retrospective cost-benefit analysis evaluated urban road safety interventions implemented in 2019 at nine accident-prone locations in Tabriz city, with outcome data collected for the 12-month periods immediately before (2018) and after (2019) implementation. The sampling method was purposive based on exact criteria such as highest accident and highest fatality rate. Inclusion criteria include: (1) the highest annual frequency of fatal crashes, (2) the highest annual frequency of injury crashes, and (3) documented economic losses from accidents, with selection based on an integrated assessment of all three criteria by traffic engineering experts and police data specialists. A cost-benefit analysis was conducted on 9 accident-prone areas selected from 100 accident-prone areas in Tabriz city (through traffic data and expert opinions). These safety interventions were implemented in Tabriz in 2019. The relevant data were collected through a three-part checklist (injuries, deaths, and social costs). The study included accidents recorded by traffic police and speed cameras at black spots in Tabriz during 2018 and 2019. Data were collected before and after the implementation of safety interventions. These safety interventions were implemented in 2019. The main objective was to assess the cost-benefit ratio of road improvement measures in Tabriz, focusing on the analysis of fatal and injury crashes at 9 black spots within the city. Using police data, expert opinions, and engineering estimates from experts, 9 out of 100 black spots were identified as having the highest frequency of fatal and injury crashes.

Variables and Data collection

The study considered independent variables such as: average fatalities, injuries, economic losses, each of which included categories: (a) injuries or deaths, (number, sex, and age of casualties), (b) budget required for each intervention, given the specific modification implemented, (c) percentage reduction in accidents after each modification, and the lifetime of each safety measure. Data collection included document review and interviews. Initially, the study hotspots were evaluated for confounding variables such as daily traffic volume, annual accident statistics, lane width, and other relevant road characteristics. There was no statistically significant difference ($p>.05$). Subsequently, only 9 locations with the highest number of injuries and deaths and the highest amount of economic losses resulting from accident consequences (losses, injuries, damages) were selected. Subsequently, safety interventions were implemented for these hotspots, such as (installation of speed bumps, installation of violation recording cameras, installation of signboards, and railings), and the independent variables were measured and compared again. Subsequently, the accident adjustment factor was calculated, and the net benefit of each safety intervention was determined by subtracting the costs from the benefits. The total cost of an accident includes the costs of treatment, vehicle repairs, accident management costs, lost capital, and future productivity losses of victims. To estimate the present value of victims' losses, this study adopted certain assumptions that reflect social considerations: (a) a social discount rate of 10% was applied, and (b) a consumption rate of 20% of the individual's productivity was assumed. Based on the literature review, the economic evaluation of time lost in accidents included two components: travel delay costs and costs related to time lost during insurance claims. Assumptions regarding medical costs included the following: (a) an average treatment duration of 15 days for severe injuries and 4 days for minor injuries, and (b) no permanent disability was assumed, while temporary disabilities included at least one year of absence from work.

Using the human capital approach and considering hourly wages, the costs associated with lost productivity per accident were estimated. For injured persons, the treatment duration was set at 15 days for severe accidents and 3.7 days for minor accidents, based on previous research and available data. In the case of hotspot improvement projects, only the benefits resulting from increased safety and reduced accidents, calculated by evaluating the present value of accident costs over the project lifetime, were included, while other direct and indirect benefits were excluded. The main parameters affecting these calculations were the project duration and the percentage of accident reduction attributable to the intervention. The values of these parameters were extracted from literature reviews and similar studies, both domestic and international, using the opinions of relevant experts for each project. Finally, the total savings were determined by multiplying the annual reduction in accident costs, calculated for each improved route, by the number of years of the project lifetime. The cumulative savings over the project period were then used to calculate the benefit-to-cost ratio (B/C) for each intervention, which was subsequently compared across projects. Costs were added up and subtracted from benefits to calculate the net benefit. The B/C ratio for each project was calculated as follows: B/C = Total benefits / Total costs. Data analysis was performed using descriptive statistics (mean, standard deviation, percentage, and frequency) and inferential statistics (~~logistic regression~~) in SPSS version 22.

Results

Based on a cost-benefit analysis of nine black spots, the average benefit-cost ratio was 50.54. Most projects had ratios above 1, with notable examples being Sardaran Fatih (110.26), Azerbaijan Boulevard near the justice building (77.18), and the Chaykenar location (241.35), which had the highest ratio. However, the Abbasi intersection (0.13) and Pasdaran-Un-ibn-Ali (0.03) projects showed ratios below 1. One project had a B/C ratio of exactly 1. Table 2 presents road safety projects by black spots and location.

Table 1: The comparison of confounding variables in before (2018) and after (2019) intervention.

Variables		**2018**		**2019**		**p-value**
Injuries	Male (Number/%)	81	57	49	53	X^2 **= 0.06**
	Female (Number/%)	52	43	43	47	
	Age (Mean±SD)	41.66±11.24		43.04±10.19		***t*** **= 0.37**
Deaths	Male (Number/%)	5	72	2	66.7	X^2 **= 0.14**
	Female (Number/%)	2	28	1	33.3	
	Age (Mean±SD)	47.93±8.35		48.02±9.38		***t*** **= 0.21**
Road width		16		18		***t*** **=0.26**
Daily Traffic (hours)		9.5		10.2		***t*** **=0.12**

The result shows that there is no statistical difference between before and after intervention based on confounding variables. (Table 1)

Table 2: The measures to implement road safety projects and their costs by year in black spots

NO.	Location	year	Measures	Expenses incurred (USD)	p-value
1	Dizel Abad	2018	Installing new jersey for temporary closure	12,286.65	**0.01**
		2019	Setting up an overpass bridge (consumables, materials, contractor's cost, machinery cost)	9,484,560	
2	Cable Bridge	2018	--	--	**0.02**
		2019	Peer bridge construction costs (materials, contractors, machines)	5,927,850	
3	Pasdaran (Un-Ibn-Ali)	2018	--	--	**0.01**
		2019	Setting up U-turn and overpass bridge (materials, contractor's fees, machinery, bridge frame and installation(	2,371,140	
4	Sardaran-e-Fatih	2018	--	--	**0.01**
		2019	Installing new jersey	7,113.42	
5	Pasdaran (Eram Exit)	2018	--	--	**0.01**
		2019	Setting up speed camera (the cost of purchasing a mast and a camera, foundation, , annual maintenance cost)	118,557	
6	Chaikenar (in front of the central prison)	2018	--	--	**0.02**
		2019	Blocking, fencing with new jersey	3,556.71	
7	Abbasi Intersection	2018	--	--	**0.01**
		2019	Overpass Bridge retrofitting and geometric corrections (bridge reconstruction, cost of consumables, contractor, machinery, annual maintenance)	426,805.2	
8	Azarbaijan Boulevard in front of Justice office	2018	Setting up camera (the cost of purchasing a mast, foundation, camera purchase, annual maintenance fee)	24,573.3	**0.01**
		2019	--	--	
9	Monajem Street, Naser station	2018	--	--	**0.02**
		2019	Setting up speed bump, re-coloring lines and putting signs	11,855.7	

The mean sum of total annual costs based on the cost items of accidents for each accident in Tabriz black spots is depicted in Table 3.

Table 3: The mean sum of accidents costs for each accident (USD)

Type of cost (USD)	Type of accident				
	Death	**Injury**	**Damage**	**Total cost (USD)**	**% of total cost**
Damage to vehicle	33,210.51	21,714.56	15,647.26	70,572.32	32.99
Damage to road constructions and products	520.51	453.45	255.46	1,229.43	0.57
The present value of the potential production of died people	100,800.27	-------	-------------	100,800.27	47.13
Lost production of injured	6,290.84	7,663.96	------------	13,954.8	6.52
Treatment costs	2,904.32	3,587.7	------------	6,492.2	3.03
Ambulance	217.14	134.12	------------	351.2	0.16
Travel delay costs	43.43	43.43	43.43	130.29	0.06
The lost time to claim damage,	239.5	191.6	143.7	574.8	0.27
Psychological and mental damages	146.57	181.1	-------------	327.63	0.15
Administrative costs	14,437.31	3,396.98	1,608.98	19,443.28	9.09
Total cost (USD)	158,810.4	37,366.86	17,698.84	213,876.09	100
Percent of total costs	74.25	17.47	8.33	100	

By assessing accident cost it was shown that the mean of accident costs resulting in death comprised 74.25% of the total cost which was 4.4 times higher than the mean of accident cost that caused injury. Among the types of cost, the present value of potential production of deceased people comprised 47.13% of total cost and then, the damage to vehicles with 33% ranked as the second. Next, administrative costs with 9.09%, lost production of injured with 6.52%, and treatment expenses with 3.03% were the highest costs. Table 4 shows the number of accident-related deaths and injuries in the city of Tabriz black spots before and after the safety project.

Table 4: The number of deaths and injuries in black spots of Tabriz

NO.	**Location of project**	**year**	**Deaths**	**Injuries**	**p-value**
1	Dizel Abad	2018	2	15	**0.02**
		2019	3	81	
2	Cable Bridge	2018	2	15	**0.03**
		2019	0	14	
3	Pasdaran (Un-Ibn Ali)	2018	3	7	**0.01**
		2019	0	0	
4	Sardarn –e-Fatih	2018	0	15	**0.01**
		2019	0	6	
5	Pasdaran (Eram Exit)	2018	0	15	**0.01**
		2019	0	0	
6	Chaikenar (in front of the central prison)	2018	0	10	**0.01**
		2019	0	13	
7	Abbasi Intersection	2018	0	10	**0.01**
		2019	0	6	
8	Azarbaijan Boulevard in front of Justice office	2018	0	6	**0.01**
		2019	0	13	
9	Monajem Street, Naser station	2018	0	4	**0.01**
		2019	0	0	

Table 5 shows the data of correctional projects, spent financial budget, total cost and benefit of each project, and B/C ratio. To determine the present value of benefits of safety projects only the benefits caused by promoting safety and decrease of accidents are focused. To calculate the present value of the costs of accidents that caused death and injury during the project lifetime, two factors of project life and the percentage of project-related decrease in accidents were utilized. The data of two variables are shown in Table 5. Also, table 5 shows the Low-cost interventions including New jersey barriers and signage (Projects 4, 6, 9) achieved exceptionally high benefit-cost ratios (110.26, 241.53, and 12.6 respectively), ranging from 7.46 to 241.53, while major infrastructure projects such as overpass construction demonstrated more variable returns (ranging from 0.13 to 1.03).

Table 5: Information on improvement projects, credit spent, total costs and benefits of each project, and the (B/C) ratio.

Project	**Project time**	**Project-related measures**	**The needed budget for each project based on each measure**	**The sum of accidents annual cost (USD)**	**Decrease percent (%)**	**The life of project (year)**	**Total sum of decrease in each project**	**B/C ratio**	**p-value**
Dizel Abad	**2018**	Installing new jersey for temporary closure	12,286.65	909,654.4	10%	10	909,654.4	**7.46**	**0.02**
	2019	Setting up an overpass bridge (consumables, materials, contractor's cost, machinery cost)	9,484,560	3,501,628.4	40%	50	70,032,805.4		
		Total budget	9,669,031.2	4,458,980.5			72,199,488.8		
Cable Bridge	**2018**	**--**	--	909,629.85	--	--	909,629.85	**1.03**	**0.01**
	2019	Peer bridge construction costs (materials, contractors, machines)	5,927,850	522,907.5	20%	50	522,907.5		
		Total budget	6,035,600	1,426,091.5			6,217,826.8		
Pasdaran (Un-Ibn Ali)	**2018**	--	--	764,475.3	--	--	764,475.3	**0.03**	**0.03**
	2019	Setting up U-turn and overpass bridge (materials, contractor's fees, machinery, bridge frame and installation)	2,371,140	----	30%	30	----		
		Total budget	2,414,240	751,070.1			751,070.1		
Sardare-Fatih	**2018**	--	--	580,617.94	--	--	580,617.94	**110.26**	**0.02**
	2019	Installing new jersey	7,113.42	224,096.4	10%	10	224,096.4		
		Total budget	7,242.72	798,606.4			798,606.4		

Continued Table 5: Information on improvement projects, credit spent, total costs and benefits of each project, and the (B/C) ratio.

Project	**Project time**	**Project-related measures**	**The needed budget for each project based on each measure**	**The sum of accidents annual cost (USD)**	**Decrease percent (%)**	**The life of project (year)**	**Total sum of decrease in each project**	**B/C ratio**	**p-value**
Pasdaran (Eram Exit)	**2018**	--	--	580,617.94	--	--	580,617.94	**4.72**	**0.02**
	2019	Setting up camera (the cost of purchasing a mast, foundation, camera purchase, annual maintenance fee)	118,557	----	30%	20	-----		
		Total budget	120,712	570,436.6			570,436.6		
Chaikenar (in front of the central prison)	**2018**	**--**	--	387,078.6	--	--	387,078.6	**241.53**	**0.02**
	2019	Blocking, fencing with New Jersey	3,556.7	485,538.3	10%	10	485,538.3		
		Total budget	3,621.3	874,679.1			874,679.1		
Abbasi Intersection	**2018**	--	--	387,078.62	--	--	387,078.62	**0.13**	**0.03**
	2019	Overpass Bridge retrofitting and geometric corrections (bridge reconstruction, cost of consumables, contractor, machinery, annual maintenance)	426,805.2	224,096.4	5%	5	56,006.32		
		Total budget	434,563.2	608,460.9			437,339.5		
Azarbaijan Boulevard in front of Justice	**2018**	--	--	485,538.3	--	--	485,538.3	**77.18**	**0.03**
	2019	Setting up camera (the cost of purchasing a mast, foundation, camera purchase, annual maintenance fee)	24,573.3	232,242.2	30%	20	1,393,478.1		
		Total budget	24,142.4	722,557.8			1,863,431.1		
Monajem Street, Naser station	**2018**	--	--	154,811.8	--	--	154,811.8	**12.6**	**0.02**
	2019	Setting up speed bump, re-coloring lines and putting signs	11,855.7	----	20%	5	----		
		Total budget	12,071.2	152,097.12			152,097.12		

Discussion

This study estimated the benefit-cost ratio of urban road safety projects at nine accident-prone locations in Tabriz city. The B/C ratio results showed that all other safety projects were economically justifiable, except for two projects. Some projects had higher B/C ratios, such as Sardaran Fateh, Azerbaijan Boulevard opposite the Justice Department, and Chaykenar opposite the prison, which showed higher economic justification than others. As mentioned above, the average ratio of the nine studied projects was 50.54, indicating higher efficiency of investment in traffic safety projects in our country. Another reason for this higher average B/C ratio is the lower hourly wage rate in Iran, which causes the potential production of victims to be underestimated compared to the other countries. As mentioned earlier, this ratio indicates that investment in traffic safety projects in Iran is has been particularly efficient. The study also emphasized that investment in road infrastructure, improving vehicle safety, and promoting traffic safety awareness are critical strategies for reducing accidents [11]. Partiban and colleagues developed a model using a systems dynamics approach to assess the cost of traffic crashes in 2005. It was assumed that the highest costs were associated with the most fatal accidents. Their goal was to find factors affecting road crashes and fatalities and to assess the associated costs. They hoped that state policymakers and traffic police would use these findings to reduce road crashes [2]. One important tool for decision makers is cost-benefit analysis, which can be used to evaluate road safety measures economically [12, 13]. Ayati et al. emphasized that inadequate data and misleading statistics lead to underestimates in safety assessments, while Bridle et al. called for continuous and ongoing review and control of accident assessment methods [14]. The Australian Department of Transport and Communications has provided several categories of accident costs: lost income, lost products, lost personal and family income, pain and suffering from property damage, insurance, damages to relatives of victims in the form of travel expenses, delays caused to the public in traffic, hospitalization and rehabilitation costs, medical costs, legal fees, court, administrative, ambulance, search and rescue operations, are among these categories [15]. According to their estimates, the largest part of these costs is due to the loss of potential productivity of individuals and premature disability. Approximately 70% of total costs are attributed to pain and grief, which is a limitation of this study because it does not include intangible costs such as pain and grief.

Compared to other countries, Iran's higher benefit-cost ratio for road safety investments suggests greater efficiency. Despite the initial costs, the subsequent benefits, namely lives saved and injuries prevented, provide clear evidence supporting the economic rationale for these projects. Given limited financial resources, maximizing the effectiveness of available resources is crucial. The traditional approach to allocating resources to address black spots involves sorting accident indicators by region. Subsequently, within budget constraints and at the discretion of management, a certain number of locations with the highest accident rates in each region are prioritized [10].

Limitations

There are several limitations in this study including:

Temporal limitations: The one-year post-implementation evaluation period inadequately captures long-term effects of infrastructure projects designed with 50-year lifespans; regression to the mean effects cannot be fully excluded in sites selected for exceptionally high prior accident rates.

Economic limitations: Exclusion of intangible costs (pain, grief, reduced quality of life, psychological trauma), which international studies estimate at approximately 70% of total accident costs; this substantially underestimates the true social burden.

Methodological limitations: Reliance on police-recorded accident data, which systematically underreports non-fatal minor injuries; assumptions regarding treatment duration (15 days severe, 3.7 days minor) may not reflect actual Iranian healthcare patterns; wage-based productivity loss estimates fail to capture the value of life components beyond economic productivity.

Generalizability limitations: Single-city study in Tabriz may not represent conditions in other Iranian urban centers with different traffic patterns, infrastructure conditions, and enforcement capabilities; findings may not translate to rural road settings.

Data quality limitations: Currency devaluation during the study period affects cost comparisons; weather-related variations in accident rates are not controlled; traffic volume changes are not systematically accounted for in this regard.

Therefore, it is suggested that in the future, a study with more samples in different locations be conducted. Also, the cost amounts are from the past several years, and due to the devaluation of the country's currency, these amounts will also change.

Conclusion

The cost-benefit analysis in this study showed that although there are costs associated with human resources, infrastructure, equipment, and materials for road safety projects targeting black spots, these interventions are not only cost-effective but also very cost-effective investments. While the initial maintenance costs are high, the reduction in deaths and injuries over time results in a significant return on investment in subsequent years, an aspect that policymakers and planners should prioritize. The research emphasizes the significant economic value of safety measures and suggests continued financial support, while recommending more data collection and a more comprehensive approach to cost analysis that includes less tangible benefits.

Conflict of interest

The authors declare no conflict interests. This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Data availability statement

Full data included in article or supplementary online materials; additional data available upon request.

Acknowledgements

Authors wish to express their gratitude to the deans and directors of Road Traffic Injury Research Centre of XXX University of Medical Sciences for their financial and academic support.

Ethical Considerations

The study design was approved by the Ethics Committee of XXX University of Medical Sciences (No: IR.XXX.XX.XXX.X.XX).

References

[1] Bamir M, Masoud A, Dehnavieh R. Future Risks, Insecurity of Iranian Roads on Health Sector: Do Policymakers Know Innovative Solutions? SSPP. 2020;9(33):214-21.

[2] Takale DG, Gunjal SD, Khan VN, Raj A, Gujar SN. Road accident prediction model using data mining techniques. NeuroQuantology. 2022;20(16):2094-101. [DOI: 10.48047/NQ.2022.20.16.NQ880299]

[3] Ahmadvand A, Abtahi Z. Road safety evaluation methods. 2009.

[4] Morgado MA, Jalles F, Lobo S, Abecasis F, Gonçalves M. Road traffic injuries and road safety measures–can we do any better. Pediatr Therapeut. 2017;7(319):2161-0665. [DOI:10.4172/2161-0665.1000]

[5] Haghighi F, Karimi E. Evaluation and statistical validation of black-spots identification methods. Inter J Transp Eng. 2018;6(1):1-15. [DOI:10.22119/ijte.2017.52977]

6] Keymanesh M, Ziari H, Roudini S, Nasrollahtabar Ahangar A. Identification and prioritization of “black spots” without using accident information. Model Simul Eng. 2017;2017(1):1832654.

[7] Špačková O, Straub D. Cost-benefit analysis for optimization of risk protection under budget constraints. Risk Anal. 2015;35(5):941-59. [DOI: 10.1111/risa.12310]

[8] Harwood DW, Rabbani EK, Richard K, McGee H, Gittings G. Systemwide impact of safety and traffic operations design decisions for 3R projects. 2003.

[9] Hamidizadeh MR, Shafiei Nikabadi M, Naderi R. Setting Policy for Road Fatalities Reduction in Country by using System Dynamics Method. SMSJ. 2017;8(31):61-82.

[10] Abdolmanafi SE, Karamad S. A new approach for resource allocation for black spot treatment (case study: The road network of Iran). J Saf Res. 2019;69:95-100. [DOI: 10.1016/j.jsr.2019.03.001]

[11] Mehregan N, Gholizadeh A, Mohammadi F. Investigating the relationship between Traffic safety and economic growth in Iran. Iranian J Appl Econ. 2011;1(3):99-117.

[12] Yannis G, Papadimitriou E, Evgenikos P, editors. Cost-benefit assessment of selected road safety measures in Greece. Proceedings of the 13th International Conference on Road Safety on Four Continents, Warsaw; 2005.

[13] Golestani M, Sadeghi-Bazargani H, Harzand-Jadidi S, Soori H. Evaluation of cost-effectiveness of single-credit traffic safety course based on Kirkpatrick model: a case study of Iran. BMC Med Educ. 2024;24(1):128. [DOI: 10.1186/s12909-024-05122-w]

[14] Ayati E, Ahadi M. Estimation of the cost of damage to vehicles in rural road accidents in Iran. J Transp Res Rec. 2008;5(1).

[15] Atkins AS. The Economic and Social Costs of Road Accidents in Australia: with Preliminary Cost Estimates for Australia in 1978. 1981.