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Cost-Effectiveness Evaluation of Selected Road Safety Measures

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EXTENDED ABSTRACT

Overview

Evidence based policy making is supported by accurate scientific information about crash risks and the cost-effectiveness of appropriate road safety measures, this approach is becoming increasingly prominent in road safety practices worldwide. However, despite aspiring for evidence based policies, it can be difficult for policy makers to access and understand the scientific literature, especially given limited timeframes.

SafetyCube (Safety CaUsation, Benefits and Efficiency; www.safetycube-project.eu) is a European funded research project under the Horizons 2020 programme which provides insight into crash risk factors and the effectiveness of road safety measures. A European Road Safety Decision Support System (DSS) has been developed which aims to enable policy-makers and stakeholders to select and implement the most appropriate strategies and cost-effective approaches to reduce casualties of all road user types and all severities.

The effectiveness of road safety measures is assessed through relevant cost-benefit analyses (CBAs) conducted through a purpose-made Economic Efficiency Evaluation (E^3) calculator. A CBA allows the joint evaluation of the effectiveness of measures in reducing crashes of different severity and to provide information on the socio-economic return of road safety measures.

In this paper, the cost-benefit assessment of selected road safety measures for infrastructure and road user behavior carried out by the NTUA research team within the SafetyCube project is presented for seven different scenarios that stakeholders are likely to encounter.

Method

The SafetyCube project has developed a DSS [1] (www.roadsafety-dss.eu) which provides detailed information about approximately 1200 research studies and summarizes the current state of knowledge for 51 road safety measures topics, via application of a standardized methodology for synthesizing scientific knowledge into an accessible and comprehensive format. A comprehensive taxonomy has been developed for road users, road infrastructure and vehicles for risk factors and road safety measures after consultation with stakeholders [2]. The scientific literature relating to each specific road safety measure has been systematically searched and screened and the results of identified studies were coded. This led to the compilation of several concise synopses containing those results, which included effectiveness indicators (color codes). For further detail of the SafetyCube methodology see [3,4].

The Economic Efficiency Evaluation (E^3) calculator was developed within the SafetyCube project. In this tool, information regarding the effectiveness of a certain road safety measure (i.e. percentage of crashes prevented) and its implementation costs are presented. In addition, such a tool can determine the costs and benefits in monetary terms and allows for further analyses. It includes crash cost estimations for European countries as calculated within the project [3]. The E^3 calculator is currently incorporated in SafetyCube DSS. Further information for the development and the theoretical framework underlying the calculator can be found in [4].

The main outcome of the CBA is the benefit-to-cost ratio (BCR) which constitutes an estimate of measure effectiveness; a value higher than 1.0 means that the costs are more effective than the measures. Measures were thus ranked based on their BCRs to inform stakeholders. The results of a CBA are considerably dependent on the underlying assumptions about the effect of the concerned measure. However, effect estimates are – even in the best documented cases – only known within a certain uncertainty margin. It is therefore useful to run a sensitivity analysis based on some alternative assumptions about the effects of the measure, in order to show to which extent BCRs are sensitive to changes in the underlying effect estimates.

The road safety measures that have been assessed as effective ("green" or "light green" color code) within the SafetyCube project were examined with regard to their effectiveness. Overall, 17 measures have been analyzed as per their cost-effectiveness for infrastructure [5], 12 for road user behavior [6], and several for vehicle systems are in progress. All of these analyses are currently available online for road safety stakeholders on the DSS. In this research, a selection of CBAs carried out by the NTUA team is presented. These were for infrastructure: road safety audits, installation of safety barriers, treatment of high risk sites, installation of traffic signals, installation of chevron signs; for road user behavior: DUI checkpoints & breath testing and general police enforcement of speeding.

Results

Crash cost data was obtained from high quality scientific studies and reports, and crash costs per country as well as inflation values and currency conversion rates for transforming monetary values to the baseline (reference year/currency: 2015/Euros) were available and ready to use within the calculator [3, 4].

If available the upper and lower limits of the 95% confidence intervals of the estimates were used. In the ideal case these estimates were resulting from a meta-analysis, in other cases the used values result from one or two particular studies. The used values represent a lower or higher effect than expected. Similarly, expert estimates for lower (-50%) and higher (+100%) measure costs were tested. Finally, a "worst case" scenario (high cost + low measure effectiveness) and a "best case" scenario (low cost + high measure effectiveness) were formulated, resulting in seven scenarios together with the baseline.

Results for the topics analyzed by the authors within the "road infrastructure" and "behavior" are shown on Table 1. Green figures (positive BCR values) denote effective cases, while red figures (negative BCR values) denote non-effective cases.

It can be observed that road safety measures addressing a critical point in a focused manner, such as road safety audits, installation of safety barriers and high risk sites treatment have considerably higher BCRs, meaning that they are appear to be more gainful than others. This highlights the need for careful monitoring of the road safety levels on a more microscopic level instead of solely relying on broader treatments. Measures typical for country roads, such as chevron signs or traffic signal installation there, were found to be effective by a smaller degree, possibly due to the very low number of affected crashes. A noteworthy result is that general police enforcement of speeding was found to be marginally effective, perhaps due to overall higher implementation costs (though this varies with each scenario).

It should be highlighted that in two cases more than one CBAs were deemed as informative and were conducted, mainly to capture different applications of road safety measures. Firstly, the cost-effectiveness of two measure types ("light measure" – less disrupting and costly vs. "heavy measure" – more disrupting and costly) applied in tandem with audits were investigated. Similarly, the cost-effectiveness of traffic signal installation in highways and in county roads were explored.

Similar analyses have been conducted by other SafetyCube partners; all results are available in the DSS [1] and in respective project Deliverables [5-8].

Measure		Benefit-to-cost ratio (BCR)						
		Best estimate	Low measure effect	High measure effect	Low measure cost: -50%	High measure cost: +100%	Worst case scenario = high cost + low effect	Best case scenario = low cost + high effect
Road infrastructure	Road safety audits – light measure case	**21.7**	16.4	27.0	43.5	10.9	8.2	54.0
	Installation of safety barriers	**19.5**	10.6	25.4	39.1	9.8	5.3	21.2
	High risk sites treatment	**16.1**	13.2	18.4	32.2	8.1	6.6	36.8
	Traffic signal installation – highways	**3.7**	1.8	5.2	7.4	1.9	0.9	10.5
	Road safety audits – heavy measure case	**2.9**	2.2	3.6	5.7	1.4	1.1	7.1
	Installation of chevron signs	**2.7**	1.4	5.5	5.5	1.4	0.7	10.9
	Traffic signal installation – county roads	**1.1**	0.5	1.5	2.2	0.5	0.3	3.1
Behavior	Law and enforcement – DUI checkpoints, breath testing	**7.3**	5.7	9.4	14.6	3.7	2.9	18.8
	Law and enforcement – General police enforcement of speeding	**1.0**	0.7	1.3	2.0	0.5	0.4	2.6

Table 1. BCRs for all seven scenarios for examined measures

Conclusions

Using a standardized approach to coding scientific literature it has been possible to evaluate the cost-effectiveness of road safety measures and synthesize relevant findings into a standardized format for policy makers. Most of the analyzed measures appear to be effective across all scenarios, which highlights the value of meaningful road safety interventions to anticipate and prevent crashes and all their associated costs.

The E^3 calculator is accessible in the DSS, and users are encouraged to revisit existing CBAs by adjusting the input values with respect to their specific case/context, for a customized outcome. Despite the attempt to present the information in ways that allow the comparative assessment of the selected measures as per any key element of the CBA, it is apparent that any comparative analysis must be addressed with much caution. There are case-specific factors that might limit result transferability, such as considerably low effectiveness results.

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