IRTAD Conference 2026
Better Road Safety Data for Better Safety Performance
15-17 April 2026 Athens, Greece
International Transport Forum
irtad International Traffic Safety Data and Analysis Group
National Technical University of Athens

Do Key Performance Indicators really measure road safety performance?

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Abstract

The European Union has set ambitious road safety targets, aiming to halve fatalities and serious injuries between 2020 and 2030 and to approach zero by 2050 (EC, 2019). Monitoring progress requires not only outcome indicators, such as fatalities and serious injuries, but also intermediate road safety performance indicators – so called Key Performance Indicators (KPIs) – that capture risk factors, which reflect the unsafe operational conditions and thus influence road safety performance (ETSC, 2001).

KPIs typically include speeding, seat belt wearing rate, or use of mobile phones while driving. Several countries worldwide have collected and analyzed KPIs (Aarts et al., 2025), among others, to:

- set targets to be achieved in the medium and long term
- monitor progress towards targets
- identify policy measures that need to be taken
- assess whether the policy measures implemented have led to the desired results
- monitor changes in contributing factors
- detect emerging trends at an early stage

The Baseline project was the first large-scale attempt to harmonize KPI collection across Europe (18 member states) for eight "standard" indicators. Building on this foundation, the Trendline project extended the coverage to 25 member states and also the scope of KPIs by developing additional "experimental" indicators in areas not yet systematically covered (Van den Berghe et al., 2026).

Nevertheless, one criterion of a useful KPI is a "proven association with road crash and injury risks" (EC, 2022), i.e., the validation of a KPI. For example, the association between driving speed and crash frequency, as well as severity, is generally known (OECD/ITF, 2018); however, there are differences given by the levels of spatial and temporal aggregation, as well as different road types, varying measurement approaches or statistical techniques – which may explain why the signs of association between speed and crashes vary across different contexts (e.g., Yuan et al., 2021; Das et al., 2022). In addition, multiple KPIs play a role at the same time, which calls for the application of multivariate statistical modelling (Papadimitriou and Yannis, 2013).

The goal of this study is to investigate the association between a set of KPIs and final outcomes, i.e., crashes and injuries – in other words, checking how the KPIs measure road safety performance. While diploma theses by Konstantopoulos (2023) and Papagianni (2023) explored these associations using the Baseline KPIs and linear regression, the present study will use the most recent Trendline KPI data and a more suitable negative binomial regression.

Following the standard practice of multivariate regression in road safety (Yannis et al., 2017; Ambros et al., 2018), this modelling approach will be adopted for the study. The model form will be:

$$N = \exp(\beta_0) \cdot E^{\beta_1} \cdot \exp\left(\sum_{i=2}^{n} \beta_i x_i\right)$$

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where N represents outcomes (number of crashes, injuries, etc.), E is exposure, x are explanatory variables (KPIs), and β are regression parameters. Exposure (e.g., vehicle-kilometers, population, vehicle fleet) is considered in power form and other variables in exponential form; statistical distribution is negative binomial, which satisfies conditions of count and non-negative character of outcome data.

In total, three datasets will be used:

- Outcomes (crashes, injuries, etc.) will be obtained from the CARE database.
- Exposure data will be obtained from Eurostat or individual national sources.
- KPIs will be obtained from the final Trendline results.

Based on the available data, suitable aggregations will be selected and used in the modelling. Based on varying subsets of variables, different model variants will be tested and compared.

The modelling and statistical significance testing are expected to reflect the explanatory value of individual KPIs, i.e., checking which KPIs really measure road safety performance and how much. This may also enable discussing the potential reduction of the collected KPIs.

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Keywords: road safety; safety performance; key performance indicator