Methodology for the Evaluation of Safety Interventions

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Abstract

In recent decades, automotive telematics and driver monitoring systems have been introduced in the industry in order to provide real-time and post-trip interventions and feedback to the driver. A few driver monitoring technologies and platforms have been used to record driving performance, focus on key risk indicators and provide safety interventions. Within that group of tools, interventions have been indicated to significantly enhance driving behavior and road safety. The purpose of the current study is to provide a methodology for safety intervention evaluation in order to keep driver behavior within acceptable boundaries of safe operation (i.e. Safety Tolerance Zone). To that aim, the most appropriate assessment variables from the i-DREAMS platform, related to the logic model of change were identified and some recommendations for the i-DREAMS project were provided. In order for the methodology to be designed, past experience on similar projects was exploited in order to derive a list of methods, indicators, utilized Key Performance Indicators (KPIs) and evaluation criteria mostly suitable for evaluating the project's safety interventions. Three different methods (i.e. before-after analysis, case-control trials and questionnaires) were identified and therefore, the evaluation was conducted in terms of the outcomes proposed in the logic model of change. Results from literature review indicated that safety promoting goals and performance objectives had the greatest effect on the assessment of interventions. Driver behavior indicators, such as speeding, harsh acceleration or braking had the strongest impact on the interventions evaluation, while driver related characteristics, such as distraction, stress, fatigue, drowsiness and attention appeared to have lower impact. Taking into account the experimental studies, the design of a customized feedback strategy will assist in performing the appropriate evaluation of interventions needed for the improvement of driver behavior.

Keywords: i-DREAMS project; Safety Tolerance Zone; real-time; post-trip; evaluation; safety interventions.

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1. Introduction

Road crashes, traffic fatalities and occupational injuries comprise important problems in public health [1], but in the last years, the number of road crashes, fatalities, serious and slight injuries have tended to remain stable or even reduced in several countries [2]. It is worth mentioning that this decreasing trend can be attributed to the effectiveness of road safety interventions [3]. In particular, in-vehicle interventions are meant to assist and support vehicle operators not only in real-time (i.e. while driving) but also in post-trip (i.e. after the end of the trip). The most effective interventions are those that eliminate and reduce the hazard and are not dependent on the changes in road users' behavior or on their knowledge of road safety issues [4]. It should be noted that safety interventions based exclusively on education have been found to be ineffective in reducing road traffic injuries [5].

In recent decades, automotive telematics and driver monitoring systems have been introduced in the industry in order to provide real-time and post-trip feedback to the driver. A few driver monitoring technologies and platforms that have been used to record driving performance, focus on key risk indicators and provide safety. Within that group of tools, interventions have been indicated to significantly enhance driving behavior and therefore, road safety. There are two different types of interventions: real-time and post-trip interventions. Regarding the former, signals are provided to the driver while driving with the help of an in-vehicle warning system. With respect to the latter, signals are given to the driver after driving.

Within the above framework, the i-DREAMS[2] project aims to define, develop, test and validate the concept of the 'Safety Tolerance Zone' (STZ), with a smart Driver, Vehicle & Environment Assessment and Monitoring System. The term 'Safety Tolerance Zone', although abstract in nature, refers to a real phenomenon, i.e. self-regulated control over transportation vehicles by (technology assisted) human operators in the context of crash avoidance. Driving task complexity indicators (e.g. road layout, weather conditions, time of the day) and driver background factors (e.g. fatigue, distraction, sleepiness) will be taken into consideration and a continuous real-time assessment will be created to monitor and determine if a driver is within acceptable boundaries of safe operation (i.e. STZ). In addition, safety-oriented interventions and post-trip feedback will be provided in order to prevent drivers from getting too close to the boundaries of unsafe operation.

The purpose of the i-DREAMS interventions is to effectively increase driver safety by supporting the drivers in their driving task. To achieve this aim, information that will be used within the interventions will be provided by a risk monitoring instrument. The intervention mechanism will be based on the STZ concept. According to the STZ, a driver can be in three different phases: Normal Driving phase, Danger phase and Avoidable Accident phase. Firstly, Normal Driving refers to the phase, where conditions at that point in time suggest that a crash is unlikely to occur and therefore, the crash risk is low and the operator is successfully adjusting their behavior to meet task demand; no real-time interventions are necessary. Secondly, the Danger phase is characterized by changes to the Normal Driving that suggest a crash may occur and thus, there is an increased crash risk. At this phase, a crash is not inevitable but becomes more likely; an alert will be offered. Lastly, the Avoidable Accident phase occurs when a collision scenario is developing, but there is still time for the operator to intervene to avoid the crash. In this phase, the need for action is more urgent to denote that if there are no changes or an evasive manoeuvre performed by the operator, a crash is very likely to occur; an intrusive warning signal will be provided.

The main purpose of this paper is to provide a methodology for the evaluation of both real-time and post-trip safety interventions, which will be developed to improve driver safety through keeping the driver within the boundaries of the STZ. In more specific terms, the current work aims to address the following objectives:

- Identify the appropriate assessment variables from the i-DREAMS platform, which are related to safety outcomes, safety performance goals, performance objectives and change objectives.
- Define the crucial indicators and measurements for the quantification of the impact of real-time and post-trip safety interventions.

The key research question the paper is addressing is:

- Which are the crucial aspects that the intervention assessment methodology should tackle in order to keep the driver within safe boundaries?

[2] Further general project information can be found on the website: https://idreamsproject.eu/

In order to assess the effectiveness of the safety interventions, the outcome and process evaluation are implemented. Outcome evaluation, applies to whether targeted factors changed as a result of the intervention or not, while process evaluation aims to determine which parts of the intervention were effective and which not. In addition, the logic model of change behind the i-DREAMS interventions (comprising of Safety Outcomes (SO), Safety Promoting Goals (SPG), Performance Objectives (PO) and Change Objectives (CO) is presented and the dependency among the different levels is highlighted. Moreover, it is sought to link the SO, SPG, PO, and CO with driving behavior and safety critical indicators, in order to identify the potential measurements to be provided from the i-DREAMS platform and will be utilized for intervention assessment. Furthermore, a variety of methods and study designs are overviewed in order to estimate the safety effects of interventions as efficiently as possible.

The structure of this research is presented as follows. In the beginning, the i-DREAMS intervention strategy specifications, along with the main targets, features and particularities of interventions are provided. The purpose and philosophy as well as the logic model of change behind the real-time and post-trip i-DREAMS interventions are analyzed. Then, the assessment of interventions that could be exploited for the i-DREAMS intervention methodology is highlighted, based on the logic model of change. The evaluation strategy along with the methodological design are presented in order to turn the available measurements into meaningful information on the level of driving safety. Finally, conclusions and practical recommendations are drawn.

2. Road Safety Background

In order for the methodology to be designed, the specifics of the i-DREAMS interventions were overviewed and past experience on similar projects was exploited in order to derive a list of methods, indicators, utilized Key Performance Indicators (KPIs) and evaluation criteria mostly suitable for evaluating the safety interventions.

2.1. Naturalistic driving studies

Several intervention studies occupy an important role in research due to the emphasis on crash prevention and post-trip intervention technology improved safety outcomes, especially for work-related drivers. To begin with, Payyanadan et al. [6] monitored crash risk events in order to assess the interventions. In addition, the percentage of time drivers spent within the speed limit and exceeding the speed limit as well as the percentage of time exceeding the speed limit compared to other drivers was evaluated [7]. Toledo et al. [8] showed that the rates of harsh events, such as harsh accelerations or brakings, turns and lane changes can be used as risk indicators for the involvement in road crashes. Summary statistics of the crash rates in the periods before and after the exposure to the in-vehicle data recorder (IVDR) feedback were provided and a comparison of driver performance indicators was made through a before-after analysis.

Fujii et al. [9] investigated the change objectives and discussed psychological and behavioral strategies that influence individual awareness and address other, various psychological factors to encourage voluntary behavior change. A before-after analysis was conducted and drivers were asked to answer a questionnaire about their driving habits. In addition, the impact of behavioral and emotional driver factors, such as fatigue, drowsiness or distraction on driving performance was investigated [10]. Using post-trip intervention technology and alerts, drivers can reliably quantify the risk associated with a specific driving behavior, such as speeding, number and severity of harsh events (e.g. braking, acceleration, cornering) or driving aggressiveness. Driver scores were collected through a web-platform and a before-after analysis was conducted in order to evaluate the interventions. In addition, physiological factors, such as fatigue, drowsiness and distraction were assessed and a before-after analysis was made to evaluate the different values or rates of physiological indicators.

Toledo and Shiftan [11] assessed data regarding safety related events and supplementary events, such as lateral acceleration, braking or speeding, in three experimental phases: no feedback, limited feedback to the worst drivers, and full feedback. A before-after analysis was conducted and changes in the rate of events reflected safety (e.g. frequency of speeding, harsh accelerations and harsh braking) were identified in order to assess the interventions. In other two studies [12, 13], interventions, in the form of in-cab sounds and lights were provided. Also, summary reports with some basic performance measures, such as speeding, harsh braking and excessive idling were given to drivers at the end of their trip. A meta-analysis was conducted to assess risky driving behaviors as well as the frequency of extreme braking incidents. The objective of another naturalistic driving study [14] was to evaluate whether two types of feedback from an in-vehicle monitoring system (IVMS) could reduce the incidence of risky driving behavior. A before-after analysis was used and results indicated that both performance objectives and change objectives were assessed for the evaluation of interventions.

2.2. Simulator studies

With regards to driving simulator studies, critical situations can be highly controlled and trained within driving simulator experiences [15]. An important goal for simulator training is to provide feedback and help drivers to improve their driving performance. A few studies have shown positive effects of simulator training on driving competence in on-road conditions. First of all, Roberts et al. [16] developed an interesting simulator study which was conducted to evaluate driver's distraction, through real-time and post-drive mitigation systems. It should be noted that change objective (i.e. motivation) was used for the assessment of the interventions and a before-after analysis was conducted. The post-drive mitigation system consisted of coaching drivers on their performance and encouraging social conformism by comparing their performance to peers. Another simulator experiment was implemented which assessed the differences in driving performance and eye-movement patterns among different drives and compared these across treatments [17]. Safety outcomes, such as collision with lead vehicle and collision with oncoming traffic as well as performance indicators, such as speeding, acceleration, tailgating and lane deviation were evaluated in a meta-analysis method.

An interesting finding of Toledo and Lotan [18] indicated that the exposure to post-trip interventions had a positive effect on driver performance and, therefore, safety. The safety promoting goals of vehicle control and speed management were evaluated per their effectiveness and examples of these measurements/manoeuvres included lane changes, harsh acceleration/braking and excessive speed. The quality of performance of the detected manoeuvres was also assessed in a before-after analysis. Furthermore, Zhao and Wu [19] conducted a driving simulator study to assess driving speed and compare the effectiveness and acceptance of the Intelligent Speeding Prediction System (ISPS) as well as the Intelligent Speed Adaptation (ISA) through a before-after analysis.

Moreover, Wong et al. [20] investigated how effective voice commands are in influencing people’s speed on a semi-autonomous vehicle regardless of how occupied the driver is with a secondary task. Drivers were first given a warning at the approach of one of driving scenarios, such as roundabouts, lane changes, T-junctions. This was then followed by one of three different execution commands (indicate left/right, braking, speed), which varied both in tone and phrasing. Driving indicators, such as harsh braking and speed were assessed in a before-after methodology and assertive and non-assertive voice commands were given in an identical set of driving videos separately. The results showed that participants responded quicker to assertive voice commands despite how immersive the secondary task was. Lastly, Roenker et al. [21] compared simulator training and useful field of view (UFOV) functional training in older drivers. A before-after analysis was conducted and authors assessed safety promoting goals of speed management (i.e. speeding) and driver fitness (i.e. attention) before training, immediately after training, as well as eighteen months after the training period.

3. Methodology

In order to sketch out a methodology for the assessment of safety interventions, an overview of already utilized methodologies that could be exploited for the i-DREAMS intervention assessment methodology was performed. Since the i-DREAMS interventions aim to improve driver safety, four different levels of driver safety are presented. The highest level targeted by the i-DREAMS interventions consist of the safety outcomes (e.g. the likelihood of crash occurrence, for example, frontal crashes, side crashes or rear crashes). The second highest level consists of the safety promoting goals. These are the behaviors that need to change in order for the safety outcomes to be realized. The second lowest level refers to the performance objectives. These are the more specific actions or behavioral parameters that need to change in order for the safety promoting goals to be achievable. The lowest level consists of the change objectives. They refer to the underlying behavioral determinants that need to change for the performance objectives to become realizable [22].

Taking into account the variety and combination of the levels of driver safety (SO, SPG, PO and CO), a link with the potential measurements was made in order to assess them. SO are dependent upon SPG, which by extension are dependent upon PO, which therefore are dependent upon CO. In order not to lose the logic strength of the change strategy (i.e. change objectives → performance objectives → safety promoting goals → safety outcomes), suitable measures for each of the links in this causal chain have to be considered in relation to each other when assessing intervention effects. Consequently, the assessment variables were evaluated at different levels where there exist a causally link with each other.

4. Results

4.1. Criteria/Perspectives

The evaluation and the adoption of safety interventions can only be successful if the technology is effective in reducing the target risk and when it is also used efficiently by the driver. If the driver does not accept the feedback technology, misuse or disuse of the interventions is evident [23]. The safety-related measures and criteria appropriate to the methodology for the evaluation of interventions within the i-DREAMS are separated into two categories; these which are related to the user and the others which are related to safety.

In order to make the evaluations reach their full potential, their quality should be as high as possible. Three quality requirements are important in this respect: user acceptance, user acceptability and reliability [24]. It should be noted that user acceptability is related to the actual use of the system, so the behavior of the driver will be investigated when receiving signals of the system during driving. In addition, since user acceptance is related to the intention to use a system, it is based on individual attitudes, expectations and experience, obtained during actual use, as well as their subjective evaluation of expected benefits. Lastly, with regards to the reliability, a model answer which is typically used so that drivers can compare their individual skills and assess their strengths and weaknesses can be designed. This allows to assess as accurately and objectively as possible. Specifically, a model output indicates which elements should be given particular focus on the assessment processing. When there are several evaluators for the same task, an appropriate structure and strategy is highly recommended: this creates a consensus on the criteria that must be used to assess and makes sure that everything is evaluated from the same point of view.

4.2. KPIs and surrogate safety

KPIs can be determined in order to compare the efficiency of the interventions with considerations on the implementation with on-board devices to be used to recognize episodes of specific driving behavior in real-time and post-trip. As crashes could be triggered by multiple factors, KPIs should take into account not only qualitative but also quantitative indicators. Based on the methodology for the evaluation of safety interventions, the performance indicators that appeared to have the greatest effect on the assessment of interventions are presented below. A distinction is made between behavioral and physiological indicators. It should be noted that the available KPIs, which are going to be evaluated, can be delivered as rate, absolute values, numerical scores, absolute number of warnings or a binary variable. Table 1 lists the variety of i-DREAMS safety outcomes, safety performance goals, performance objectives and change objectives along with potential measurable variables from the i-DREAMS platform that could be used for assessment.

Table 1: Different levels of driver safety (SOs, SPGs, POs, and COs) along with the appropriate variables from the i-DREAMS platform

SOs	SPGs	POs	COs	Potential measurements
Frontal crash -Vehicle to Vehicle - Vehicle to obstacle - Vehicle to VRU	Driver fitness	Fatigue	Capability	**Distraction** (Handheld mobile phone use, Hands on wheel)
Side crash -Vehicle to Vehicle - Vehicle to obstacle - Vehicle to VRU	Vehicle control	Distraction	Opportunity	**Inattention** (Handheld mobile phone use, Hands on wheel)
Rear crash -Vehicle to Vehicle - Vehicle to obstacle - Vehicle to VRU	Sharing the road with others	Sleep deprivation	Motivation	**Fatigue** (KSS score, Long driving hours, Time driving)
Roll-over/derailment crash	Speed management	Acceleration	Behavior	**Sleepiness/ Drowsiness** (KSS score, Long driving hours)
Crash with injury for passengers	Use of safety devices	Deceleration		**Poor visibility/ Weather** (wipers on)
		Steering		**Acceleration/ Deceleration** (number of harsh accelerations/ brakings and aggressiveness level)
		Tailgating		**Speeding** (speeding percentage and average speed over speed limit)
		Lane discipline		**Overtaking** (number of illegal overtaking events)
		Overtaking		**Risky hours** (driving during 00:00-05:00)
		Forward collision avoidance		**Lane discipline** (number of lane departure warnings)
		Lane departure avoidance		**Forward collision avoidance** (number of FCW)
		Vulnerable Road User (VRU) collision avoidance		
		Speeding (speed limit exceedance)		

4.3. User acceptance and user acceptability

The success of the i-DREAMS technology depends on whether drivers find the technology beneficial for their driving and safety. If drivers do not accept the interventions, the technology will not increase the driver's safety. Since user acceptance is related to the intention to use a system, it is based on individual attitudes, expectations and experience, obtained during actual use, as well as their subjective evaluation of expected benefits [25]. The change (or absence of change) in driver behavior in response to the interventions will be an indication of acceptance. In particular, by observing the behavior of a driver, conclusions about acceptance can be derived, e.g. if a driver presses or does not press the brake when receiving a warning about braking, or if the brake response time when receiving a warning is too large.

At the same time, since user acceptability is related to the actual use of the system, the driver's behavior will be investigated when receiving signals of the system during driving. It is important to gather information on how the drivers feel about the i-DREAMS technology. Hence, the subjective assessment of drivers will be valuable additional information to keep improving the system. Several studies propose standardized survey scales to measure aspects of acceptability; thus, survey techniques will be used.

4.4. Reliability

Reliability of the different interventions is a major concern for all drivers. The reliability assessment will inform the extent to which the technology was perceived to be useful or not and provide detailed feedback from users which can be used to build upon and explain findings.

A search of the literature revealed little in the way of detailed reliability testing techniques for technology other than very comprehensive reliability audits. Such audits are used in safety critical industries like the aerospace and nuclear sectors, the process of these audits would be far too detailed for i-DREAMS to replicate as they use a highly complex systems perspective approach and are a whole discipline in themselves. However, it should be mentioned that at the other end of the scale product development audits give managers a tool for tracing how well their concept products are being developed. In that case, the reliability assessments should be taken into account for the i-DREAMS needs, as it is essential to know how reliable the participants perceived the technology to be.

For example, the guide created by Crucible Design [26] consisting of a single question on reliability with a 4-point scale rating from ‘unreliable- regularly fails to work correctly’ to ‘A work horse- 100% reliable’ can be taken into consideration. Similarly, simplistic ratings of reliability have been used in academic literature such as by Wiegmann et al. [27] who measured perceived reliability of a diagnostic aid by administering a post-experimental questionnaire rating the reliability using a scale that ranged from 0% (completely unreliable) to 100% (completely reliable).

At the same, reliability in its most basic form i.e. how many times did the technology objectively cease to work or encounter problems could be also taken into account in i-DREAMS. A reliability assessment looking into whether the technology served its purpose, added value and allowed the user to depend on it in all situations will be useful to gather. For instance, real-time warnings may produce many false positives; thus, this will effect driving behavior.

4.5. The RE-AIM framework

The process evaluation focuses on the quality of material designs, the quality of implementation and the adoption of the intervention. Within the process evaluation, particular focus will be given to variables within the RE-AIM framework [28]. This is a widely known framework for process evaluation. It should be noted that the abbreviation “RE-AIM” stands for: Reach, Effectiveness, Adaption, Implementation and Maintenance. “Reach” is the absolute number, proportion, and representativeness of individuals who are willing to participate in a given initiative. “Effectiveness” is the impact of an intervention on outcomes, including potential negative effects, quality of life, and economic outcomes. “Adoption” is the absolute number, proportion, and representativeness of settings and intervention agents who are willing to initiate a program. “Implementation” refers to the intervention agents’ "fidelity" to the various elements of an intervention’s protocol. This includes consistency of delivery as intended and the time and cost of the intervention. “Maintenance” is the extent to which a program or policy becomes institutionalized or part of the routine organizational practices and policies. Maintenance also has referents at the individual level. At the individual level, it is defined as the long-term effects of a program on outcomes 6 or more months after the most recent intervention contact [29].

5. Discussion

In order to analyze the intervention processes, three methodological approaches have widely been used: before-after analysis, case-control and questionnaires and the evaluation was conducted in terms of the outcomes proposed in the logic model of change. Furthermore, the RE-AIM framework was the most commonly used tool for the process evaluation. All the aforementioned methods are established tools, but their distinct epistemological properties enable them to illuminate different aspects of interventions.

5.1. Before-after analysis

With regards to the methods that are going to be used for the evaluation of interventions, before-after analysis is proposed. In particular, “before” refers to a measurement being made before an intervention is introduced to a group and “after” refers to a measurement being made after its introduction. Equivalent terms for “before” and “after” are “pre” and “post”. It should be noted that the before-after design offers better evidence about intervention effectiveness than the other non-experimental designs. The before-after analysis is most useful in demonstrating the immediate impacts of short-term programs. However, it was revealed that it is less useful for evaluating longer term interventions. This is because over the course of a longer period of time, more circumstances can arise that may obscure the effects of an intervention. These circumstances are collectively called threats to internal validity.

Before-after analysis can be used for both quantitative (i.e. safety outcomes and safety promoting goals) and observed qualitative indicators (i.e. performance objectives, change objectives). For instance, repeated measures analyses of variance (ANOVA) will be conducted in order to compare pre-test data with post-test data. Specifically, safety outcomes can be measured by means of crash occurrence, conflicts as well as by additional surrogate safety variables, like time-to-collision (TTC). Safety promoting goals as well as performance objectives will be based on the detection of events while driving. Lastly, change objectives (i.e. attention, understanding, emotion, punishment sensitivity and environmental context and resources) will be measured with a survey, and a comparison will be made before and after receiving warnings. It should be mentioned that punishment sensitivity (i.e., the degree to which an individual’s behavior is inhibited by punishment-relevant stimuli) is another potentially relevant determinant that can facilitate motivating the drivers to adapt their behavior.

5.2. Questionnaires

It is worth mentioning that a key indicator provided by questionnaires (i.e. performance objectives, and change objectives), is that researchers can gain valuable information about key issues from a large proportion of drivers, using few but reliable resources. If intervention outcomes are measured using pre- and post-intervention questionnaires, one should not overlook the practicality of also measuring process using questionnaire items. Compared to conducting lengthy interviews, it is convenient for respondents to also answer a number of process questions that measure key constructs known to be relevant for implementation and that can be linked to quantitative outcome evaluation of interventions [30-32].

Qualitative indicators such as change objectives (i.e. capability, motivation, behavior change, understanding, emotion, punishment sensitivity and environmental context and resources) will be measured by survey items as well as performance objectives (i.e. speeding, harsh acceleration, harsh braking, headway, fatigue etc.) will be measured by the on-vehicle technology.

5.3. Case-control designs

Apart from before-after analyses and questionnaires, results from literature review indicated that case-control designs, where cases are represented by drivers who operate with intervention assistance, and controls are drivers who operate without interventions could be also utilized to assess intervention efficiency.

5.4. Summary

Figure 1 illustrates the overall processing and methodology for the evaluation of interventions.

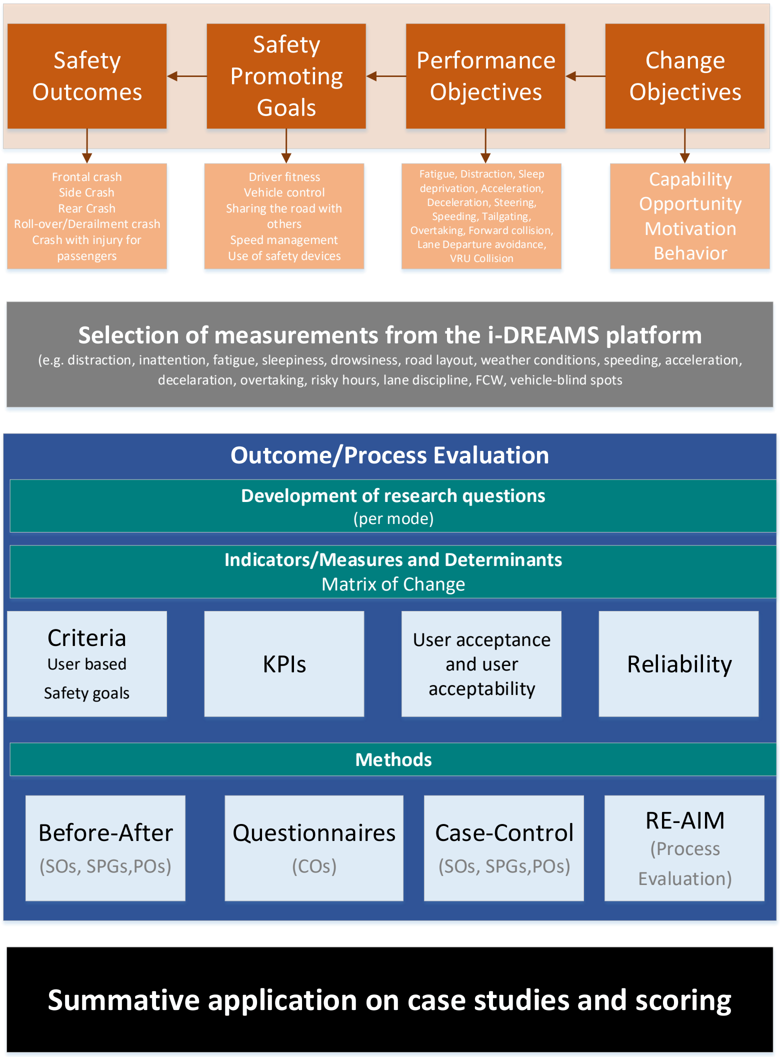

Figure 1: The overall methodology for the evaluation of interventions

6. Conclusions

This paper aimed at providing the methodology for the evaluation of safety interventions within i-DREAMS, which will be developed to improve driver safety through keeping the driver within the boundaries of the STZ. In order for the methodology to be designed, a review of similar methodologies and past experience on similar projects was exploited so as to derive a list of methods, indicators and evaluation criteria mostly suitable for evaluating the project's safety interventions. In addition, some recommendations for the i-DREAMS project were provided. As the intervention logic is based on the quadruplet of safety outcomes, safety promoting goals, performance and change objectives, the evaluation methodology was based on measurements that most accurately assess the performance of the intervention in terms of the four aforementioned parts.

The majority of the examined studies, focusing on the assessment and the effectivity of the interventions, mostly used a before-after analysis, presenting the overall statistics of events' occurrences, as well as safety outcomes, safety promoting goals, performance objectives and change objectives. In addition, questionnaires were also used to assess the interventions, while the case-control trials and meta-analysis, for the assessment of interventions, was a methodology implemented in fewer studies. The RE-AIM framework can be utilized for individual process evaluation. Furthermore, the evaluation of safety interventions was based on specific criteria (i.e. user acceptance and user acceptability and reliability). After obtaining scores for each individual criterion, a summative evaluation score will provide the overall assessment of a safety intervention. Lastly, KPIs were taken into account both qualitatively and quantitatively.

Results from the literature findings indicated that safety promoting goals and performance objectives had the greatest effect on the assessment of interventions. In particular, driver behavior indicators, such as speeding, harsh acceleration or braking had the strongest impact on the interventions evaluation, while driver related characteristics, such as distraction, stress, fatigue, drowsiness and attention appeared to have lower impact. With regards to safety outcomes, collisions with lead vehicle and collisions with oncoming traffic were mostly used in order to evaluate the effectiveness of interventions.

Taking into account the on-road and simulator studies, the design of a customized feedback strategy will assist in performing the appropriate evaluation of interventions needed for the improvement of driver behavior. Thus, a comparison between countries and different transport modes can be made, which will subsequently enhance the intervention performance evaluation and the quality of the assessment results.

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