An Overview of Risk Factors Related to Driver Distraction: Reviews and Meta-Analyses

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Abstract

The objective of this study is the comparative assessment of driver distraction related risk factors with the explicit purpose of ranking their impact on road safety. Existing studies were selected and analysed in a set taxonomy, of which distraction includes 11 risk factors. For each risk factor the applied methodology included rigorous literature search and selection, analysis of studies in terms of design, methods and limitations and synthesis of findings and meta-analyses, when feasible. 37 high quality studies were selected and analysed. Results indicate that cellphone use in any form is the most detrimental type of distraction. Conversation with passengers, cognitive overload and inattention, and outside factors were found to have a modest impact, while listening to music and operating devices were found to have an unclear impact. Three meta-analyses were also conducted, determining the proportions of crashes that occur due to drivers conversing with passengers or operating devices.

Keywords: *Road safety; driver distraction; meta-analysis; risk factors; risk classification; crash proportion*

Περίληψη

Στόχος της παρούσας εργασίας είναι η συγκριτική αξιολόγηση των παραγόντων επικινδυνότητας που είναι σχετικοί με την απόσπαση της προσοχής των οδηγών με σκοπό την κατάταξη των επιπτώσεών τους στην οδική ασφάλεια. Πραγματοποιήθηκε ανάλυση υπαρχόντων ερευνών μέσω συγκεκριμένης ταξινόμησής τους, από την οποία προκύπτουν 11 παράγοντες επικινδυνότητας απόσπασης της προσοχής. Για κάθε παράγοντα επικινδυνότητας ακολουθήθηκε αυστηρή βιβλιογραφική ανασκόπηση, ανάλυση των πλαισίων, των μεθόδων και των μειονεκτημάτων των ερευνών, σύνθεση των αποτελεσμάτων τους και πραγματοποίηση μέτα-αναλύσεων όπου αυτό ήταν δυνατό. 37 έρευνες υψηλής ποιότητας επιλέχθηκαν τελικά προς ανάλυση. Τα αποτελέσματα δείχνουν ότι η χρήση κινητού τηλεφώνου σε οποιαδήποτε μορφή έχει πολύ αρνητικές επιπτώσεις στην οδική ασφάλεια. Η συζήτηση με συνεπιβάτες, η πληροφοριακή υπερφόρτωση και οι εξωγενείς παράγοντες έχουν σημαντικές, αλλά περίπλοκες, επιπτώσεις, ενώ οι επιπτώσεις της ακρόασης μουσικής και του χειρισμού συσκευών κρίνονται ασαφείς. Πραγματοποιήθηκαν τρεις μέτα-αναλύσεις, καθορίζοντας το ποσοστό ατυχημάτων με αίτια την συζήτηση με συνεπιβάτες και του χειρισμού συσκευών.

Λέξεις-κλειδιά: *Οδική ασφάλεια, απόσπαση οδηγού, μέτα-ανάλυση, παράγοντες επικινδυνότητας, κατάταξη επικινδυνότητας, ποσοστό ατυχημάτων*

1. Introduction

The European Union (EU) has made substantial progress in improving road safety and reducing traffic fatalities. In the decade up to 2010, the number of fatalities reduced by 45% and the total number injured reduced by 30% (EuroStat, 2012). To further reduce the road casualties, it is necessary to understand the risks involved. Safety CaUsation, Benefits and Efficiency (SafetyCube) is a European Commission supported Horizon 2020 project with the objective of developing an innovative road safety Decision Support System (DSS) that will enable policy-makers and stakeholders to select and implement the most appropriate strategies, measures and cost-effective approaches to reduce casualties of all road user types and all severities. It is the first DSS worldwide that will provide information not only on measures, but also on risk factors that induce road safety problems and consider and provide information on infrastructure, vehicle and human factors.

One of the most critical groups of factors affecting road safety outcomes is driver distraction (Elvik et al., 2009). The term 'driver distraction' comprises all activities that are simultaneous to driving but unrelated to it, such as using a cellphone (hand-held or hands-free talking, texting), using navigational and information devices, interacting with passengers, listening to music, observing outside factors, and others. Distraction essentially involves the partitioning of the attention of drivers, thus reducing the amount of attention devoted to driving.

The extra amount of mental workload and cognitive functions that drivers have to undertake to cope with distracting activities reduce their reflexes and increase reaction times to events (both the time to mentally register the events and the time to physically react to them), as understood internationally and supported by many studies.

The existing literature indicates that there are patterns of persistent road safety problems related to driver distraction in the European countries, especially as emerging technologies are created and implemented in vehicles (such as In-Vehicle Information Systems – IVIS). This raises the need for further insight into the identification of specific driver distraction risk factors and their impacts on road safety outcome indicators, which is not possible through the analysis of available macroscopic data alone.

The objective of this study is to provide a comparative assessment and critical review of a variety of driver distraction related risk factors with the explicit purpose of ranking them based on how detrimental they are towards road safety outcomes (i.e. crash risk, frequency and severity). This evaluation was conducted by examining studies from the existing literature, selected and analysed on the basis of a dedicated common methodology.

2. Methodology

Within the SafetyCube project ‘risk factor’ refers to any factor that contributes to the occurrence or the consequence of road accidents. Risk factors can have a direct influence on the risk of an accident occurring, on the consequences of the accident (severity), or more indirectly by influencing a Safety Performance Indicator (SPI). All elements of the road system (driver, vehicle and environment) are potential crash risk factors.

For the analysis of driver distraction related risk factors, a dedicated methodology was developed as follows (Martensen et al. 2017):

- a stakeholders' consultation was carried out in order to identify needs of the potential DSSusers and professionals interested in the field of driver distraction and related road safety.
- a taxonomy of risks was created, in order to systematically classify areas and topics to be analysed.
- a dedicated methodology was developed for searching the literature and identifying the most relevant, high quality and recent studies; moreover, tools were developed in order to analyse studies, systematically code them and assess their findings so that they can be accessible in the DSS.

2.1 A taxonomy of driver distraction risk factors

The aim of creating a taxonomy is to identify the relevant topics covering all aspects of driver distraction risk factors, and structure them in a meaningful way (e.g. general topics, specific topics), to serve as the back-bone of the analyses. A comprehensive list of risk factors specific to driver distraction was created on the basis of several key publications. Relevant information was then sought on their general description, the related risk mechanisms, and a rough assessment of the safety effects (high / low or range of values, if known). In order to do so, existing studies on human-related risk factors were thoroughly reviewed (Elvik et al. 2009; Naing et al., 2007, Otte et al., 2009, Wallén Warner et al., 2008)

The entire taxonomy of risk factors related to humans utilised in the SafetyCube project is not presented here for the economy of space and the reader is referred to Talbot et al. (2016). General categories of driver distraction aspects were firstly considered as topics and then specific risk factors were formed and finalized. The driver distraction elements that are examined fall into three general topics and are structured as follows:

Table 1: *Distraction risk factors*

Distraction topics	Distraction within vehicle or within the riding or walking situation	Distraction outside vehicle (if car user)	Distraction through state of mind and cognitive overload
Specific distraction risk factors	• Cellphone use – handheld • Cellphone use – hands-free • Cellphone use – texting • Music & Entertainment Systems • Operating Devices • Conversation with Passengers • Animals, insects, others	• Watching persons, situations • Static objects (advertisement, traffic management information) • Sun, other vehicles' lights	• Distraction through state of mind (pondering etc.) and cognitive overload • Inattention, daydreaming

2.2. Finalization of topics – Stakeholder contribution

The SafetyCube project had already identified a core group of stakeholders from government, industry, research, and consumer organizations covering the three road safety pillars: vehicle, infrastructure, road user. Several workshops and consultations took place from the beginning of the project with key stakeholders to synthesize the requirements of the Decision Support System (DSS).

It was decided that the DSS should not be limited to EU policy-makers, but also be applicable for local authorities. It is intended that the system will help policy makers make an "informed decision". Moreover, it has to be an impartial system, which will not advocate for specific measures – the intention is "to guide, rather than to dictate". Using this structured approach to policy making should eventually enhance public acceptance of measures by providing a solid evidence base for decisions. In addition, it was suggested that the DSS should include robust data, allowing for critical analysis and transparency, there should be access to the studies used and to all results as well.

The main expected outcomes of the DSS are the following:

- Recommended good quality studies covering the topics at each taxonomy level
- Contextual information on studies (local, environmental, etc.), limitations of studies, implementation difficulties
- A meta-analysis where possible
- A range of solutions suitable for addressing any particular road safety problem

2.3. Dedicated Methodology for the assessment of risk factors

The aim of the development of a common methodology was to collect information for each risk factor in a uniform way to allow for the ranking of risk factors in a standardised manner. This included developing a literature search strategy, a 'Coding template' to record key data and meta-data from individual studies, and guidelines for summarising the findings per risk factor.

Collating information from a variety of studies each of which may use different underlying theories, designs and methods represented a big challenge. Therefore the approach and 'coding template' developed was designed to be flexible enough to capture important information but also facilitate the comparison between studies. These documents and the associated instructions and guidelines can be found in Martensen et al. (2017).

2.3.1. Literature search and Study Selection

For each of the identified risk factor topics a standardised literature search was conducted in order to identify relevant studies to include in the Decision Support System (DSS) and to form a basis for a concluding summary (synopsis) and further analyses. In some cases, however, insufficient literature was identified and some risk factors could not be consolidated into a synopsis. The literature searches were carried out between May and September 2016. The literature search, study coding and synopses creation for a particular risk factor was completed within the same SafetyCube partner organisation. The process was documented in a standard format to make the gradual reduction of relevant studies transparent.

The main databases used to search for driver distraction risk factors were the following: Scopus, TRID, Google Scholar, Science Direct, Taylor & Francis Online, Springer Link.

The aim was to find studies that provided an estimate of the risk of being in a crash due to the presence of the risk factor. Therefore, studies considering crash data were designated the most important. However, while the actual occurrence of crashes can be seen as the ultimate outcome measure for road safety, SPIs have in recent years been taken into consideration to quantify the road safety level (Gitelman et al., 2014). SPIs include driving behaviour, like speed choice and lane positioning. These metrics give an indication of safe (or unsafe) driving behaviour. The SPI variables included for analysis are those for which there is some scientific evidence of an association with increased crash risk. For some risk factors, studies considering SPIs are included in addition to those focusing directly on crashes. However, where possible, the selected studies for coding all contained crash data.

Since the study design and the outcome variables are just basic criteria, for some risk factors the literature search had the potential to yield an excessive number of related studies and therefore additional selection criteria were adopted. Furthermore, on major and well-studied driver distraction risk factors, meta-analyses were available and the results of these were identified and incorporated. While the aim was to include as many studies as possible for as many risk factors as possible, it was simply not feasible, given the scope and resources of the project, to examine all available studies for all risk factors and their variants. The general criteria for prioritizing studies to be selected for further analysis and eventual inclusion in the DSS were based on the following guideline:

- Key meta-analyses (studies already included in the key meta-analysis were excluded)
- Most recent studies
- High quality of studies
- Country origin: Europe before North America/Australasia before other countries
- Importance: number of citations
- Language: English
- Peer reviewed journals

According to the level of detail of the topic and the history of research in the field, the exact approach to prioritisation and number of studies that were eligible for 'coding' varied. Another noteworthy point is that studies were included that examine several distraction aspects simultaneously, and thus offers insight and codeable information to many specific risk factors. An example of this is a study by Landsown (2012), which examined the distraction impacts of two types of cellphone use (handheld and texting), music & entertainment systems, operating devices, conversation with passengers and others.

A challenge within the task of identifying studies to be included in the repository of risk factor studies was to distinguish between risk factors and countermeasures. For example, studies dealing with the absence of a safety barrier may be designed to record e.g. crashes before and after the installation of a safety barrier. Although dealing with a risk factor, these studies describe effects resulting from the treatment of a risk factor/application of a remedial measure. Such studies will be coded and considered within the subsequent measures analysis of SafetyCube activities.

2.3.2. Study Coding and Quality Control

Within the aim of creating a data-base of crash risk estimates related to driver distraction risk factors, a template was developed to capture relevant information from each study in a manner that this information could be uniformly reported and shared across topics within the overall SafetyCube project. Guidelines were also made available for the task of coding with detailed instructions on how to use the template. The coding template was designed to accommodate the variety and complexity of different study designs. At the same time its complexity required partners to learn how to use it. For each study the following information was coded and will ultimately be presented in the DSS:

- Road system element (Road User, Infrastructure, Vehicle) and level of taxonomy so that users of the DSS will be able to find information on topics they are interested in.
- Basic information of the study (title, author, year, source, origin, abstract)

- Road user group examined
- Study design
- Measures of exposure to the risk factor
- Measures of outcome (e.g. number of injury crashes)
- Type of effects (within SafetyCube this refers to the numerical and statistical details of a given study in a manner to quantify a particular association between exposure (either to a risk factor or a countermeasure) and a road safety outcome)
- Effects (including corresponding measures e.g. confidence intervals)
- Limitations
- Summary of the information relevant to SafetyCube (this may be different from the original study abstract).

For the full list of information provided per study see Martensen et al. (2017). Completed coding files (one per study) were uploaded to a relational database which serves as the back-end of the DSS.

2.3.3. Synopses and ranking of risk factors

The syntheses of studies for each topic were made available in the form of a summary, termed 'synopsis', indicating the main findings for a particular risk factor derived from meta-analyses or another type of comprehensive synthesis of the results (e.g. vote-count analysis or review type analysis), according to the guidelines and templates available in Martensen et al. (2016).

In general, synopses were created on different levels of the risk factor taxonomy, dependent on the availability of studies for a certain topic. The synopses contain context information for each risk factor from the literature that could not be coded (e.g. literature reviews or qualitative studies). However, not all the coded studies that will populate the DSS are included in the analysis of the synopsis. For some risk factors it was possible to code only a few studies which will be included in the DSS but there was not enough information to write a synopsis.

The synopses aim to facilitate different end users: decision-makers looking for global estimates vs. scientific users interested in result and methodological details. Therefore, they contain sections for different end user groups that can be read independently. The structure of each risk factor synopsis, including the corresponding sub items (uniform for human, vehicle, and infrastructure related risk factors), is as follows (It should be noted that slight differences occur between synopses due to the variability in information from the literature):

- Summary: Abstract, Overview of effects, Analysis methods
- Scientific overview: Short synthesis of the literature, Overview of the available studies, Description of the analysis methods, Analysis of the effects (meta-analysis, other type of comprehensive synthesis like vote-count table or review-type analysis)
- Supporting documents: Details of literature search, Comparison of available studies in detail (optional)

The final step for each synopsis that was compiled was the ranking of risk factors and for that purpose a colour code scale was created, as described in the following. The colour code indicates how important this risk factor is in terms of the amount of evidence demonstrating its impact on road safety as regards increasing crash risk, frequency or severity:

- Red: Risky. Consistent results showing an increased risk of crashes or injuries when exposed to this risk factor.
- Yellow: Probably risky. Some evidence that there is increased risk when exposed to this risk factor, but results are not consistent. This could be because while the majority of studies demonstrate a risk, there may be some studies with inconsistent results. Or, studies indicate a risk but are few in number or have methodological weakness.
- Grey: Unclear. Studies report opposite effects. There are few studies with inconsistent results, few studies with weak indication or risk.
- Green. Probably not risky. Studies consistently demonstrate that this risk factor is not associated with increased crash risk, frequency or severity.

3. *Results and discussion*

3.1. Quantitative review

In total, more than 37 studies on driver distraction related risk factors have been coded, providing 78 instances of input for the examined risk factors – as explained before, studies can provide information for several risk factors. Ultimately 8 synopses have been authored for inclusion in the DSS, namely by merging the three distraction factors concerning outside vehicle subtopics and deciding to only include the topic of animal, insect and similar relevant distractions in the DSS on a coded study level.

A detailed assessment of distraction related road safety risk factors is presented in Table 2. Results are separated for each factor, with some studies being repeated when they have input for multiple instances. From the quantitative review of studies it readily becomes apparent that most distraction activities are detrimental to a numerous road safety indicators and outcomes, from the more straightforward (crash count and risk, and injury severity risk) to the more indirect (reaction times and lane keeping/tracking). These findings correspond to the general consensus of the literature and stand to reason as well.

3.2. Meta-analyses for specific distraction risk factors

Some of the studies that were included only conducted descriptive statistical analyses, therefore it was not possible to determine the exact impact of the various distraction factors at first. Those studies formed the database, however, for the meta-analyses which follow.

The process to ascertain that a meta-analysis is feasible for a risk factor was established and followed for all risk factors. After the results of the coded templates were reviewed together, the following criteria were examined:

- A minimum required number of studies is required (3 in particular).
- Studies used the same methodology (absolute proportion of accidents) are essential.
- The sampling frames for the studies have to be similar.

The available studies that were located allowed for the meta-analytic investigation of the absolute proportions of crashes for the factors of operating devices (IVIS etc.) and conversation with passengers. In the second instance it was also possible to conduct separate analyses for all passengers and adults only (excluding adolescents and children), granting additional insights.

Table 2: *Overview of driver distraction related problems and associated outcomes*

Risk factor		Studies analysed	Outcome																						Quantitative estimate					
			Attention reduction	Braking distance/performance	Crash count	Crash risk	Crash and near-crash risk	Detection distance	Eye movements/Eyes-off-road time	Fatigue	Headway	Injury severity	Lane changing times	Lane keeping/Tracking	Most distracting activity	Overall safety level reduction	Reaction/response/movement time	Reckless behaviour	Signal use	Speed	Speed variance	Speed limit/Sign violations	Tailgating times	Traffic controls use	Difference/Count/Frequency	Absolute proportion	Correlation coefficient	Odds ratio	Relative risk	Slope
Cellphone use - handheld	1	Backer-Grøndahl and Sagberg, 2011				—*																							▪	
	2	Belligner et al., 2009															↑*								▪					
	3	Caird et al., 2008															↑			↑							▪			
	4	Consiglio et al., 2003															↑								▪					
	5	Dingus et al., 2016				↑																						▪		
	6	Donmez and Liu, 2015										↑*																▪		
	7	Elvik, 2011				↑*																						▪		
	8	Fitch et al., 2015							↑*																	▪				
	9	Horrey and Wickens, 2006												↑		↑	—										▪			
	10	Klauer et al., 2014					↑*																					▪		
	11	Lansdown, 2015					—																			▪				
	12	Simmons et al., 2016					↑*																					▪		
	13	Wang et al., 1996			—*																					▪				
Cellphone use - hands-free	1	Backer-Grøndahl and Sagberg, 2011				—*																							▪	
	2	Caird et al., 2008									—			—			↑			—							▪			
	3	Consiglio et al., 2003															↑								▪					
	4	Elvik, 2011				↑*																						▪		
	5	Fitch et al., 2015							—*																	▪				
	6	Horberry et al., 2006																		↑	↑				▪					
	7	Horrey and Wickens, 2006												↑		↑	↑										▪			
	8	Hunton and Rose, 2005			↑*																					▪				
	9	Kass et al., 2007			↑*																	↑			▪					
Cellphone use - texting	1	Caird et al., 2014			↑				↑*		↑			↑			↑*			↑		↑					▪			
	2	Dingus et al., 2016				↑																						▪		
	3	Donmez and Liu, 2015										↑																▪		
	4	Fitch et al., 2015							↑*																	▪				
	5	Lansdown, 2015					—*																			▪				
	6	Rumschlag et al., 2015												—*											▪	▪				▪
	7	Simmons et al., 2016					↑																					▪		
	8	Wang et al., 1996			—																					▪				
Music - Entertainment System	1	Belligner et al., 2009															—*								▪					
	2	Brodsky and Slor, 2013	—				—*		↑*	↓	—			↑					—		—			↓	▪					
	3	Consiglio et al., 2003															—*								▪					
	4	Hatfield and Chamberlain, 2008					—*							—*						—*	—*	—*			▪					
	5	Horberry et al., 2006																		↑		↑			▪					
	6	Lansdown, 2015					—																			▪				
	7	Young et al., 2012							↑		↑			↑											▪					
Operating devices	1	Dingus et al., 2016				↑																						▪		
	2	Lansdown, 2015					—																			▪				
	3	McEvoy et al., 2007				—																				▪				
	4	Neyens and Boyle, 2008										↓																		▪
	5	Reyes and Lee, 2008							↑								↑								▪					
	6	Wang et al., 1996			—																					▪				
Conversation with passenger	1	Consiglio et al., 2003																		↑					▪					
	2	Dingus et al., 2016				↑																						▪		
	3	Donmez and Liu, 2015										↑*																▪		
	4	Fu et al., 2015																				↑*								▪
	5	Lansdown, 2015					—																			▪				
	6	McEvoy et al., 2007				—																				▪				
	7	Neyens and Boyle, 2008										↑																		▪
	8	Sullman, 2012													↑											▪				
	9	Wang et al., 1996			—																					▪				
Outside vehicle factors [Static objects]	1	Bendak and Al-Saleh, 2010												↑				↑	—			—	—		▪					
	2	Edquist et al., 2011											↑														▪			
	3	Klauer et al., 2014					↑*																					▪		
	4	Terry et al., 2008		↑*						↑	—						↑								▪					
	5	Yannis et al., 2011			—																						▪			
	6	Young et al., 2019							↑				↑	—			—								▪					
Outside vehicle factors [Sun, vehicle lights]	7	Mitra, 2014			↑*																							▪		
	8	Mitra and Washington, 2012			↑																									▪
	9	Theeuwes et al., 2002						↑												↑					▪					
Outside vehicle factors [Watching persons]	10	Donmez and Liu, 2015										↑*																▪		
	11	McEvoy et al., 2007				—																				▪				
	12	Wang et al., 1996			—																					▪				
State of mind/cognitive lo [Inattention]	1	Donmez and Liu, 2015										↑*																▪		
	2	Fu et al., 2015																				—								▪
	3	McEvoy et al., 2007				—																				▪				
	4	Neyens and Boyle, 2008			—																					▪				
	5	Wang et al., 1996			—																					▪				
State of mind/cognitive lo [Cognitive overload]	6	Berthie et al., 2015	↑															↑								▪				
	7	Faure et al., 2016							↑*																▪					
	8	Harbluk et al., 2007		↑					↑*							↑*		↑*				↑			▪					

Key: ↑ negative effect on road safety; - not significant; ↓ positive effect

Note: An asterisk (*) denotes that the outcome is the most predominant from a number of relevant outcomes

The statistical analyses were conducted as per the methodology described in a relevant study (Viechtbauer, 2010). The number of crashes due to every risk factor as well as the total number of crashes had to be defined for each study. Then, the estimate and the variance of the raw proportion was estimated for each study. For every meta-analysis the Q test was conducted to determine the importance of heterogeneity among the true effects of the sample, and according to its results, the type of meta-analysis was determined: random effects or fixed effects. Funnel plots were also produced to detect potential publication bias, in which case there would be a need for correcting the estimates. The numerical results of the meta-analyses are shown on Table 3 which follows:

Table 3: *Meta-analyses results for operating devices and conversation with passengers*

Number	Variable	Estimate	Std. Error	p-value	95% CI
1	Proportion of crashes due to operating devices (IVIS, navigation devices, etc.)	0.0107	0.0045	0.0186	(0.0018, 0.0195)
2	Proportion of crashes due to conversation with passengers - all passengers	0.0437	0.0258	0.0907	(-0.0069, 0.0943)
3	Proportion of crashes due to conversation with passengers - adult passengers only	0.0746	0.0343	0.0294	(0.0075, 0.1418)

The analyses show that when synthesizing different study outcomes, about 4.4% of driver distraction related crashes occur due to conversation and interaction with all categories of passengers. Interestingly, when considering adult passengers only, this percentage rises to 7.5%, suggesting that adults are more demanding in cognitive effort in order for the driver to keep up while engaged in conversation. Moreover, about 1.1% of driver distraction related crashes occur due to operating devices (such as IVIS, navigation devices, etc.), which suggests a very modest impact of this risk factor overall.

For all three instances of the examined risk factors, the Q test was significant, suggesting considerable heterogeneity among the true effects. Therefore, the random effects meta-analysis is preferred and there was no need to perform a fixed effects meta-analysis. Similarly, the funnel plots appeared to be symmetric suggesting that there is no evidence for publication bias, and therefore there was no need to correct the estimates.

3.3. Classification and interpretation of results

Table 4 presents the risk factors separated by colour code. In total, the three cellphone-related risk factors were given the colour Red, indicating that there is consistent evidence that these risk factors have an overtly negative effect on road safety in terms of increasing crash risk, frequency or severity. The specific risk factors in the red category demonstrate that the greatest driver distraction related risk stems from using cellphones in one form or another. This is a finding consistent with international research so far, and it is important as it offers insight and perspective into designing and prioritizing the countermeasures for driver distraction.

A further three risk factors were considered to be Yellow, demonstrating some evidence of negative impact to road safety, however, problems of weak findings, inconsistency between studies or few studies means that the evidence for risk was not considered sufficient to be coded Red. It is very likely that these are risky but at the moment not enough research of high quality has been conducted to confirm this. This likely indicates a need for more in-depth and broader analyses to capture the precise effects of those topics and reach a decision on their degree of impact on road safety, but it can be reasonably claimed that this impact is detrimental.

The final two risk factors were considered to be Grey indicating that there was not enough evidence to draw a clear conclusion about their impact on road safety. This represents a gap in road safety scientific literature, and it would definitely be beneficial for future research to consider addressing each of these factors. This demonstrates that the scientific literature is not currently meeting all the needs of road safety stakeholders for evidence-base.

***Table 4:** Driver distraction related risk factors ranking by colour code*

Red (Risky)	Yellow (Probably risky)	Grey (Unclear)
! Cellphone use (hand held)	! Conversation with passengers	? Music – entertainment systems
! Cellphone use (hands free)	! Cognitive overload and Inattention	? Operating devices
! Cellphone use (texting)	! Outside Vehicle Factors (Watching persons, Static objects, Sun/other vehicles' lights)	

4. *Conclusions and next steps*

The present paper describes the identification and evaluation of driver distraction related risk factors. It outlines the related results of the SafetyCube project, which aimed to identify and evaluate those risk factors, amongst others, and related road safety problems by (i) presenting a taxonomy of driver distraction related risks, (ii) identifying topics of concern for relevant stakeholders and (iii) evaluating the relative importance for road safety outcomes (crash risk, injury severity, behavioural variables etc.) within the scientific literature for each identified risk factor. To help achieve this, this research initially exploited current knowledge (e.g. existing studies) and, where possible, existing accident data (macroscopic and in-depth) in order to identify and rank risk factors related to driver distraction.

In order to develop a comprehensive taxonomy of driver distraction related risks, an overview of distraction safety across Europe was undertaken to identify the main types of related risks using key resources and publications. To evaluate the scientific literature, a SafetyCube methodology was developed and applied to driver distraction risk factors. This uniformed approach facilitated systematic searching of the scientific literature and consistent evaluation of the evidence for each risk factor. It also allowed for a consistent and evidence-based ranking of the examined distraction risk factors, on the basis of a dedicated ‘colour-code’ scale.

In total, three risk factors were given a Red code (all types of cellphone use), another three were given a Yellow code (e.g. conversation with passengers and cognitive overload and inattention) and two were given a Grey code (e.g. music and operating devices).

Apart from the previous analyses, the possibility of performing a meta-analysis was examined for all risk factors using a set of qualitative and quantitative criteria for the identified studies. After this process was completed, it was possible to conduct two meta-analyses on the distraction risk factors of conversation with passengers and operating devices. The meta-analyses concerned the absolute proportions of crashes that occur due to drivers being engaged with these risk factors. Findings include that about 4.4% of driver distraction related crashes occur due to conversation with passengers, and, when considering adult passengers only, this percentage rises to 7.5%. Furthermore, only about 1.1% of driver distraction related crashes occur due to operating devices, which indicates their lesser impact.

The limitations of this work should be noted. The process of allocating colour codes was related to both the magnitude of risk observed and the level of evidence for this. It is possible for a risk factor with a yellow colour code to have a greater impact on road safety (e.g. increased severity of crashes) than a risk factor coded red, if there was limited evidence of its risk. Because of this it is important to recognise that road safety benefits may be expected from implementing measures to mitigate any red or yellow coded driver distraction risks.

Findings are limited both by the implemented literature search strategy and the quality of the studies identified. The common approach using the TRID search database was adopted since this is a rich source of information for research into the relationship between driver distraction and crashes/safety. However, TRID is an American database which may have artificially increased the number of American studies reviewed. Nevertheless, the studies identified were of sufficiently high quality to inform understanding of the risk factor.

Due to resource constraints, prioritising of study coding was necessary for risk factors with many identified studies. Across all risk factors, priority was given to studies which considered crashes over changes in driving behaviour or effects of safety performance indicators such as speed. This approach focused on studies with the highest methodological quality, however, it is possible that some detail of level of risk may have been missed by failure to consider a broad range of methodological approaches. Finally, within the considered literature, crash risk and crash frequency are much more commonly studied than crash severity. For some risk factors this makes it difficult (or impossible) to consider the implications for injury causation.

The coded studies and synopses for the driver distraction risk factors will be accessible to the users of the DSS; pilot operation is expected to start mid-2017, and full operation mid-2018 (end of the SafetyCube project). The next task of SafetyCube is to identify measures that will counter the identified risk factors. Priority will be placed on investigating measures aimed to mitigate the risk factors identified as Red. The priority of risk factors in the Yellow category will depend on why they were assigned to this category and whether or not they are an important topic. Overall, the final DSS will support evidence-based policy making. When deciding how to allocate limited resources for improving road safety, the DSS will increase awareness of the relative evidence for risk of each factor and therefore assist in decision making.

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