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Comparative assessment and ranking of infrastructure related crash risk factors

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Abstract

The objective of this study is the comparative assessment and review of infrastructure related risk factors with the explicit purpose of ranking them based on how detrimental they are towards road safety (i.e. crash risk, frequency and severity). This evaluation was conducted by examining studies from the existing literature. These were selected and analysed using a specifically designed common methodology. All risk factors to be analysed were structured in a taxonomy. The infrastructure risk factors covered 10 areas with several risk factors in each area (59 risk factors in total), examples include: alignment features (e.g. horizontal-vertical alignment deficiencies), cross-section characteristics (e.g. superelevation, lane, median and shoulder deficiencies), road surface deficiencies, workzones, junction deficiencies (interchange and at-grade) etc. Consultation with infrastructure stakeholders (international organisations, road authorities, etc.) took place in dedicated workshops to identify user needs for the DSS, as well as topics of particular importance. The following analysis methodology was applied to each infrastructure risk factor:i) A search for relevant international literature, ii)Selection of studies on the basis of rigorous criteria, iii) Analysis of studies in terms of design, methods and limitations, iv) Synthesis of findings - and meta-analysis, when feasible. More than 270 high quality studies were selected and analysed. In total, 6 original meta-analyses were carried out, as well as 31 other syntheses. This allowed the ranking of infrastructure related risk factors into three groups: risky (8 risk factors), probably risky (21 risk factors), and unclear (7 risk factors).

Objectives

- This study **aims to assess** and review infrastructure risk factors
- Explicit purpose is to **rank** them based on their impacts towards road safety
- The analysis was carried out within the **SafetyCube** project, which aims to **identify and quantify** the **effects of risk factors and measures** related to behaviour, infrastructure or vehicle, and **integrate** the results in an **innovative road safety Decision Support System** (DSS).

Methodology

- Consultation with stakeholders were carried out to identify user needs from the DSS and **"hot topics"** in the field of infrastructure safety.
- Studies were selected and analyzed in a **taxonomy**, to systematically classify areas and topics to be analyzed
- Literature search process and study identification and coding tools were developed
- Studies published in scientific journals were **prioritized** over conferences over grey literature.
- **Specific criteria** were set and followed:
  i. Study year: 1990 or newer
  ii. Good overall quality
  iii. Verification and transferability of results
  iv. Existing meta-analyses prioritized at all times.
- **Analysis** of studies in terms of design, methods and limitations
- **Aiming for synthesis** of findings & conducting meta-analysis when feasible.
- If not, **vote count** analysis is conducted, or **qualitative** (review type) analysis otherwise

Identification of "hot topics" by road infrastructure stakeholders

A. Urban road safety (detailed ranking was not possible)	**B. Self-explaining and forgiving roads**	**C. Road safety management**	**D. ITS applications**
1.Pedestrians / cyclists	1.Removing obstacles	1.Quality of measures implementation	1.ISA
2.Upgrade of crossings	2.Introduce shoulder	2.Appropriate speed limits	2.Dynamic speed warning
3.New crossings	3.Alignment (horizontal / vertical)	3.Enforcement	3.ADAS and active safety with V2I
4.Junctions / roundabouts treatments for VRU	4.Sight distance	4.Availability of cost-effectiveness data	4.Implementation of VMS
5.Visibility	5.Traffic signs 6.Raised crossings / intersections	5.Workzones	

Study Elements analyzed

- Road system **element** (Road User, Infrastructure, Vehicle) and **level of taxonomy** so that users of the DSS will find information they are interested in
- Basic **information of the study** (title, author, year, source, origin, abstract)
- **Road user** group examined
- Study **design** / Limitations
- Measures of **exposure** to the risk factor - Measures of **outcome** (e.g. number of injury crashes)
- **Type of effects** (quantified exposure - to a risk factor or a measure - and road safety outcome)
- Statistical **effects** (including corresponding measures e.g. confidence intervals)
- **Summary** of information relevant to SafetyCube (may be different from original abstract)

Results from Studies analyzed

- More than **270 studies** on infrastructure related risk factors have been coded
- Approximately **3500 effects** were found for the examined risk factors
- **37 synopses** have been authored for inclusion in the DSS (including **5 original meta-analyses**) (some of the original 50 topics factors were merged)
- **Many different outcomes** were observed from identified studies
- Most risk factors are detrimental to road safety - crash indicator figures

Results – Ranking of Infrastructure Risk Factors

Red (Risky)	Yellow (Probably risky)	Grey (Unclear)
! Effect of Traffic Volume on safety	! Occurrence of Secondary crashes	? Congestion as a risk factor
! Risks associated with Traffic Composition	! Absence of Transition curves	? Risks associated with the distribution of traffic flow over arms at junctions
! Road Surface - Inadequate Friction	! Risk of Different Road Types	? Adverse weather - Frost and snow
! Workzone length	! Adverse weather - Rain	? Workzone duration
! Low Curve Radius	! Poor Visibility - Darkness	? Frequent curves
! Number of Lanes	! Superelevation	? Densely spaced junctions
! Absence of paved shoulders	! High grade	? Acceleration / deceleration lane length
! Narrow Shoulders	! Presence of Tunnels	
	! Narrow lanes	
	! Undivided road	
	! Narrow median	
	! Risks associated with Safety Barriers and Obstacles	
	! Sight Obstructions (Landscape, Obstacles and Vegetation)	
	! Ramp Length	
	! At-grade junctions - Number of conflict points	
	! Risk of different junction types	
	! Skewness / Junction angle	
	! At-grade junctions - Poor sight distance	
	! At-grade junctions - Gradient	
	! Uncontrolled rail-road crossing	
	! Poor junction readability - Absence of road markings and crosswalks	
	! Poor junction readability - Uncontrolled junction	

Results – Crash Indicators of Infrastructure Risk Factors

Infrastructure Element	Specific Risk Factor	Colour code	Crash risk	Crash frequency	Crash severity	Hot topic (Yes/No)
Exposure	Effect of Traffic Volume on safety	Red	↓	↑	-	N
	Risks associated with Traffic Composition	Red	↓	↑	-	N
	Occurrence of Secondary crashes	Yellow	↑	-	-	N
	Congestion as a risk factor	Grey	-	↑	-	N
	Risks associated with distribution of traffic flow over arms at junctions	Grey	-	-	↑	N
Road Surface	Inadequate Friction	Red	↑	-	↑	N
Road Type	Risk of Different Road Types	Yellow	-	↑	↑	N
Road environment	Adverse weather - Rain	Yellow	-	↑	-	N
	Adverse weather - Frost and Snow	Grey	-	-	-	N
	Poor Visibility - Darkness	Yellow	↑	-	↑	N
Presence of workzones	Workzone Length	Red	↑	↑	-	Y
	Workzone Duration	Grey	-	-	-	Y
Alignment - Road Segments	Low Curve Radius	Red	-	↑	↑	Y
	Absence of transition curves	Yellow	↑	-	-	Y
	High Grade	Yellow	-	↑	↑	Y
	Presence of Tunnels	Yellow	-	↑	↑	Y
	Frequent curves	Grey	-	-	-	Y
	Densely spaced junctions	Grey	-	-	-	Y
Cross-Section - Road Segments	Number of lanes	Red	-	↑	↑	N
	Absence of paved shoulders	Red	-	↑	-	Y
	Narrow shoulders	Red	-	↑	-	Y
	Narrow lanes	Yellow	-	↑	-	N
	Undivided Road	Yellow	-	-	↑	N
	Narrow Median	Yellow	-	↑	↑	N
	Risks associated with safety barriers and obstacles	Yellow	-	↑	↑	Y
	Sight obstructions (Landscape, Obstacles and Vegetation)	Yellow	-	-	-	Y
	Superelevation	Yellow	↑	↑	-	N
Alignment - Junctions	Ramp length	Yellow	-	-	↑	N
	At-grade junctions -Number of conflict points	Yellow	-	↑	-	Y
	Risk of different junction types	Yellow	↑	-	↑	Y
	Skewness / junction angle	Yellow	↑	-	↑	Y
	Poor Sight Distance	Yellow	↑	-	-	Y
	Gradient	Yellow	↑	-	↑	N
	Acceleration/Deceleration lane length	Grey	-	-	-	N
Traffic Control - Junctions	Uncontrolled Rail-Road Crossing	Yellow	↑	-	↑	N
	Poor junction readability - absence of road markings and crosswalks	Yellow	-	-	↑	N
	Poor junction readability-Uncontrolled junctions	Yellow	-	↓	↑	N

Conclusions

- **Identification, evaluation and ranking** of infrastructure related risk factors was conducted:
  i. 8 risk factors were given a Red code (consistently risky)
  ii. 20 risk factors were given a Yellow code (probably risky)
  iii. 7 factors were given a Grey code (unclear risk)
- The **greatest risk** is across several aspects of infrastructure design and traffic control
- **4 'hot topics'** were rated risky: 'small work-zone length', 'low curve radius', 'absence of shoulder' and 'narrow shoulder'
- Results of the analysis may be cautiously considered **generally transferable** based on country samples (predominantly European, Australian, and North American studies)

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