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An assessment of the effectiveness of formal tools to address road network deficiencies

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Abstract
Modern road networks are complex systems that not only serve the need for transport of people and goods, but must also meet high standards of safety and reliability. Consequently, several **tools** have been developed to detect and address **road network deficiencies**. These tools include **road safety audits and inspections and high risk sites identification**. While many modernized countries have been implementing them extensively, there is little evidence of the quantitative impacts of those tools, as often these are attributed to secondary measures that occur as a result of their implementation. This research aims to capture the quantitative impacts of these tools and provide a well-rounded approach for road safety stakeholders to use in all stages of road environment management. 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). 9 high quality studies were selected and analyzed for the aforementioned measures. Results indicate that road safety audits and inspections prove **highly beneficial overall** in reducing crashes and crash rates; with a **relevant meta-analysis confirming the results**. Similarly, high risk site identification was found to be **significant in providing crash and injury severity reductions** for the cases they were implemented. These results offer valuable insights that were previously undefined and can be generalized for other cases with caution.

Methodology
- Studies were selected and analyzed in a set **taxonomy** – road safety audits and inspections and high risk sites identification were explicit topics.
- Studies published in scientific journals were **prioritized** over conferences over grey literature.
- **Specific criteria**: Study year: 1990 or newer, good overall quality, verification and transferability of results, existing meta-analyses prioritized at all times.
- **Analysis** of studies in terms of design, methods and limitationss
- **Synthesis** of findings and meta-analysis when feasible

Analysis for high risk site identification
After collectively reviewing the studies, the following points were observed:
- There is an adequate number of **observations**, however:
- The studies have used **different methods** for analysis
- There are **similar indicators** but expressed differently
- The sampling frames were **different, and lacked statistical verification**
- There were **two existing meta-analyses** already included

A new meta-analysis was not appropriate; a review type analysis was selected. The effect of the high risk site treatment measures is given via **qualitative analysis**.

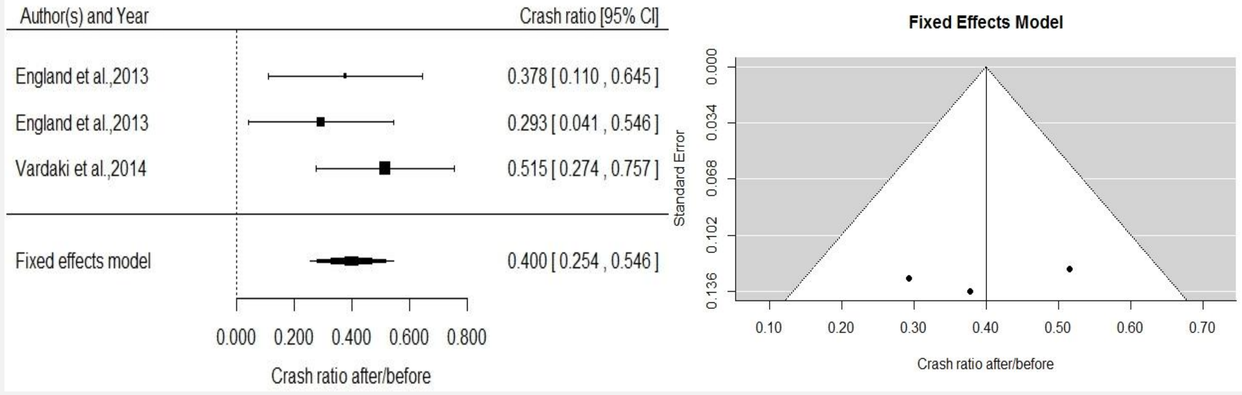
- Injury crash reductions apply across **all segment types,** to isolated road sites and road sections.
- **Crash Modification Factors** (CMFs) are **positive** when examining injury crashes or severe injury only crashes.
- The number of injured road users appears to be **reduced uniformly for all road user groups**, with one exception: a very small increase in the number of injured cyclists for a control group (risk sites treated later than the main test area).
- Crash percentage numbers were found to be reduced for **both urban and rural areas** after implementing high risk site treatment measures, once again indicating their effectiveness.

Results – High risk site identification
- The effects of high risk site identification on road safety are **positive overall**.
- Two existing meta-analyses were examined with several effects: they report statistically **significant reductions in injury crashes** of 28% and 24% to 27%.
- Two other studies report a 15% **reduction in overall crash percentages** or **absolute numbers**: reduction from 16 crashes to no crashes after implementing high risk site treatment.
- These results are statistically verified and support the overall conclusions.

Meta-analysis for road safety audits
After collectively reviewing the studies, the following points were observed:
- There is an adequate number of **observations** (3 reported results in 2 studies)
- Those studies have used **similar methods** for analysis
- There are **similar indicators** (though at times expressed differently)
- The sampling frames seemed to be **compatible**

A meta-analysis was thus conducted: the overall estimate of the raw proportion of crashes after conducting road safety audits compared to the proportion of crashes before conducting road safety audits was investigated. This means that the crash level after the audits was about 40% of what was before, i.e. a **reduction of 60%, which was statistically significant**.

- A funnel plot was also produced in order to detect potential publication bias.
- The plot is symmetrical, suggesting that there is **no strong evidence for publication bias**, which was confirmed numerically as well.



Results – Road safety audits and inspections
- The effects of road safety audits and inspections on road safety tend to be **positive overall**.
- 3 of the examined studies show **uniform reductions** in crash numbers
- 2 studies show crash reduction in most examined cases, with some minor increases in isolated cases.
- Typically, these **increases are in damage crashes rather than injury crashes**; they are effects of crash mitigation.
- All reported secondary measures appeared to have a beneficial effect.
- The **meta-analysis conducted indicates a 60% reduction in the numbers of crashes, after conducting road safety audits in a road segment**.
- Therefore there are potential gains from more widespread use of road safety audits.
- Only one study examining road safety inspections was found – knowledge gap?

Cost-Benefit Analyses
Sample cost-benefit analyses (CBAs) were conducted within the SafetyCube project, to help with the prioritization of measures. Indicative CBA results are provided,
For a period of analysis of 25 years:
- For road safety audits, with an implementation cost of about 3,000€ per site, the **cost-benefit ratio was 4.7** for the EU-28 area.
- For high risk site identification, with an implementation cost of about 21,500€ per site, the **cost-benefit ratio was 1.2** for the EU-28 area.

Note: the above figures concern the application of the formal tools only, not any secondary road safety measures implemented as a result.

Conclusions
- All examined formal tools to address network deficiencies (road safety audits, road safety inspections and high risk site identification) are **beneficial overall** for road safety, reducing crashes and mitigating their consequences.
- They are **non-intrusive processes** – they can improve road sites and networks without disrupting traffic flows (secondary measures that are implemented afterwards may do so).
- The CBAs showcase that the examined tools are **worthwhile and effective measures** that can be prioritized over other road safety interventions with less cost-benefit ratios.

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