9. Traffic safety measures

Introduction

Traffic safety measures (TSMs) are intended to reduce traffic injury frequency and severity. Not all safety measures are effective, and some might even compromise safety despite the good original intentions. Before introducing any measure, it is highly important to consult available TSM catalogues to find the most up-to-date estimates of the effectiveness (and costs). Having a limited budget, the most cost-effective measures should be prioritized for implementation.

Learning outcomes

After completing this module, the students should be able to:

- know and find reliable catalogues of traffic safety measures
- find individual TSMs and their effects in the catalogues
- interpret the documented effects of TSMs
- understand uncertainty related to estimated TSM effects
- understand complexity of estimating combined effects of TSMs
- understand the difference between 'subjectively expected' and 'objective' effects of a TSM and mechanisms explaining the phenomenon
- understand the principles of TSM classification taxonomies
- convert CMF and accident reduction indicators into each other
- classify potential TSM for a given safety problem applying different taxonomies
- using the knowledge from TSM catalogues, estimate the actual accident/injury reduction for a given traffic environment
- apply different TSM classification taxonomies to address a given safety problem and discover 'cells' or 'layers' of a given taxonomy for which no measure is yet applied
- use the knowledge from TSM catalogues to make informed decisions and set priorities among a list of suggested measures based on their effectiveness and cost-effectiveness.

Key messages to learners

- Strictly speaking, there is not much difference between 'accident contributing factors' and 'traffic safety measures'. Both affect the probability (or/and severity) of accidents. Absence of a known measure that reduces accident risk could be seen as an accident contributing factor.
- There are many ways for traffic safety measures to be classified, such as Haddon's matrix (before-during-after accident), active vs. passive vehicle safety features, immediate vs. system-level measures, in relation to the risk-exposure-consequences dimensions, causality chain, time line, etc. Their practical value is in helping to think about 'what else' can be done to address a particular traffic safety problem.
- The Safe System approach encourages to apply multiple protection measures for each safety problem. No single measure cannot guarantee 100% safety, but together they 'support' each other not allowing a situation to develop into fatalities/injuries (Swiss cheese model).

- Effectiveness of a traffic safety measure is often expressed as a ‘crash modification factor (CMF)’, or as a ‘accident frequency reduction in per cent’. These two indicators are easily convertible into each other. The same safety measure usually has different effect on different accident types, severity levels, etc. and might also depend on other conditions (e.g. traffic flow, geometry, etc.). It is more correct to talk about ‘crash modification functions’ that can account for that, but practically we seldom have enough data to develop them.
- There is always an uncertainty involved in estimation of the CMFs. Sometimes it is not possible to say with certainty whether a measure is positive or negative for safety (or have no effect). The priority in implementation should always be given to measures that are certain to have positive safety effects.
- CMFs are usually available for a measure used on its own. Estimation of safety effects for several measures used simultaneously is complex. If an accident is prevented by the first measure, it should not be double-counted as also prevented by the second measure. Therefore, the added safety effect of the second measure will be lower compared to if it was used on its own.
- Quite often, there is a discrepancy in subjective expectation of how a measure will contribute to safety and its actual, objective effect. This can often be attributed to the ‘behavioural adaptation’, i.e. people starting to behave differently (often riskier or less careful) due to the measure presence. Therefore, proper evaluation of measures is very important. Often, the better is the quality of the evaluation study design, the less is the objective safety effect is found.
- The costs of traffic safety measure introduction is another important aspect to consider. With a limited budget for traffic safety improvements, one should start with the most cost-effective measures to ensure the highest return (lives saved per money invested).
- There is a significant bulk of knowledge available with regards to effectiveness (and costs) of various traffic safety measures. Some traffic measure databases/catalogues are provided in the recommended literature section.

Learning activities

Exercise 1

Fill in the Haddon's matrix with at least two examples in each cell for a given traffic safety problem.

Example A: Motorcycle riders are overrepresented in traffic fatalities

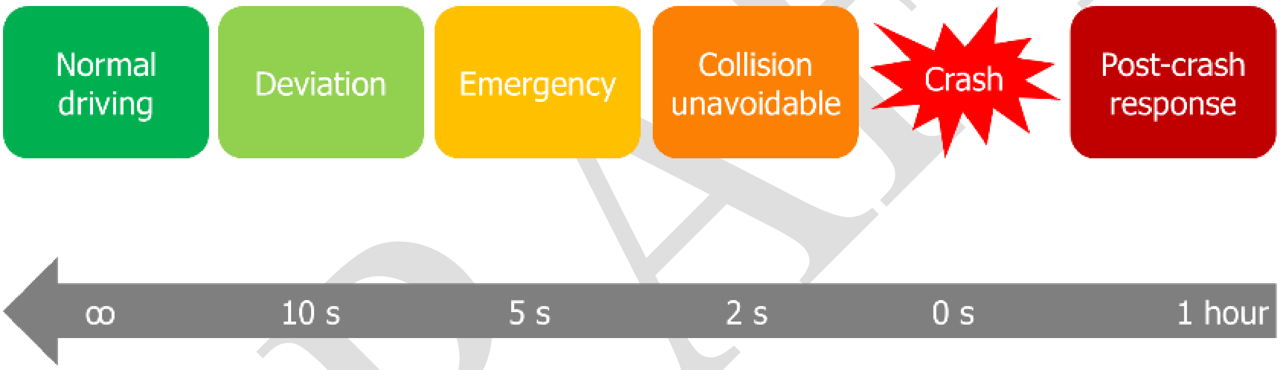
	Pre-crash	During crash	Post-crash
Road user	Proper education and risk awareness Limiting working hours of commercial riders to prevent fatigue	Wear a helmet and protective closing	…
Vehicle	ABS brakes for motorcycles	…	…
Infrastructure	Lower speed limits Improve road friction	…	…

Example B: A particular road section has high number of fatalities occurring at night time, mostly due to single drive-off-road accidents

	Pre-crash	During crash	Post-crash
Road user	Awareness of risks related to driving when fatigued Scheduling rest breaks for commercial drivers	Wearing seat belts	Legal duty to assist when witnessing an accident First medical aid as part of driver curriculum
Vehicle	Fatigue warning system Lane departure warning system	Passive safety features: seatbelts, airbags, etc.	…
Infrastructure	Rumble strips along the road edges	Barriers along trees/large rocks to mitigate the collision severity	…

Exercise 2

For the same traffic safety problem, place the suggested measures on the accident timeline:



Example: A particular road section has high number of fatalities occurring at night time, mostly due to single drive-off-road accidents

Normal driving	Deviation	Emergency	Collision unavoidable	Crash	Post-crash
Fatigue warning system Education about risks related to fatigued driving …	Lane departure warning system …	Rumble strips …	Autonomous braking systems Activation of passive safety features in vehicle …	Passive safety features …	e-Call to emergency services …

Exercise 3

A certain safety measure is expected to reduce drive-off-road accidents in curves by 25%. The road length is 230 km, and the curve frequency is on the average 0.35 per kilometre. In the last three years, 22 curves had one drive-off-road accident, and 13 curves had two accidents. How many accidents can one expect if half of the curves get treated with this measure? How many accidents could one expect if at the same time the traffic flow increases by 15%?

Solution:

The road has $230 \cdot 0.35 = 80$ curves. In the last three years, there were $22 + 13 \cdot 2 = 48$ accidents, which is $48 / 3 = 16$ accidents per year. On the average, the average accident frequency in a curve per year is 16 / 80 = 0.2 (i.e. one accident in five years). Now, half of the curves (80 / 2 = 40) received the treatment, which means that the accident frequency reduced by 25% and became $0.2 \cdot (1 - 0.25) = 0.15$. The other half (40 curves) remained untreated and continued to have 0.2 accidents per year. The new expected number of accidents is $40 \cdot 0.15 + 40 \cdot 0.2 = 14$ accidents. It is a reduction by 2 accidents compared to the original accident number (16).

Finally, the increase in traffic flow will affect both the treated and untreated curves. For simplification, we assume here that accidents are directly proportional to the traffic flow (each vehicle passing a curve has the same chances of getting into a drive-off-road accident). Therefore, the new expected accident number will be $14 \cdot (1 + 0.15) = 16.1$.

Does it mean that the safety measure did nothing for safety? No, the safety has improved. If all curves remained untreated, the new accident number would have been $16 \cdot (1 + 0.15) = 18.5$ accidents.

Exercise 4

Reflect on why the actual safety effects might be different from the intended for the following measures:

- Highly reflective road signs and marking

  Some drivers might increase their speed because of seeing the road better in the darkness.
- A system warning that another car is present in the 'dead zone' of the back mirror

  The driver over-relies on the system and stops turning the head to check him/herself.
- Requirement for drivers to yield at pedestrian crossings

  Pedestrians start to believe that all drivers will stop, while some might fail to notice the pedestrian.
- Resurfacing the road and making lanes wider

  Some drivers might increase their speed and drive more aggressively.
- Training children on how to behave in traffic

  Some parents might expect too much from the children, supervising them less and exposing them to greater risks.

Exercise 5

Use the suggested safety measures catalogues (e.g. SafetyCube DDS) to find whether the following measures are effective to prevent traffic fatalities:

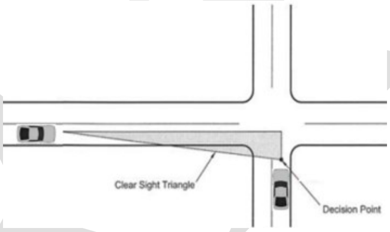
- Installation of road lighting (fatalities in the darkness are reduced by 52%: link)

- Rumble strips at centre line (head-on accidents of all severity levels reduced by 37%: link)

- One-way streets (safety effect is unclear: link)

- Age-based screening of drivers (no or even negative results of introducing age-related limitations for driving found: link)

- Improving sight distance at junctions (reduction in property-damage accidents by 12–16%; reduction is injury accident is not clear: link)



Assessment quiz

The assessment quiz can be used as a part of the examination, or as another form of learning activities.

Question 1

A traffic safety measure affects the probability/severity of accidents, but seldom is able to totally prevent them:

a. Yes (correct)
b. No (incorrect)

Comment (shown after the answer has been given): For example, consider improvement of sight distance at an intersection or increasing road surface friction. While a driver might be able to detect the other vehicles earlier, or to brake more efficiently, it is still possible that he/she will make a mistake (look, but fail to see; start braking, but too late). Thus, while such situations are likely to occur less frequently, the accident probability is still non-zero.

Question 2

The *Handbook of Road Safety Measures* (2009) suggests that speed humps before pedestrian crossings reduce injury accidents by 48% (CI -54%; -42%). This corresponds to a CMF (crash modification factor) of:

a. 1.48 (incorrect)
b. 0.52 (correct)
c. 1.52 (incorrect)
d. 0.48 (incorrect)

Comment (shown after the answer been given): CMF is calculated as a ratio of accidents frequency with and without a measure in place. Thus,

$$CMF = A_{measure} / A_{no\ measure} = [A_{no\ measure} \cdot (1-0.48)] / A_{no\ measure} = 0.52$$

Question 3

Which of the measures would you NOT recommend for immediate implementation (effect estimates are taken from the *Handbook of Road Safety Measures* (2009)):

a. Improvement of the roadside safety, e.g. increasing distance from the road edge to fixed objects: estimated change in injury accidents (-24%; -20%) (incorrect)
b. Raised intersections: estimated change in injury accidents (-34%; +98%) (correct)
c. Traffic safety education of pre-school children: the only two available studies suggest estimated change in accident risk for children who attended the classes (-50%; -3%) and (+39%; +100%) (correct)
d. Ensuring that the minimal tire tread depth is at least 2–3mm: estimated change in injury accidents (-30%; -5%) (incorrect)

Comment (shown after the answer been given): Roadside improvements and control of tires, despite some uncertainty of their accident reduction effects, have clearly positive effects on safety and should be recommended. On the other hand, the effects of raised intersection might be either positive or negative. Similarly, the two studies on pre-school children education give very contradictory results. These two measures should not be recommended—further research is needed to get more certainty of their effects (which might turn out to be negative for safety).

Recommended reading and resources for students

Traffic safety measure catalogues

- SafetyCube Decision Support System: https://www.roadsafety-dss.eu (Open Access)
- CMF Clearinghouse: https://www.cmfclearinghouse.org (Open Access)
- Traffic Safety Handbook online (in Norwegian, but Google Translate works well with it): https://www.tshandbok.no (Open Access)
- Traffic Safety Handbook, paper and pdf versions: https://doi.org/10.1108/9781848552517 (paid access)
- Highway Safety Manual (HSM), First and Second editions, paper and pdf versions: https://www.highwaysafetymanual.org/Pages/default.aspx (paid access)

Recommended (additional) reading for teacher

- Elvik, R., Høye, A., Vaa, T., & Sørensen, M. (2009). The handbook of road safety measures. Emerald Group Publishing Limited. https://doi.org/10.1108/9781848552517 (introduction chapters)
- SUPREME. (2010). Best practices in road safety: Handbook for measures at the country level. European Union. http://www.agendarutiera.ro/Files/_resurse/resurse%20europene/best%20practices%20in%20road%20safety.pdf

- Elvik, R. (2009). An exploratory analysis of models for estimating the combined effects of road safety measures. Accident Analysis & Prevention, 41(4), 876–880. https://doi.org/10.1016/j.aap.2009.05.003
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- Goel, R., Tiwari, G., Varghese, M., Bhalla, K., Agrawal, G., Saini, G., Jha, A., John, D., Saran, A., White, H., & Mohan, D. (2024). Effectiveness of road safety interventions: An evidence and gap map. *Campbell Systematic Reviews*, *20*(1), e1367. https://doi.org/10.1002/cl2.1367
- Godthelp, H., & Ksentini, A. (2024). Specific road safety issues in low- and middle income countries (LMICs): an overview and some illustrative examples. *Traffic Safety Research*, *8*, e000068. https://doi.org/10.55329/sdtu9515
- GRSP, & World Bank. (2021). Guide for road safety interventions: evidence of what works and what does not work. https://openknowledge.worldbank.org/entities/publication/16d7b276-09b1-58f8-94d6-112064b8af5f

Prepared by expert

In case you have specific questions, need a discussion partner, or just want feedback on your lecture materials, you may reach out the author(s) of this module. Please, put 'AfroSAFE curriculum' in the email subject.

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