How do we teach traffic safety?

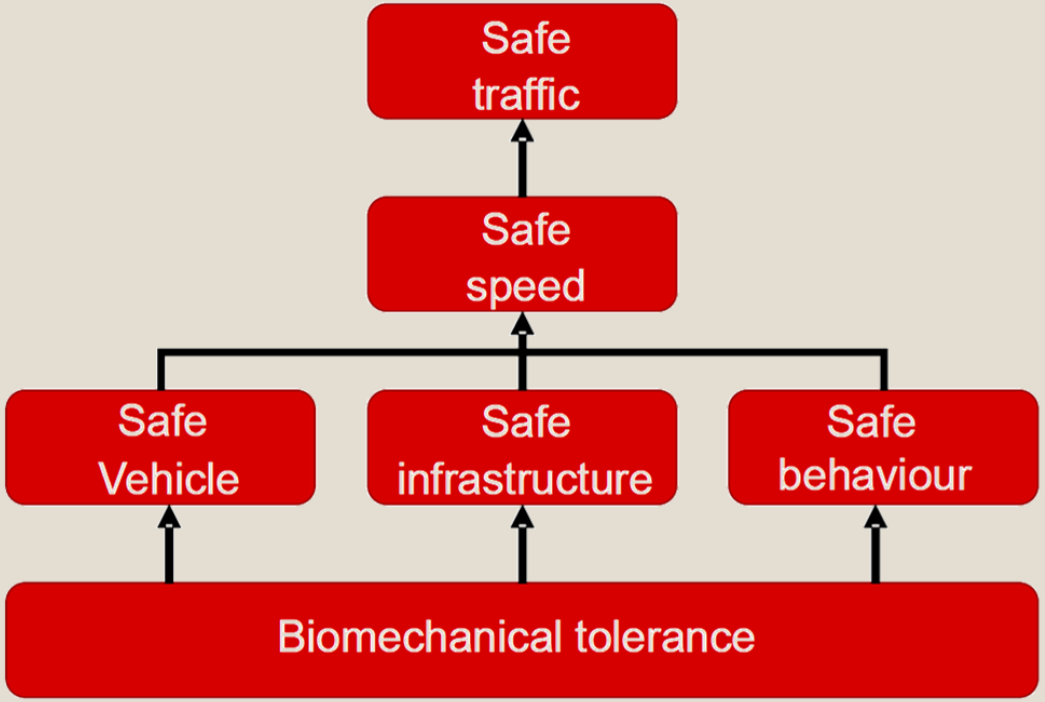
ALIAKSEI LAURESHYN | LUND UNIVERSITY, SWEDEN

...

Why Safe System?

Safe System

Source: FHWA, USA



Source: Trafikverket, Sweden

What you need to know to understand Safe System?

Framing the challenge

Solutions and implementation areas

Perspectives

Cross-border topics

Framing the challenge

Traffic safety—problem scope

Evolution of traffic safety theory and practice

Safe System approach

How to measure traffic safety

Traffic safety data

Why accidents happen?

Accident typology

Injury biomechanics

Solutions and implementation areas

Traffic safety measures: principles

Where traffic safety knowledge comes from?

Pillar 1: Traffic safety management

Pillar 2: Safe speeds

Pillar 3: Safe road users

Pillar 4: Safe vehicles

Pillar 5: Safe infrastructure

Pillar 6: Post-crash care

Perspectives

Traffic safety as part of sustainable development

Meeting preconditions of various groups

Economical aspects of traffic safety

Social aspects of traffic safety

Cross-border topics

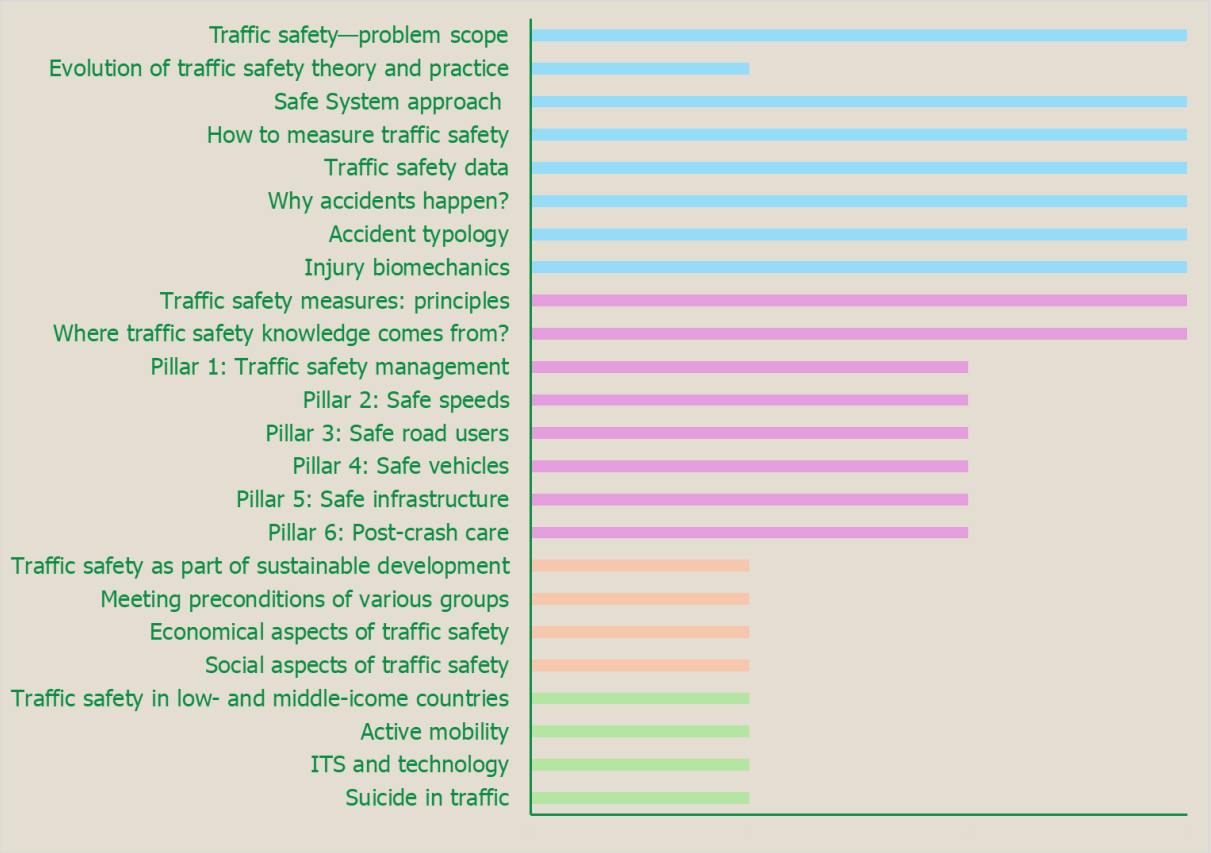
Traffic safety in low- and middle-income countries

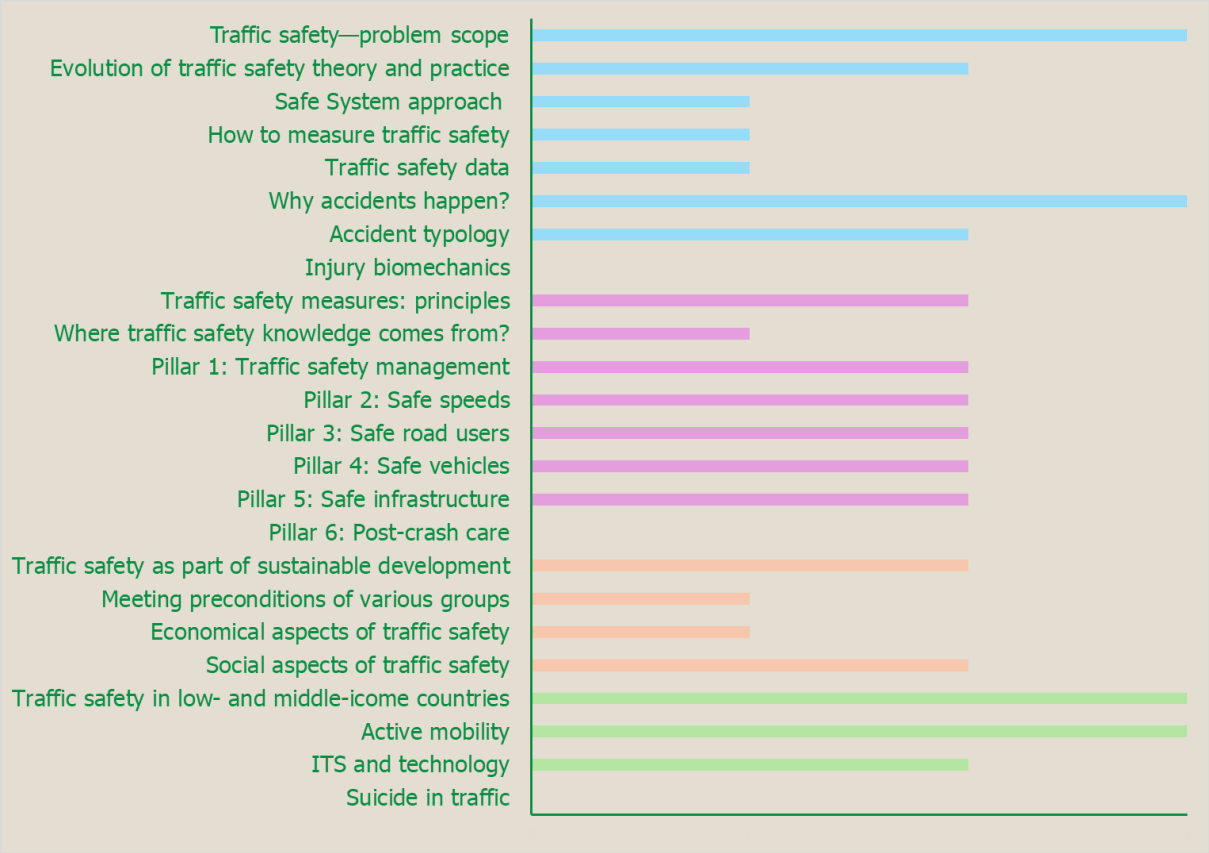
Active mobility

ITS and technology

Suicide in traffic

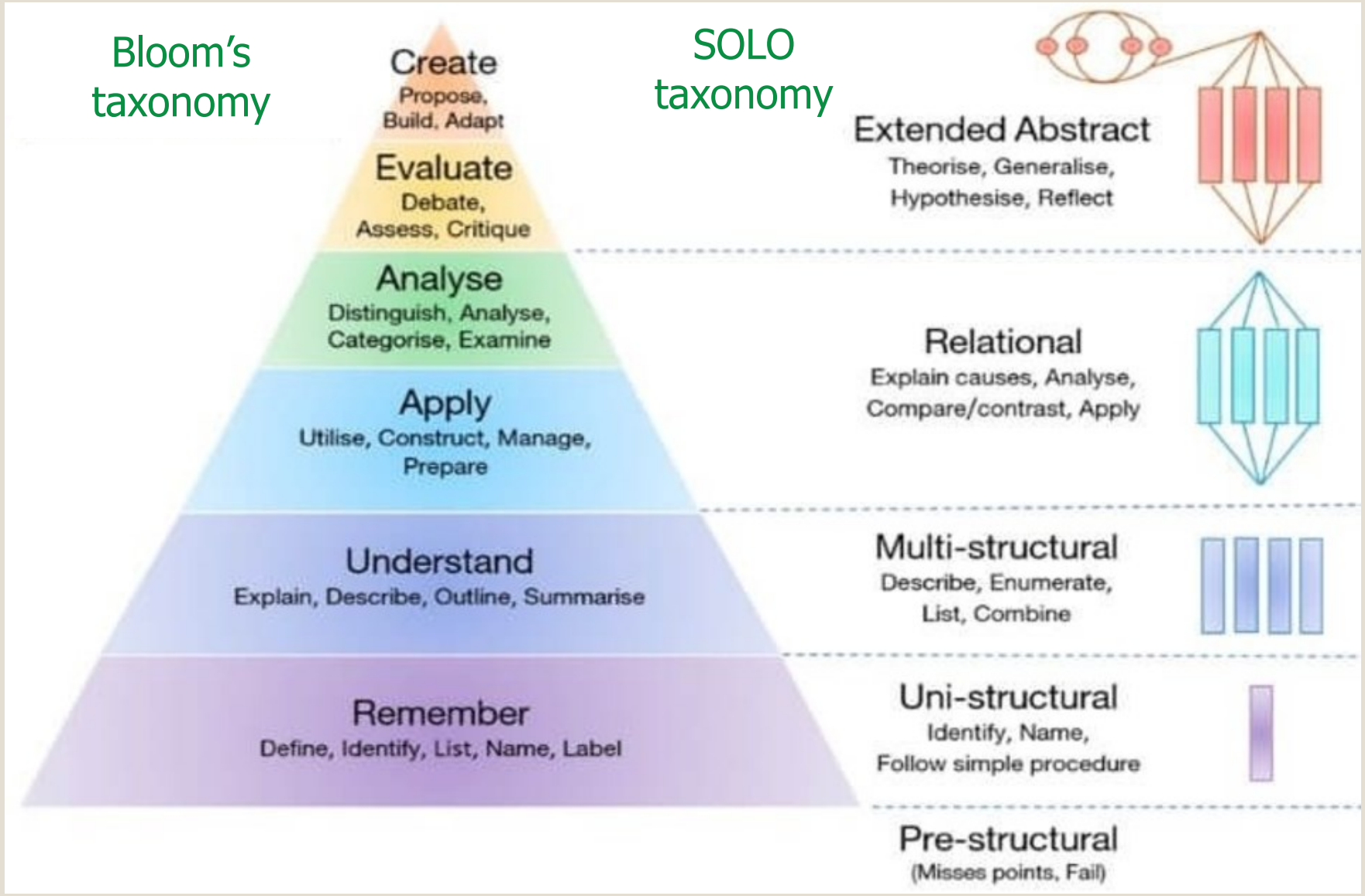
What do we actually teach?


Traffic safety—problem scope
Evolution of traffic safety theory and practice
Safe System approach
How to measure traffic safety
Traffic safety data
Why accidents happen?
Accident typology
Injury biomechanics
Traffic safety measures: principles
Where traffic safety knowledge comes from?
Pillar 1: Traffic safety management
Pillar 2: Safe speeds
Pillar 3: Safe road users
Pillar 4: Safe vehicles
Pillar 5: Safe infrastructure
Pillar 6: Post-crash care
Traffic safety as part of sustainable development
Meeting preconditions of various groups
Economical aspects of traffic safety
Social aspects of traffic safety
Traffic safety in low- and middle-icome countries
Active mobility
ITS and technology
Suicide in traffic

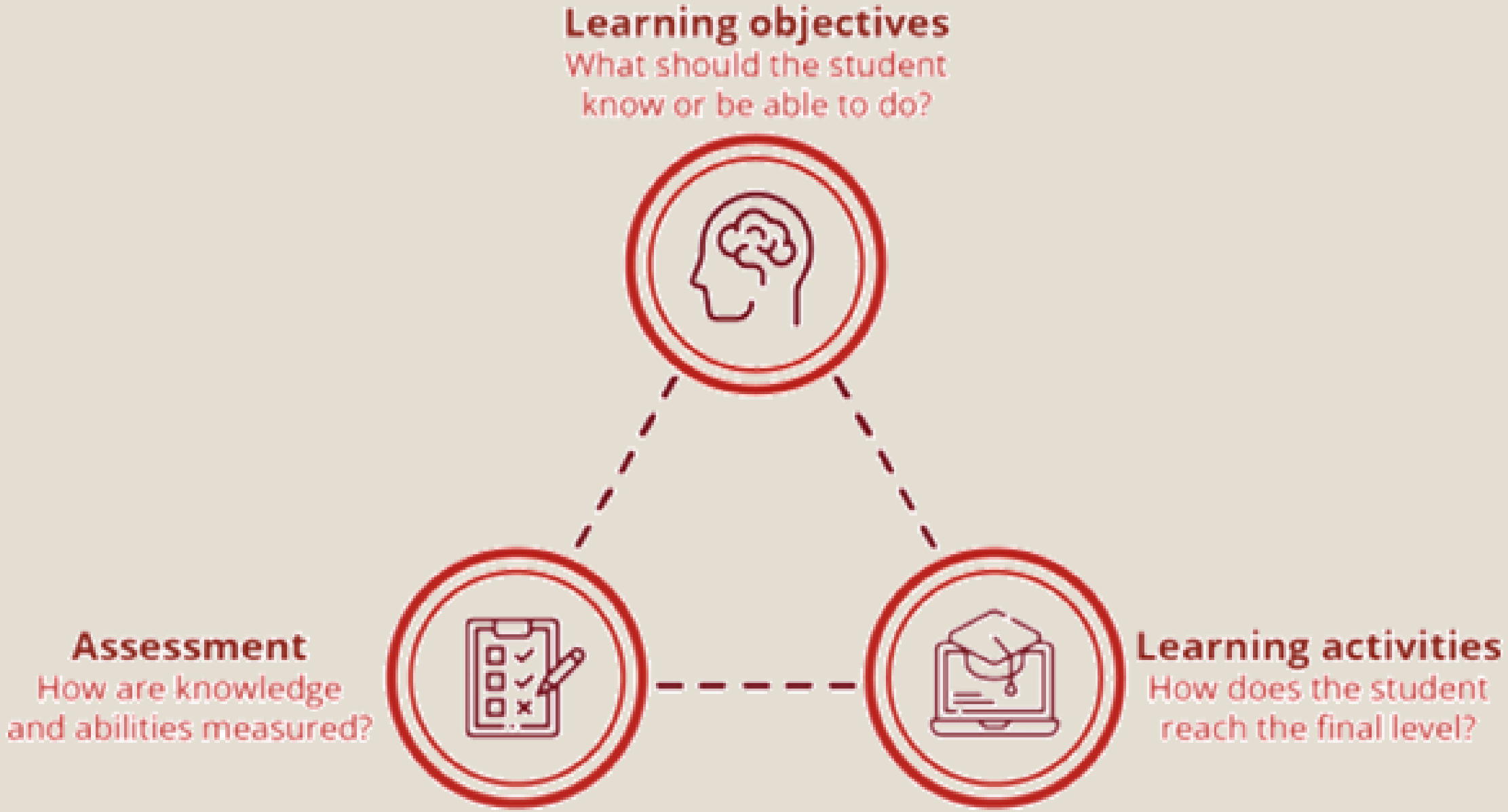

Traffic safety—problem scope
Evolution of traffic safety theory and practice
Safe System approach
How to measure traffic safety
Traffic safety data
Why accidents happen?
Accident typology
Injury biomechanics
Traffic safety measures: principles
Where traffic safety knowledge comes from?
Pillar 1: Traffic safety management
Pillar 2: Safe speeds
Pillar 3: Safe road users
Pillar 4: Safe vehicles
Pillar 5: Safe infrastructure
Pillar 6: Post-crash care
Traffic safety as part of sustainable development
Meeting preconditions of various groups
Economical aspects of traffic safety
Social aspects of traffic safety
Traffic safety in low- and middle-icome countries
Active mobility
ITS and technology
Suicide in traffic

How do you design a course?

What does it mean ‘to know’?



Constructive alignment



Traffic safety curriculum

Framing the challenge

Traffic safety—problem scope	Evolution of traffic safety theory and practice	Safe System approach	How to measure traffic safety	Traffic safety data	Why accidents happen?
Traffic fatalities and injuries statistics, globally	Traffic fatality growth since early motorization	Safe System as a paradigm shift and policy innovation	Official accident definition and its limitations	Police data and under-reporting problem	Swiss cheese model—accidents are VERY rare, many factors need to get together
Traffic fatality risks compared to other transport modes/ risky activities	Evolution of views on accident causality	Main prinicples: - Focus on fatal/severe injuries - Humans make mistakes - Human body fragility / Safe speeds - Humans make mistakes - Multiple protection layers - Shared responsibility - Continuous improvement	Accident counts vs. accident rates What is 'exposure'? How 'denominators' for accident rates tell different stories: - per registered vehicles, km driven, km roads, etc. (always growing) - per population (relatively stable over time)	Other data sources: - Healthcare data - In-depth accident investigations - Self-reporting - Insurance data - Naturalistic studies - Traffic conflict and behavioural observations - Data from autonomous vehicles - Road safety inspections and audits - Safety performance indicators - System descriptors, attitude measurements, etc.	'Legal' (deterministic) and 'probabilistic' definitions of 'cause' (see Elvik 2024, Hauer 2020)
Differences and trends in traffic fatalities—by countries, regions, income, motorization levels, etc.	Evolution of road safety management principles	Evaluations of changes due to shift to Safe System (+ examples of success stories in different contexts)	Difficulties in comparing traffic safety between periods and site (macro and micro-level): - Regression-to-the mean - Non-linearity of accidents-exposure relation		INUS condition (Insufficient, non-redundant, unnecessary, sufficient – see Shadish et al. 2002)
State of road transport system globally—safety-relevant laws, vehicle fleet, travel modes share, post-crash care	Evolution of vehicles, infrastracture and view on human in traffic	Maturity stages in Safe System implementation + integration into sustainability agenda	Accidents by severity levels (fatal, severe/slight injury, PDO)		Fundamental and consistent patterns—'Laws of accident causation' (Elvik 2006)
Case example (country of interest): differences between RU categories, age groups, gender, road types and environment (rural/urban), accident types (incl. single and falls), suicides (if data are available) Inspirational examples (things can be changed!)	Evolution of view on road and street environments—from 'criminalizing walking' to car-free cities		Exposure-risk-consequences as contributors to traffic fatality numbers. Different ways to measure exposure (distance, time, encounters) Considering door-to-door trip (e.g. case of 'safety of bus travelling') More advanced ways to present accident data, 'dimensions' of the traffic safety problems (Elvik 2008)		Causal path analysis and other tools

Traffic safety measures: principles	Where traffic safety knowledge comes from?	Pillar 1: Traffic safety management	Pillar 2: Safe speeds	Pillar 3: Safe road users	Pillar 4: Safe vehicles
Classification of TS measures: - Haddons matrix (before-, during-, post-accident vs. road, vehicle, road user) - Active and passive vehicle safety features - Sequence of events analysis (possible	Quantitative methods: - Experiment studies - Quasi-experiemental and observational studies - before-after vs. cross-sectional studies	How current practices are related to the Safe System 'ideals'?	Effects of speed on safety: - stopping distance - collision speed / injury severity - probability of accidents - probability of severe outcomes (survival	Human factors (errors, lapses, violations)	Car evolution over years

Traffic Safety Measures

Learning outcomes

Based on Bloom's | SOLO taxonomy

After completing this module, the students will be able:

- to **remember** how to find catalogues of traffic safety measures (TSMs) and their known effects;
- to **understand** how the effects of TSMs are measured and uncertainty related to that; how the combined effects of TSMs are estimated; the difference between 'subjectively expected' and 'objective' effects of a TSM and mechanisms explaining the phenomenon;
- to **apply** different TSM classifications to discover additional protection layer that can be added to improve safety;
- to **analyse** …
- to **evaluate** reasonableness of implementation of TSMs based on the available knowledge on their effects;
- to **create** …

Traffic Safety

Learning outcom

Based on Bloom's | S

After completing thi

- to **remember**
  known effect
- to **understan**
  how the com
  'subjectively
  the phenome
- to **apply** diff
  be added to i
- to **analyse** …
- to **evaluate** r
  knowledge o
- to **create** …

Key messages to learn

- Strictly speaking, there is not much difference between 'accident contributing factors' and 'traffic safety measures'. Both affect the probability (or/and severity) of an accident to occur, absence of a measure known to reduce the accident risk could be seen as an accident contributing factor.
- There are several ways traffic safety measures can be classified, such as Haddon matrix (before-during-post crash vs. road-user-vehicle, with variations), Rumar 3D-box (risk-exposure-consequences), in relation to the accident timeline, Elvik's causality chain, active vs. passive vehicle safety features, immediate vs. system-level measures, etc. Their practical use is that they help to think about 'what else' can be done to address a particular safety problem.
- The Safe System approach encourages to apply multiple protection measures (Swiss cheese model—each layer has holes, but as long as the holes do not overlap, fatalities/injuries are prevented).
- Effectiveness of a traffic safety measure is often expressed as a 'crash modification factor (CMF)' or as a reduction of accident frequency in pro 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). Implementation of measures with known positive effects should be a priority.
- CMFs are usually available for a measure used on its own. Combinations of several measures does not equal multiplication of their CMFs, more elaborated methods should be used.
- Quite often, there is a discrepancy in subjective expectation how a measure will contribute to safety and its actual, objective effect. This can often be attributed to 'behavioural adaptation', i.e. people starting to behave differently due to the measure presence. Therefore, proper evaluation of measures is very important. Often, the better evaluation study is designed, the less is the objective safety effect found.
- There is a significant bulk of knowledge available with regards to effectiveness of various traffic safety measures. Recommended knowledge catalogues are:
  - SafetyCube Decision Support System: https://www.roadsafety-dss.eu (Open Access)
  - CMF Clearinghouse: https://www.cmfclearinghouse.org (Open Access)
  - Traffic Safety Handbook: https://www.tshandbok.no (Open Access, in Norwegian); https://doi.org/10.1108/9781848552517 (from 2009, Emerald Insights, paid access).

Traffic Safety

Learning outcom

Based on Bloom's |

After completing thi

- to **remembe** known effect
- to **understan** how the com 'subjectively the phenome
- to **apply** diff be added to i
- to **analyse** ..
- to **evaluate** r knowledge o
- to **create** …

Key messages to learn

- Strictly speaking, t and 'traffic safety accident to occur, a seen as an accident
- There are several w matrix (before-duri box (risk-exposure- causality chain, act measures, etc. Thei done to address a p
- The Safe System ap cheese model—eac fatalities/injuries ar
- Effectiveness of a t factor (CMF)' or as indicators are easily different effect on on other conditions 'crash modification have enough data t
- There is always an not possible to say (or have no effect). be a priority.
- CMFs are usually a measures does not should be used.
- Quite often, there is contribute to safety 'behavioural adapta presence. Therefore better evaluation st
- There is a significa various traffic safet
  - SafetyCube Access)
  - CMF Cleari
  - Traffic Safe Norwegian) Insights, pa

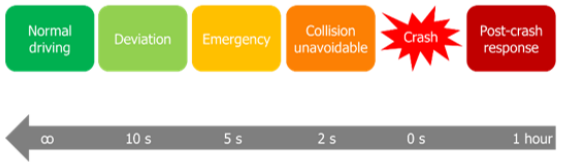
Learning activities

- **Lecture introducing the basics**
- **Exercises:**
  - **Ex. 1.** Fill in Haddon matrix with 2 examples in each cell for a given safety problem, e.g. a case accident and how it could have been prevented, or a problematic site and how the situation could be improved.

Example: Motorcycle riders are overrepresented in traffic fatalities

	Pre-crash	During crash	Post-crash
Road user	– Proper education and risk awareness – For commercial riders: limiting working hours to prevent fatigue	– Wear a helmet and protective closing – etc.	etc.
Vehicle	…	…	…
Infrastructure	…	…	…

  - **Ex. 2.** For the same case scenario, place the measures on the accident timeline:



  - **Ex. 3.** 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 own speed because of this)
    - A system warning that another car is present in the 'dead angle' of the back mirror (the driver over-relies on the system and stops turning the head to check him/herself)
    - Changing rules to drivers having to yield to pedestrians at crossings (pedestrian start to believe that all drivers will stop, while some might fail to see the pedestrian)
    - Resurfacing the road and making lanes wider (some drivers might increase their own speed because of this)
    - Training children on how to behave in traffic (some parents might expect too much of the children exposing them to greater risks)
  - **Ex. 4.** Use the suggested catalogues of traffic safety measures 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)

Traffic Safety

Learning outcom

Based on Bloom's |

After completing thi

- to **remembe** known effect
- to **understan** how the com 'subjectively the phenome
- to **apply** diff be added to i
- to **analyse** ..
- to **evaluate** r knowledge o
- to **create** …

Key messages to learn

- Strictly speaking, t and 'traffic safety r accident to occur, a seen as an accident
- There are several w matrix (before-duri box (risk-exposure- causality chain, act measures, etc. Thei done to address a p
- The Safe System ap cheese model—eac fatalities/injuries ar
- Effectiveness of a t factor (CMF)' or as indicators are easil different effect on on other conditions 'crash modificatio have enough data t
- There is always an not possible to say (or have no effect). be a priority.
- CMFs are usually a measures does not should be used.
- Quite often, there i contribute to safety 'behavioural adapta presence. Therefor better evaluation st
- There is a significa various traffic safet
  - SafetyCube Access)
  - CMF Cleari
  - Traffic Safe Norwegian) Insights, pa

Learning activities

- **Lecture introducing the basics**
- **Exercises:**
  - **Ex. 1.** Fill in Haddon matrix with 2 problem, e.g. a case accident and ho problematic site and how the situati

Example: Motorcycle riders are overrep

	Pre-crash
Road user	– Proper education a risk awareness – For commercial ri limiting working h to prevent fatigue
Vehicle	…
Infrastructure	…

  - **Ex. 2.** For the same case scenario, p

  - **Ex. 3.** Reflect on why the actual saf intended for the following measures
    - Highly reflective road signs an their own speed because of this
    - A system warning that another back mirror (the driver over-rel head to check him/herself)
    - Changing rules to drivers havin (pedestrian start to believe that to see the pedestrian)
    - Resurfacing the road and maki increase their own speed becau
    - Training children on how to be too much of the children expos
  - **Ex. 4.** Use the suggested catalogues the following measures are effectiv
    - Installation of road lighting (fa link)

Assessment quiz

1. A traffic safety measure affects the probability of accidents/injuries, 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 other vehicles earlier, or to brake more efficiently, it is still possible that he/she will make an 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.

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 = Ameasure / Anomeasure = (Anomeasure * (1-0.48)) / Anomeasure = 0.52.

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 (increasing distance from 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: two independent 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 the accident reduction effects, have clearly positive effects on safety and should be recommended. On the other hand, the effects of raised intersection might be positive or negative. Similarly, the two studies on pre-school children education give very contradictory results. This in turn might because the content of the education varied and the expectations of others. These two measures should not be recommended—more research is needed to get more certainty of their effects (which might turn out to be negative for safety).

Traffic Safety

Learning outcom

Based on Bloom's |

After completing thi

- to **remembe** known effect
- to **understan** how the com 'subjectively the phenome
- to **apply** diff be added to i
- to **analyse** ..
- to **evaluate** r knowledge o
- to **create** …

Key messages to learn

- Strictly speaking, t and 'traffic safety r accident to occur, a seen as an accident
- There are several w matrix (before-duri box (risk-exposure- causality chain, act measures, etc. Thei done to address a p
- The Safe System ap cheese model—eac fatalities/injuries ar
- Effectiveness of a t factor (CMF)' or as indicators are easil different effect on on other conditions 'crash modificatio have enough data t
- There is always an not possible to say (or have no effect). be a priority.
- CMFs are usually a measures does not should be used.
- Quite often, there i contribute to safety 'behavioural adapta presence. Therefor better evaluation st
- There is a significa various traffic safet
  - SafetyCube Access)
  - CMF Clear
  - Traffic Safe Norwegian) Insights, pa

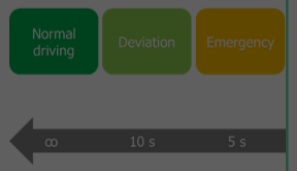
Learning activities

- **Lecture introducing the basics**
- **Exercises:**
  - **Ex. 1.** Fill in Haddon matrix with 2 problem, e.g. a case accident and h problematic site and how the situati

Example: Motorcycle riders are overrep

	Pre-crash
Road user	– Proper education a risk awareness – For commercial ri limiting working h to prevent fatigue
Vehicle	…
Infrastructure	…

  - **Ex. 2.** For the same case scenario, p



  - **Ex. 3.** Reflect on why the actual saf intended for the following measures
    - Highly reflective road signs an their own speed because of this
    - A system warning that another back mirror (the driver over-rel head to check him/herself)
    - Changing rules to drivers havin (pedestrian start to believe that to see the pedestrian)
    - Resurfacing the road and maki increase their own speed becau
    - Training children on how to bel too much of the children expos
  - **Ex. 4.** Use the suggested catalogues the following measures are effectiv
    - Installation of road lighting (fa link)

Assessment quiz

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

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

Comment (shown after the answe For example, consider improvemen surface friction. While a driver mig efficiently, it is still possible that h braking, but too late). Thus, while accident probability is still non-zer

2. *The Handbook of Road Safety M* pedestrian crossings reduce injury CMF (crash modification factor) o

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

Comment (shown after the answe CMF is calculated as a ratio of acc Thus, CMF = Ameasure / Anomea

3. Which of the measures would y estimates are taken from *The Hand*

   a. Improvement of the fixed objects): estim
   b. Raised intersections (correct)
   c. Traffic safety educa suggest estimated c (-50%; -3%) and (+
   d. Ensuring that the m in injury accidents (

Comment (shown after the answe Roadside improvements and contr reduction effects, have clearly posi other hand, the effects of raised int studies on pre-school children educ because the content of the educatio measures should not be recommen their effects (which might turn out to be negative for safety).

Recommended (additional) reading for teacher

- Elvik, R., A. Høye, T. Vaa, M. Sørensen (2009), The handbook of road safety measures (Bingley, UK: Emerald Group Publishing Limited) Second Edition, https://doi.org/10.1108/9781848552517. (*introduction chapters*)
- FHWA (n/d), 'Crash modification factors clearinghouse' (U.S. Department of Transportation, Federal Highway Administration), https://www.cmfclearinghouse.org. (*user guide sections*)
- SafetyCube DDS (2016), 'European Road Safety Decision Support System', https://www.roadsafety-dss.eu. (*quick guide, introductionary videos, webinar—links on the front page*)
- Goel, R., G. Tiwari, M. Varghese, K. Bhalla, G. Agrawal, G. Saini, A. Jha, D. John, A. Saran, H. White, D. Mohan (2024), 'Effectiveness of road safety interventions: An evidence and gap map', Campbell Systematic Reviews, 20 (1), e1367, https://doi.org/10.1002/cl2.1367.
- Hauer, E. (1993), 'Overview', in ITE (ed.) The Traffic Safety Toolbox: A Primer on Traffic Safety (Washington, DC, United States: Institute of Transportation Engineers), https://www.researchgate.net/publication/324226789_Overview_in_ITE_Traffic_Safety_Toolbox_A_Primer_on_Traffic_Safety_1993
- 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.
- Elvik, R. (2007), 'Prospects for improving road safety in Norway' (Oslo, Norway: Institute of Transport Economics), TØI report 897/2007, https://www.toi.no/getfile.php?mmfileid=9040. (*chapter 6–7*)
- Elvik, R. (2024), 'Risk factors as causes of accidents: Criterion of causality, logical structure of relationship to accidents and completeness of explanations', Accident Analysis & Prevention, 197, 107469, https://doi.org/10.1016/j.aap.2024.107469.
- Delhomme, P., De Dobbeleer, W., Forward, S., & Simões, S. (Eds.). (2009). Manual for Designing, Implementing, and Evaluating Road Safety Communication Campaigns. In Campaigns and Awareness Raising Strategies in Traffic Safety (CAST project), Cast Project, 6e PCRD. Belgian Road Safety Institute (IBSR-BIVV), Brusselshttps://www.crow.nl/downloads/documents/kpvv-kennisdocumenten/cast-manual-for-designing-implementing-and-evaluat

AfroSAFE Academy

Education

Currently, the AfroSAFE Academy works on development of a curriculum for a master-level course in traffic safety. The first pilots will be performed during 2024 at University of Zambia and University of Dar es-Salaam, Tanzania.

All course materials will be provided here under Creative Commons license, free for any African university to integrate them in own education.

https://www.ictct.net/afrosafe/education

Thank you!!!

Aliaksei Laureshyn
Lund University, Sweden

aliaksei.laureshyn@tft.lth.se

AFRO SAFE ACADEMY

www.ictct.net/afrosafe