

4. How to measure traffic safety

Introduction

Traffic safety measurement is a cornerstone of effective transport planning, policy making, and intervention design. This module introduces to the foundational concepts, indicators, and challenges involved in assessing traffic safety. Moving beyond simple crash counts, the module explores the importance of accident rates, severity classification, exposure-risk-consequence frameworks, and complementary performance indicators. Students will critically examine issues such as under-reporting, the influence of different denominators, and the complexities of comparing safety across time and space. After completion of the module, the learners will be equipped with the analytical tools and practical understanding necessary to interpret and design traffic safety assessments that reflect both user risk and systemic realities.

Learning outcomes

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

- identify key terms and definitions related to traffic safety measurement, such as accident severity categories, exposure, and safety performance indicators
- explain the difference between accident counts and accident rates, and describe the implications of choosing different denominators in safety analysis
- calculate accident rates using various exposure metrics (per population, per vehicle · kilometres travelled, etc.) and interpret their meaning in real-world contexts
- assess the effectiveness and limitations of current safety metrics and performance indicators in informing road safety policy and interventions.

Key messages to learners

- Accident/injury counts alone are not enough. Accident frequency must be contextualized using rates to reflect real risk levels, accounting for exposure such as population, distance travelled, or number of vehicles.
- Choice of denominator shapes the narrative. Accident rates per vehicle, kilometre travelled, or population can lead to very different interpretations of traffic safety trends.
- Accident severity matters. Traffic crashes are not equal and classifying them by severity (fatal, serious injury, minor, PDO) helps prioritize interventions and allocate resources effectively.
- Exposure is central to risk assessment. Exposure can be measured in time, distance, or encounters. Considering the entire door-to-door trip is essential, especially for multi-modal journeys (e.g. a trip by public transport includes also walking to the nearest stop).
- Accident statistics often under-reports reality. Official statistics frequently miss less severe accidents and certain road user groups, such as pedestrians and cyclists—especially in LMIC contexts.
- Comparing safety is not straightforward. Cross-temporal or cross-site comparisons can be misleading due to regression-to-the-mean and non-linear relationships between crashes and exposure levels.
- Simple year-to-year comparisons of accident/injury counts are misleading. What may look like an effect of a safety intervention is often a manifestation the ‘random nature’ of accidents.

Longer data series allowing to reveal trends, as well as some advanced statistical methods are necessary to handle the randomness of accidents.

- More versatile picture emerges when traffic casualties are ‘disaggregated’ as a product of exposure (amount of accident-generating activity), risk (accidents/injuries per exposure), and consequences (severity of the outcomes). Significant differences are found between road user types, age groups, etc.
- Safety Performance Indicators (SPIs) enrich analysis. Beyond crash data, indicators like seatbelt use, speeding rates, and helmet use offer insight into behaviours and system-level risks.
- System characteristics influence outcomes. Road design standards, vehicle ownership levels and driver licensing rates are critical system descriptors that frame safety conditions.

Learning activities

The learning activities could vary between exercises testing the learned concepts and the fundamental knowledge and those that require applying the knowledge on use cases and specific situations. Provide in each module between minimum 3 and maximum 5 exercises.

Exercise 1

Suggest at least two measures to describe the Exposure-Risk-Severity dimensions of a traffic safety problem:

Component	Description	Examples
Exposure	amount of accident-generating activity ...	
Risk	accidents/injuries per exposure ...	
Consequences	severity of the outcomes ...	

Possible answer:

Component	Description	Examples
Exposure	amount of accident-generating activity	population; vehicle · km driven; trips made; time spent on road; driver licences; vehicles registered; gasoline consumed
Risk	accidents/injuries per exposure	fatalities per 10 ⁶ population; crashes per 10 ⁶ km travelled; crashes per hours spent on road
Consequences	severity of the outcomes	share of fatal, severe/slight injury, and property damage accidents; fatalities per injury accident; fatalities per injured person

Exercise 2

Preparations (teacher only):

- If possible, collect the national data for at least 20–30 years covering: (i) traffic fatalities, (ii) country population, and (iii) total number of vehicles registered.
- Alternatively, find on the Internet time series for some country in Europe or North America.

With the students:

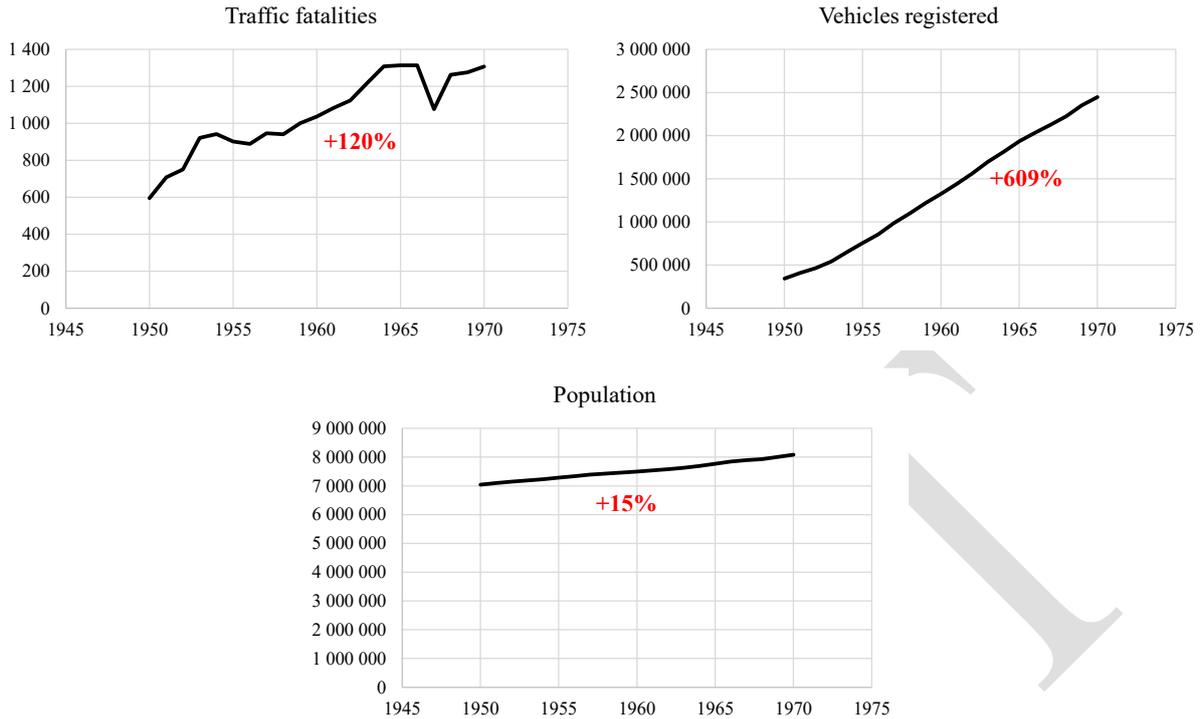
- In Excel, make diagrams displaying how fatalities, vehicles and population changed overtime. By how much (in %) have all three changed during the entire period?
- Calculate rates: (i) fatalities per vehicles registered in the country, and (ii) fatalities per population.
- Make diagrams showing how both rates changing over time. What kind of message each diagram conveys? Do we have a traffic safety problem, or will it ‘solve itself’ if we just wait for a little bit more time? Which one do you think the politicians will choose to show to their voters?

Possible answer:

Sample data from Sweden:

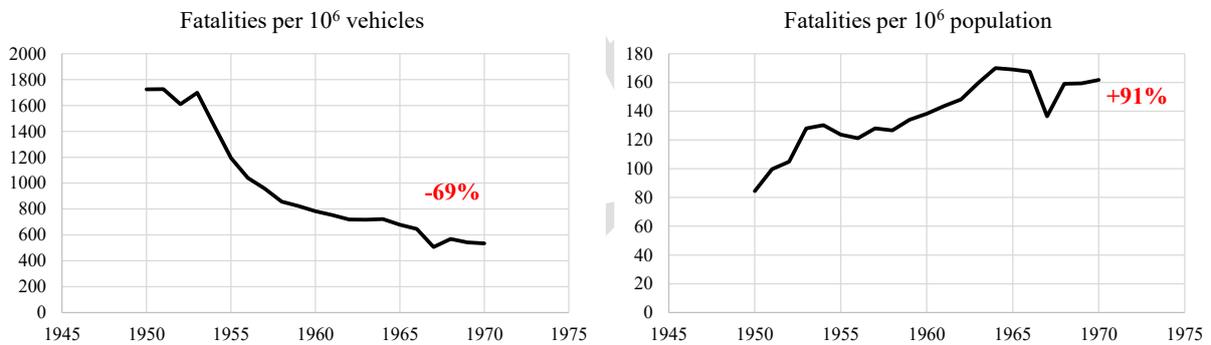
Year	Traffic fatalities	Registered vehicles	Population
1950	595	344 953	7 041 829
1951	708	410 000	7 098 740
1952	750	466 000	7 150 606
1953	921	542 000	7 192 316
1954	942	652 000	7 234 664
1955	902	755 000	7 290 112
1956	889	855 000	7 338 991
1957	946	987 000	7 388 611
1958	941	1 098 000	7 429 675
1959	1 000	1 216 000	7 462 823
1960	1 036	1 324 000	7 497 967
1961	1 083	1 439 000	7 542 028
1962	1 123	1 562 000	7 581 148
1963	1 217	1 697 000	7 627 507
1964	1 308	1 810 000	7 695 200
1965	1 313	1 934 000	7 772 506
1966	1 313	2 033 000	7 843 088
1967	1 077	2 126 000	7 892 774
1968	1 262	2 223 000	7 931 193
1969	1 275	2 350 000	8 004 270
1970	1 307	2 446 000	8 081 229

Fatality, vehicle, and population trends:



The absolute traffic fatalities more than doubles (+120%) in 20 years, a clear sign of an urgent traffic safety problem.

Fatality rates:



Since vehicles grow faster than fatalities, the per-vehicle rate gets a negative trend. The sense of urgency for action is lost. Waiting for more vehicles in the system to reduce the rate seems like a meaningful strategy (it is not!). Conversely, the population is relatively stable over time with only minor growth. As a result, the per-population rate is still growing, clearly showing the problem and demanding action now.

Exercise 3

The dataset shows crash rates per 100 000 population and per million vehicle · kilometres travelled for three African countries. Discuss which of the countries performs best/worst with regards to traffic safety. Motivate.

Country	Crashes per 10 ⁵ population	Crashes per 10 ⁶ vehicle · kilometres
Kenya	130	8.5
Ghana	105	15.2
Rwanda	90	4.2

Possible answer:

Rwanda performs best regardless of the exposure units used. Kenya has the highest crash rate per population, while Ghana has the highest rate per million vehicle · kilometres. Which is more a relevant measure? Usually, population is a fairer measure than vehicles or vehicle · kilometres. However, it is worth investigating further—could it be so that Kenyans travel significantly more than Ghanaians, over longer distances, or maybe own more vehicles due to better economy?

Assessment quiz

Question 1

Which of the following is **not** commonly included in official road traffic accident statistics:

- Pedestrian falls on sidewalks (**correct**)
- Fatal crashes involving motor vehicles (**incorrect**)
- Serious injuries from road crashes (**incorrect**)
- Injuries occurred inside a bus during travelling, or while entering/leaving the bus (**correct**)

Comment (shown after the answer has been given):

Data on property damage only (PDO) crashes are still often collected and reported, however due to high under-reporting they are almost useless for any meaningful safety analysis. Additionally, the Safe System is more interested in prevention of fatal/injury accidents and accepts that PDO accidents will continue to occur.

Question 2

Explain why it is misleading to compare crash numbers from two consecutive years without adjusting for exposure and regression-to-the-mean?

Possible answer: Year-to-year crash counts fluctuate due to randomness (and regression-to-the-mean), not necessarily because of underlying safety improvements. Failing to account for exposure (e.g. number of trips, distance travelled) can also be misleading, for example accidents may temporarily decrease due to less distance travelled and not due to changes in accident risk per kilometre.

Question 3

You are comparing traffic safety between two cities. City A has a higher number of crashes than City B, but city A is nearly double as large compared to city B. Which of the following would help you make a fair comparison?

- compare absolute crash counts between the cities (**incorrect**)
- compare crash rates per registered vehicles/registered population (**correct**)
- compare two population sizes only (**incorrect**)
- compare city budget allocations as a proxy for exposure (**incorrect**)

Comment (shown after the answer has been given):

Accident rates must be used when making comparisons. The choice of a denominator to calculate the rate still matters. Sometimes exposure data (distance travelled or people leaving) is not directly available. It could be approximated through other indicators (e.g. amounts of gasoline or some basic food product sold)

Recommended reading for students

- Nilsson, G. (2004), 'Traffic safety dimensions and the Power Model to describe the effect of speed on safety', Doctoral thesis, Lund University, Sweden.
<https://portal.research.lu.se/files/4394446/1693353.pdf> (Chapter 4 'Dimensions of the traffic safety problem')

Recommended (additional) reading for teacher

- Elvik, R. (2008), 'Dimensions of road safety problems and their measurement', *Accident Analysis & Prevention*, 40 (3), 1200–1210. <https://doi.org/10.1016/j.aap.2008.01.004>
- WHO. (2023). Global status report on road safety.
<https://iris.who.int/bitstream/handle/10665/375016/9789240086517-eng.pdf>

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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