

6. Why accidents happen?

Introduction

Accidents rarely result from a single cause—they emerge from a complex interaction of human, technical, environmental, and organizational factors. This module introduces key theories and models of accident causation, such as the Domino theory, Swiss cheese model, and system theories (e.g. STAMP), to help students understand how and why accidents occur. Emphasizing a probabilistic and systems-based view, it challenges simplistic explanations like ‘human error’ and equips students with the tools to analyse accidents and design effective prevention strategies.

Learning outcomes

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

- To define an accident cause from deterministic and probabilistic perspectives.
- To explain the core principles of single-factor, multi-factor, and systems-based accident theories.
- To recall the major accident causation theories and models, including Domino theory, Swiss cheese model, and STAMP.
- To describe how different theories account for human factors, organizational factors, and road and environmental conditions in accident causation.
- To apply each of the theory to analyze given accident scenarios and suggest strategies for prevention of similar accidents in the future.

Key messages to learners

- Traffic accidents rarely have a single cause. Usually, they are a result of a complex interplay of various contributing factors, including human, technical, organizational, and environmental elements. Understanding this complexity is crucial for effective accident prevention and analysis.
- In legal practice, a cause is ‘any action, event or process that produces a change that otherwise would not have occurred’. This deterministic approach is not very useful in traffic safety context where contributing factors (e.g. bad weather or trees by the roadside) might be frequently present, yet rarely result in accidents. The negative side effect of deterministic understanding of causation is the overfocus on human actions that, unlike road, vehicle, or legislative factors, fit well into the simplistic explanation of ‘no driver present—no accident possible’.
- Probabilistic definition of a traffic accident cause/contributing factor is ‘a circumstance, presence or absence of which changes the probability of accidents, or their severity’. Reduced sight distance does not guarantee a collision but makes it more likely. As such, absence of a known effective traffic safety measure can also be seen as a contributing factor. Such view departs from the ‘blame-the human’ paradigm and invites to focus on wider set of contributing factors, particularly those under control of the system designers.
- While human error is often a contributing factor, human actions are influenced by broader systemic and organizational contexts. Factors such as workload, training, supporting equipment, and organizational and societal culture all play a role in shaping human behaviour and performance. From the Safe System perspective, human errors are rather to be expected, and proper protective measures needs to be implemented to prevent them from developing into severe injuries and fatalities.

- The Swiss cheese model presents the chain of events leading to an accident penetrating through multiple layers of protection (each compared to a slice of Swiss cheese with randomly placed holes in it, hence the name). Even if a latent threat is present, it does not always materialized as an accident, being stopped by one or another protection layer. Reduction of accident risk thus implies adding new layers of protection and improving the effectiveness (minimizing the ‘holes’) in the existing ones.
- Domino theory presents accident as a chain of consequentially falling ‘dominos’: (i) social environment, (ii) human error, (iii) unsafe act/condition, (iv) accident, and (v) injury. By removing or ‘fixing’ any of the dominos the chain gets broken and the injury prevented.
- More modern accident causality theories (e.g. STAMP) emphasize the dynamic nature of accident generating processes and system-level (rather than individual-level) control actions and constraints (e.g. alcolocks that prevents engine from starting unless the driver passes the sobriety test). They underscore the importance of ongoing safety management and continuous improvement in safety systems. Safety is seen not as a static but a dynamic state requiring constant vigilance and adaptation.
- Modern view on causality emphasizes the role of organizational culture and management in creating a safe operating environment. Leadership commitment, clear communication, and a just culture (focusing on ‘what went wrong?’ rather than ‘whom to blame?’) are key elements in fostering safety.
- Understanding accidents causation and prevention strategies requires insights from various disciplines, including psychology, engineering, management, and organizational science. This multidisciplinary perspective allows for a more comprehensive understanding of accident causation and prevention.
- While theories provide valuable frameworks, their real value lies in practical application to analyse past accidents and prevent future ones.

Learning activities

Exercise 1

Consider the following accident scenario. Analyse the accident causation applying Domino, Swiss cheese, and STAMP models, suggesting as many as possible solutions to prevent such (and more severe) accidents in the future. Do different models ‘lead’ you to different types of solutions?

A parent was driving her two kids from a stay with the grandparents. It was a long, narrow, and winding rural road, and it started to rain. Everyone was tired, but the parent was also upset about an incident with another driver who cut her off some minutes ago. The kids started to quarrel at the back. The parent decided to play an audiobook to them and started fiddling with the car's stereo and her mobile phone. While looking down on her phone screen, she missed that the road was making a turn. The car went off the road and hit a fence surrounding a field nearby. Luckily, its poles were old and rotten, so the car went through them. The car was damaged, but luckily no one was severely injured.

Assessment quiz

Question 1

An accident contributing factor does not guarantee that an accident will happen, but they affect the probability of an accident. Accident thus is an unfortunate coincidence of many contributing factors appearing at the same time.

- Yes (correct)
- No (incorrect)

Comment (shown after the answer has been given): Unlike the deterministic causality used in law practice (factor present = bad event, factor absent = no bad event), contributing factors in traffic safety are most often probabilistic. For example, millions of cars may pass by a tree growing at a roadside, but if a driver falls asleep and drive off the road just there (two additional contributors), a fatal accident is imminent.

Question 2

Explain what is so misleading in the famous statement that ‘human factor causes 95% of traffic accidents’? (free text answer)

Recommended reading for students

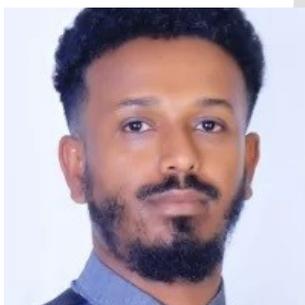
- Hauer, E. (2020). Crash causation and prevention. *Accident Analysis & Prevention*, 143, 105528. <https://doi.org/10.1016/j.aap.2020.105528>
- Hauer, E. (2022). Crash causation and prevention. ICTCT webinar, 16 October 2020. <https://www.ictct.net/webinars/october-2020/>
- Lie, A., & Tingvall, C. (2024). Are crash causation studies the best way to understand system failures—who can we blame? *Accident Analysis & Prevention*, 196, 107432. <https://doi.org/10.1016/j.aap.2023.107432>
- Shinar, D., & Hauer, E. (2024). Crash causation, countermeasures, and policy. *Accident Analysis & Prevention*, 107543. <https://doi.org/10.1016/j.aap.2024.107543>

Recommended (additional) reading for teacher

- Elvik, R. (2006). The laws of accident causation. *Accident Analysis & Prevention*, 38(4), 742–747. <https://doi.org/10.1016/j.aap.2006.01.005>
- Elvik, R. (2007), ‘Operational criteria of causality for observational road safety evaluation studies’, *Transportation Research Record*, 2019 (1), 74–81, <http://doi.org/10.3141/2019-10>
- 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>
- Leveson, N. (2023). An introduction to system safety engineering. The MIT Press. (Chapter 4 ‘Why accidents occur?’)

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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