

Swiss TPH

SSPH+/ETHZ Lecture Series "This Is Public Health"

Transportation noise: Health threat or just annoying?

Martin Röösli, 09 March 2022

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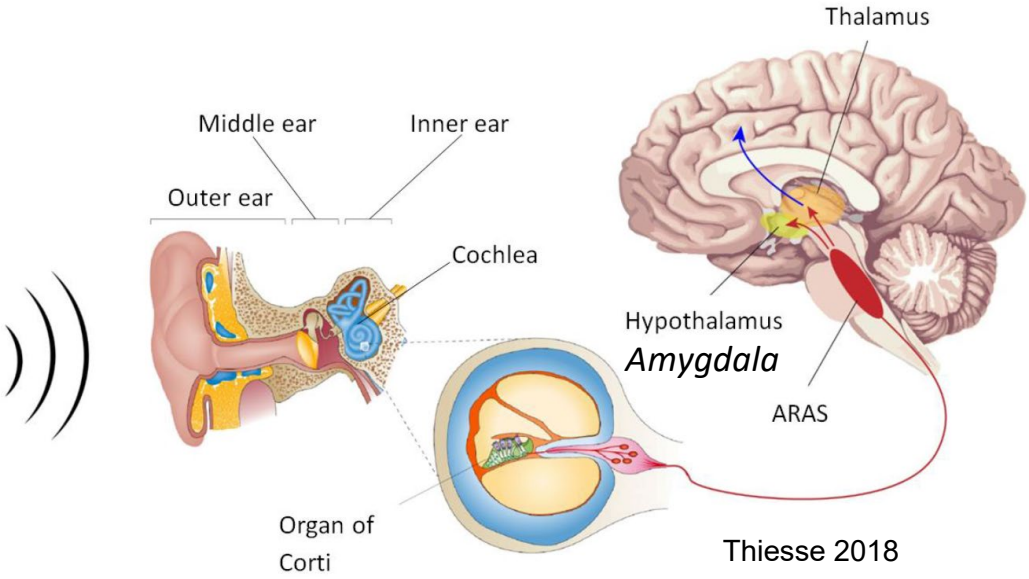
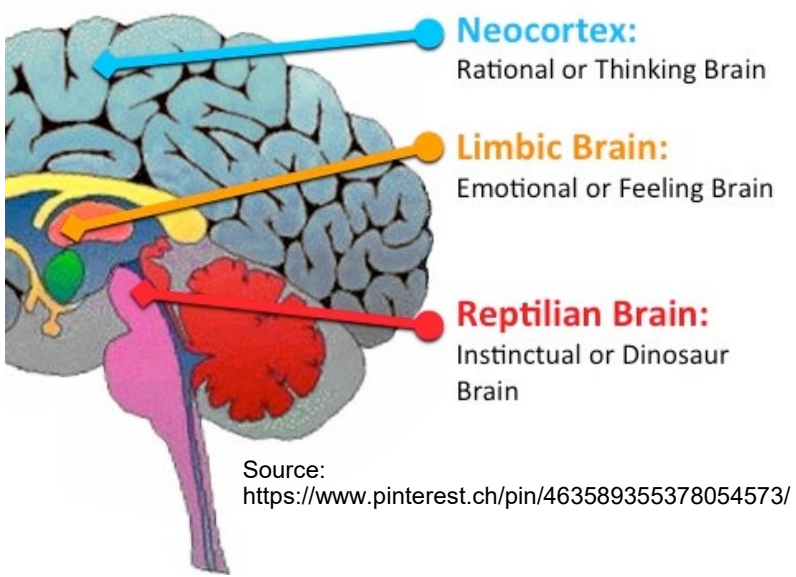
Content

- Sound processing
- From sound to noise
- Annoyance
- Cardiovascular effects
- Diabetes, depression, behaviour cognition
- New proposal for Swiss noise regulation

Sound processing



Thiesse 2018

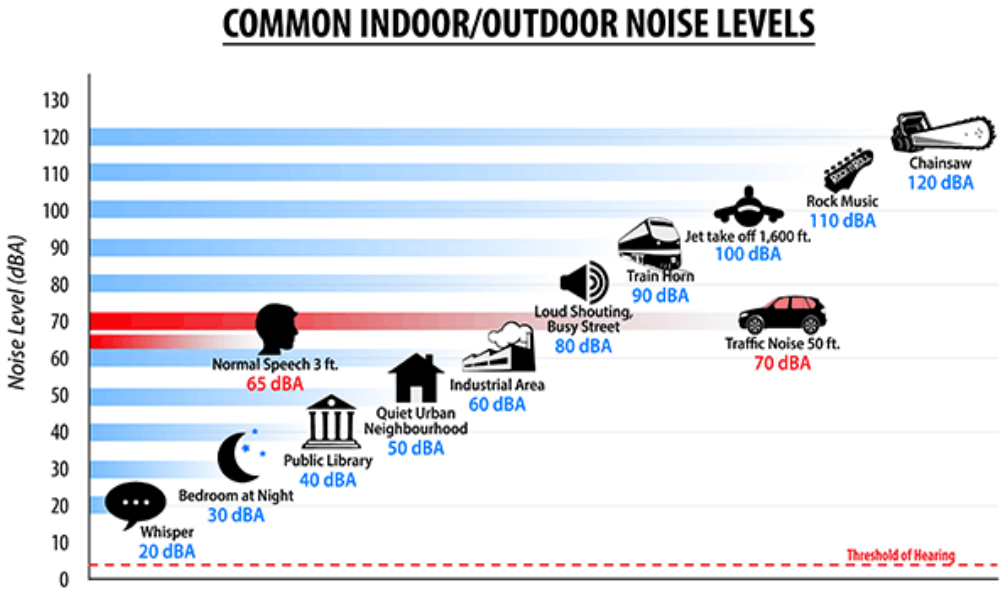


Source:
https://www.pinterest.ch/pin/463589355378054573/

«The ear never sleeps»

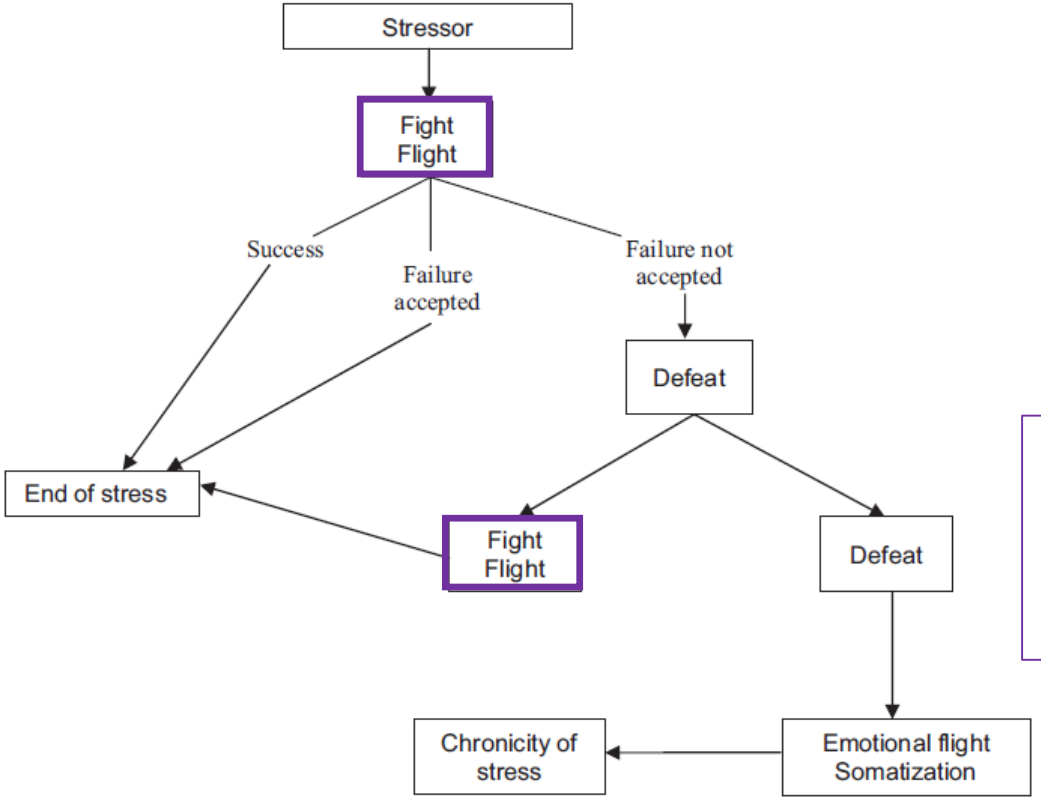
Sound

- **Sound** ≡ any pressure variation that the human ear can detect measured in decibels (dB); 0 dB 'threshold of hearing' (20 µPa) – 130 dB 'threshold of pain' (~100Pa).
- **Logarithmic:** increase of 3 dB corresponds to a doubling of the sound pressure ($10^{3dB/10}=2$)
- **Noise** ≡ audible sound that causes disturbance, impairment or health damage
- $\mathbf{L_{den}}$: Average sound level over all 24 hour periods of a year, with a penalty of 5 dB added for the evening hours penalty of 10 dB added for the night hours



From Seminole Manor

Stress Model



Lärm (german) ≡ **alarm** < -> *all'arme (ital.):* to take up rms/weapons

Hypothalamic-pituitary-adrenal axis (HPA)

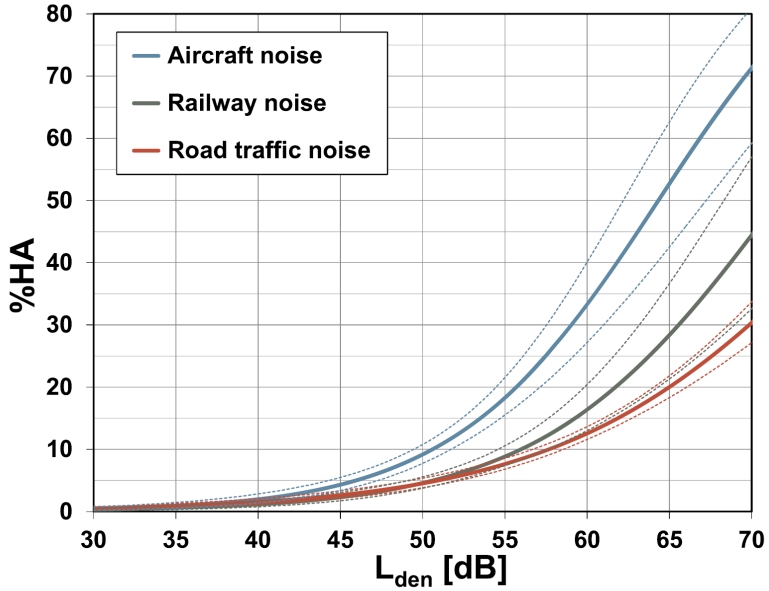
Sympathetic nervous system-adrenal medullary axis (SNA)

Recio et al, 2016

Noise annoyance

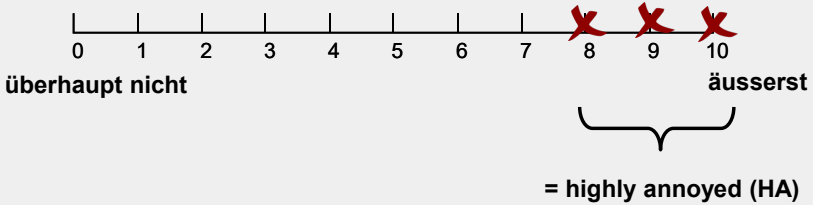
Representative survey in Switzerland (SiRENE), n= 5’592

Highly annoyed



Brink, Env Int, 2019

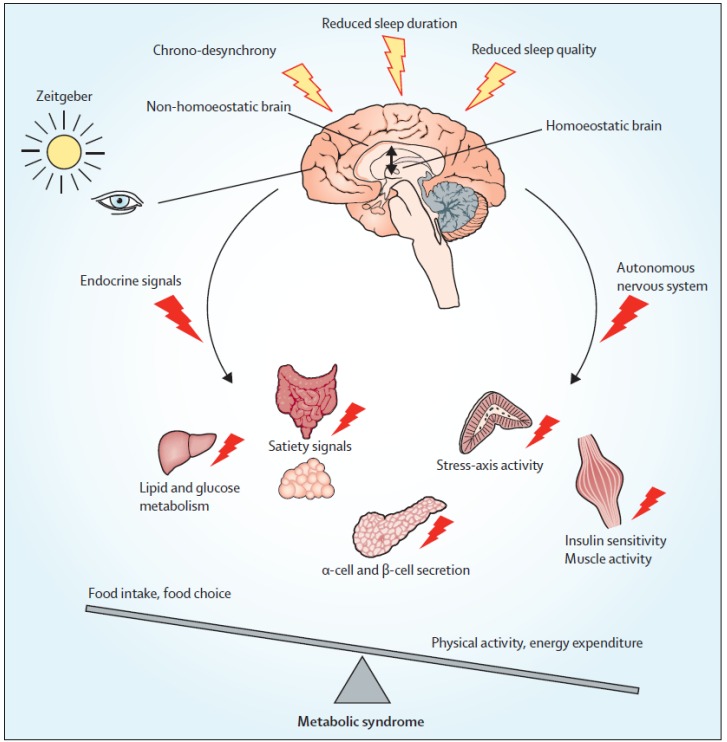
Wenn Sie an die letzten 12 Monate bei Ihnen denken, welche Zahl zwischen 0 und 10 gibt am besten an, wie stark Sie sich durch Lärm von <Lärmart> insgesamt gestört oder belästigt fühlten?



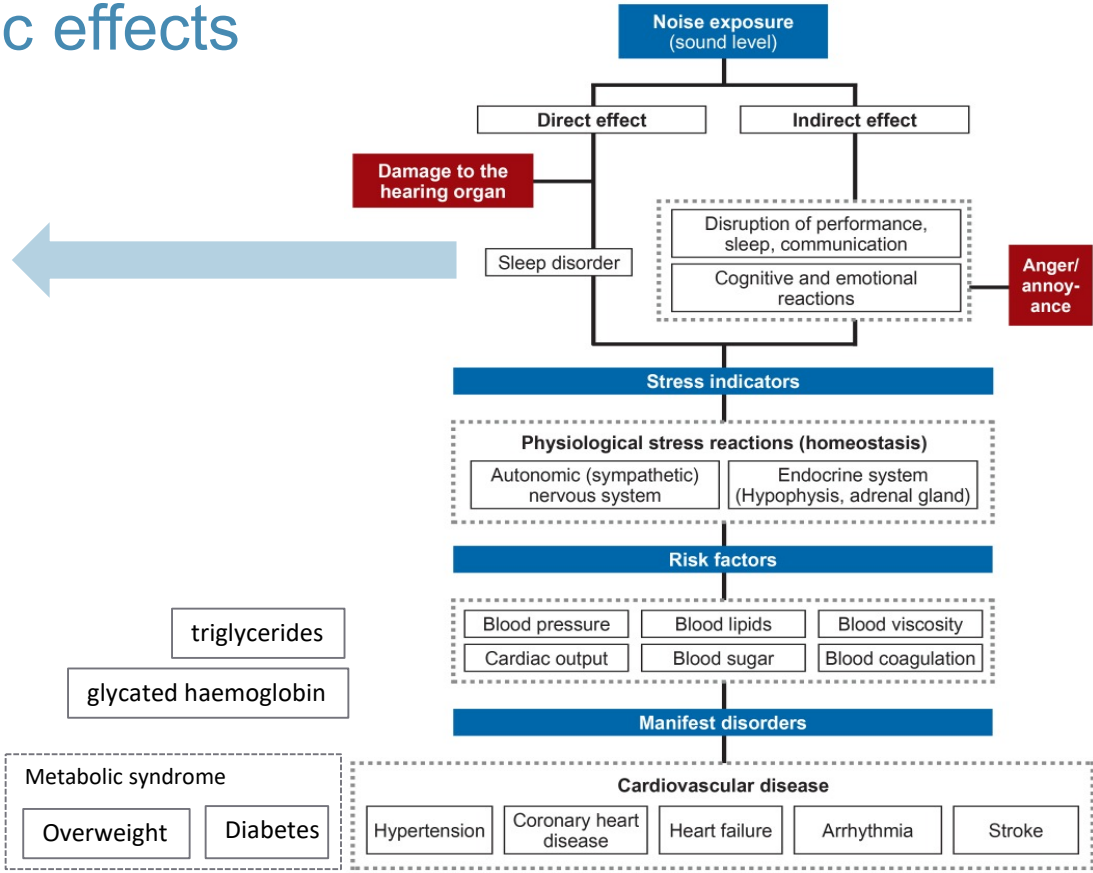
Factors affecting noise annoyance

- Level
- Timing (e.g. night or day)
- Feeling of control (e.g. own sound, predictability)
- Characteristics of sound such as tone, impulse etc.
- Attitude to the source
- Distance and orientation to the source

Noise and cardiometabolic effects



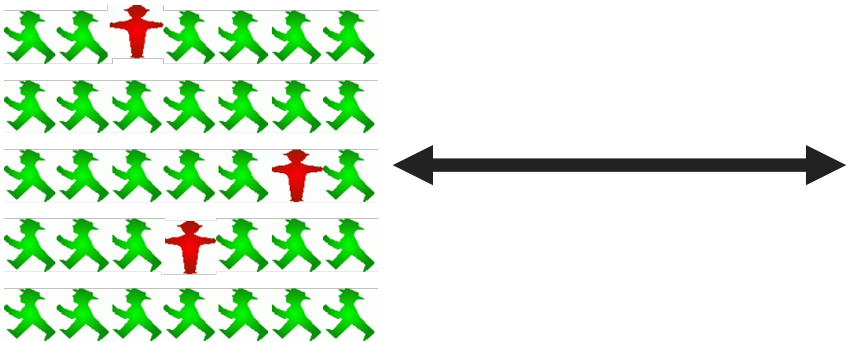
Schmid et al, 2015

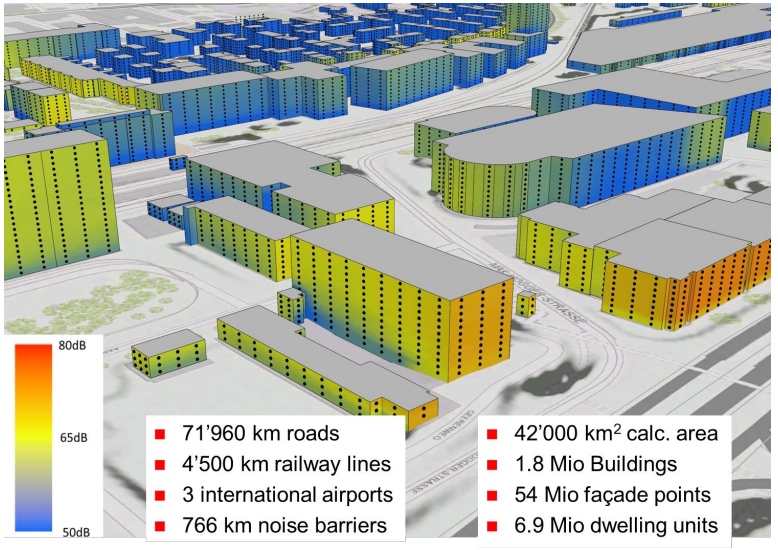


adapted from Hahad et al, 2019

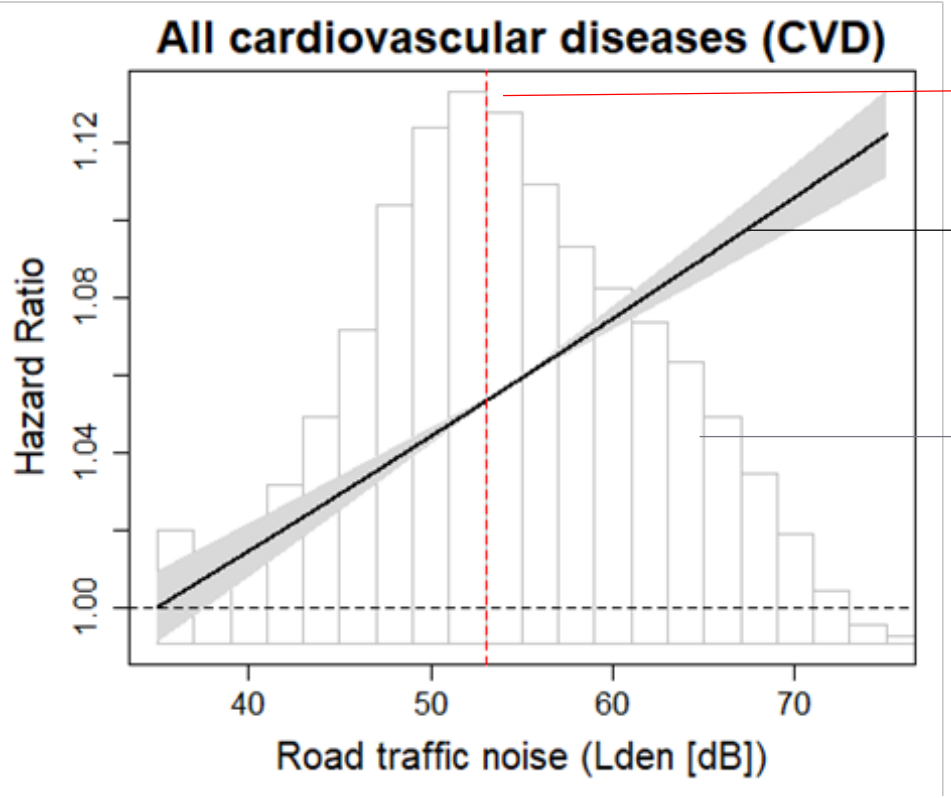
Swiss National Cohort (2000-2015)

- All inhabitants in Switzerland (4.41 million people aged >30 years)
- Mortality records and census data linked
  - Sex, civil status, education, mother tongue, nationality
  - Neighborhood, community and regional socio-economic position and unemployment rate
  - Noise: road, railway, aircraft
  - Air pollution (PM2.5)





Noise vs. cardiovascular and myocardial infarction mortality



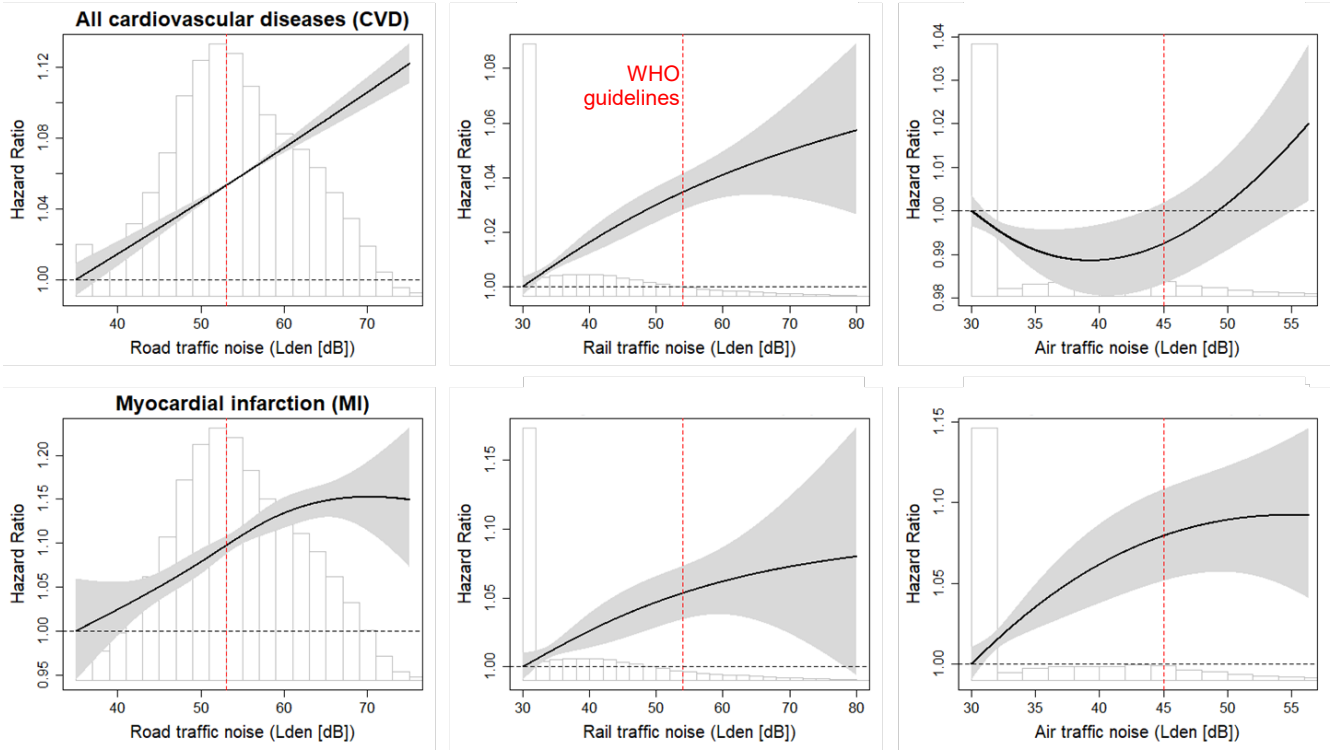
WHO guidelines

Risk increase

Noise distribution

Vienneau et al, Env Int, 2022

Noise vs. cardiovascular and myocardial infarction mortality



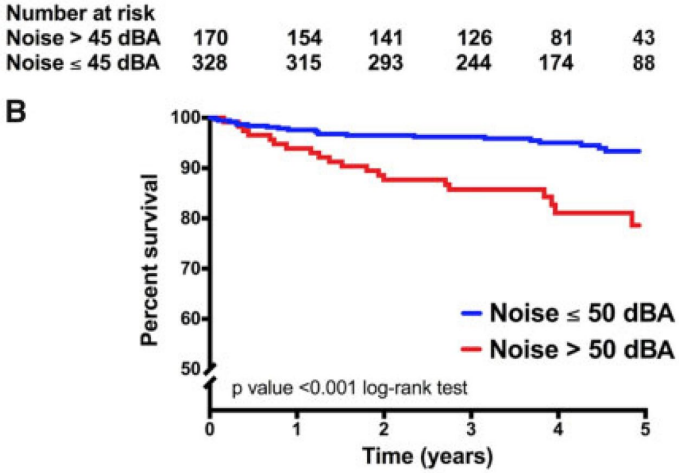
Source	Excess risk per 10 dB (%)
L_{den} Road	2.9 (2.4-3.4)
L_{den} Railway	1.3 (1.0-1.7)
L_{den} Aircraft	0.3 (-0.4-1.0)

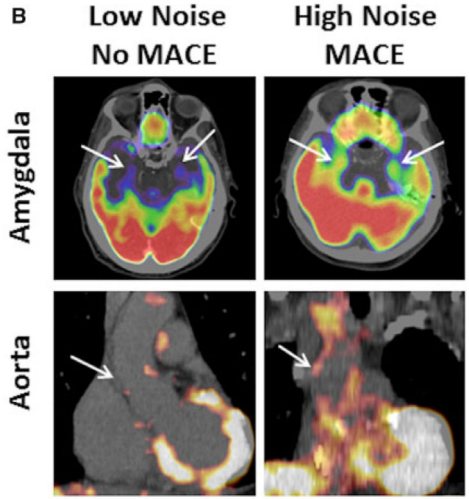
Source	Excess risk per 10 dB (%)
L_{den} Road	4.3 (2.9-5.8)
L_{den} Railway	2.0 (1.0-3.0)
L_{den} Aircraft	4.0 (2.0-6.0)

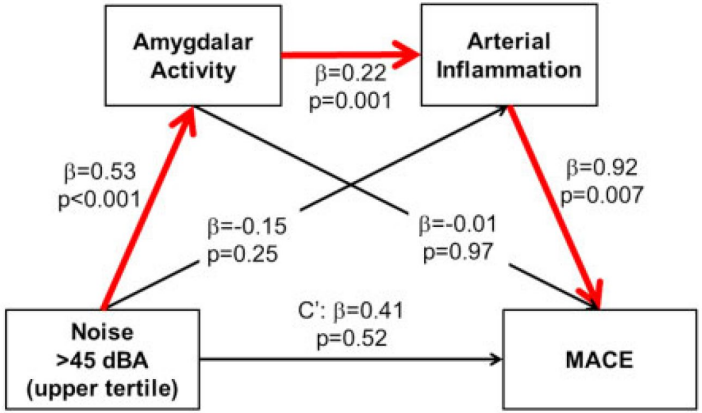
Vienneau et al, Env Int. 2022

Neurobiological mechanism (Osborne, EHJ, 2020)

- In 498 adults (N= 498) without CVD or active cancer, amygdalar metabolic activity and heightened arterial inflammation were measured, transportation noise at home modelled.
- 40 major adverse cardiovascular disease events (MACE) occurred within 4 years.







Acute cardiovascular effects?

ESC European Society of Cardiology

European Heart Journal (2021) **42**, 835–843
doi:10.1093/eurheartj/ehaa957

CLINICAL RESEARCH
Epidemiology and Prevention

Does night-time aircraft noise trigger mortality? A case-crossover study on 24 886 cardiovascular deaths

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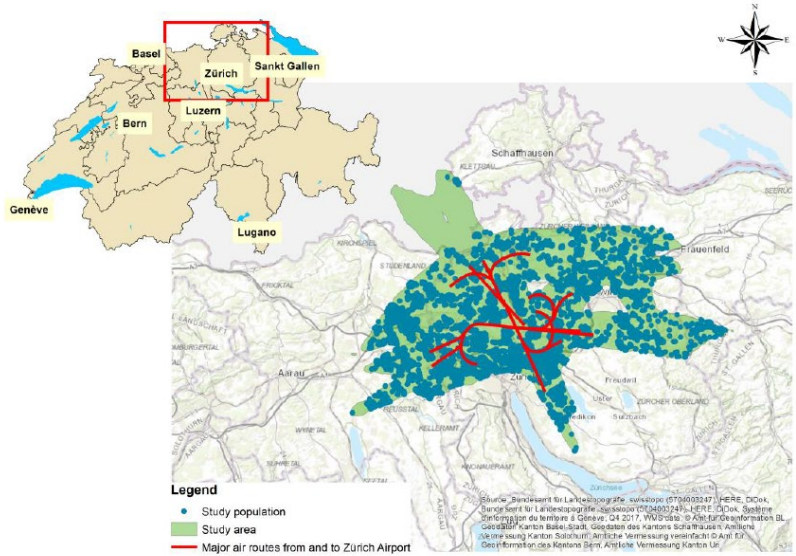
See page 844 for the editorial comment on this article (doi: 10.1093/eurheartj/ehaa984)

A case-crossover study around Zurich Airport

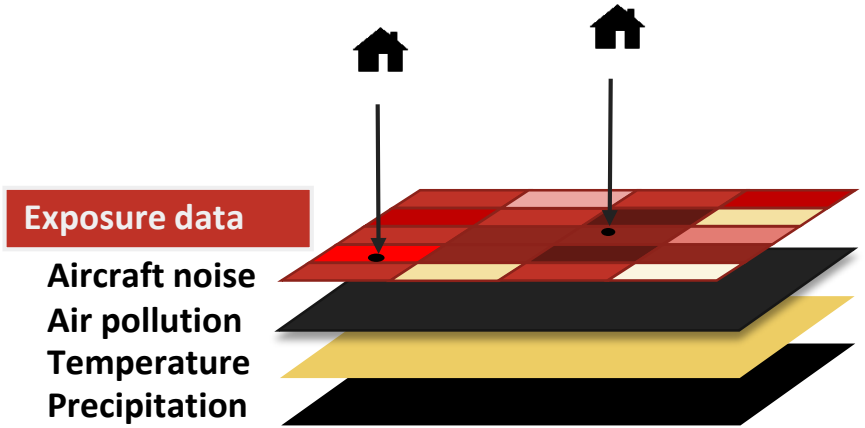
24,886 cases of cardiovascular death (2000-2015)
Swiss National Cohort



Study population and runway system at Zurich Airport

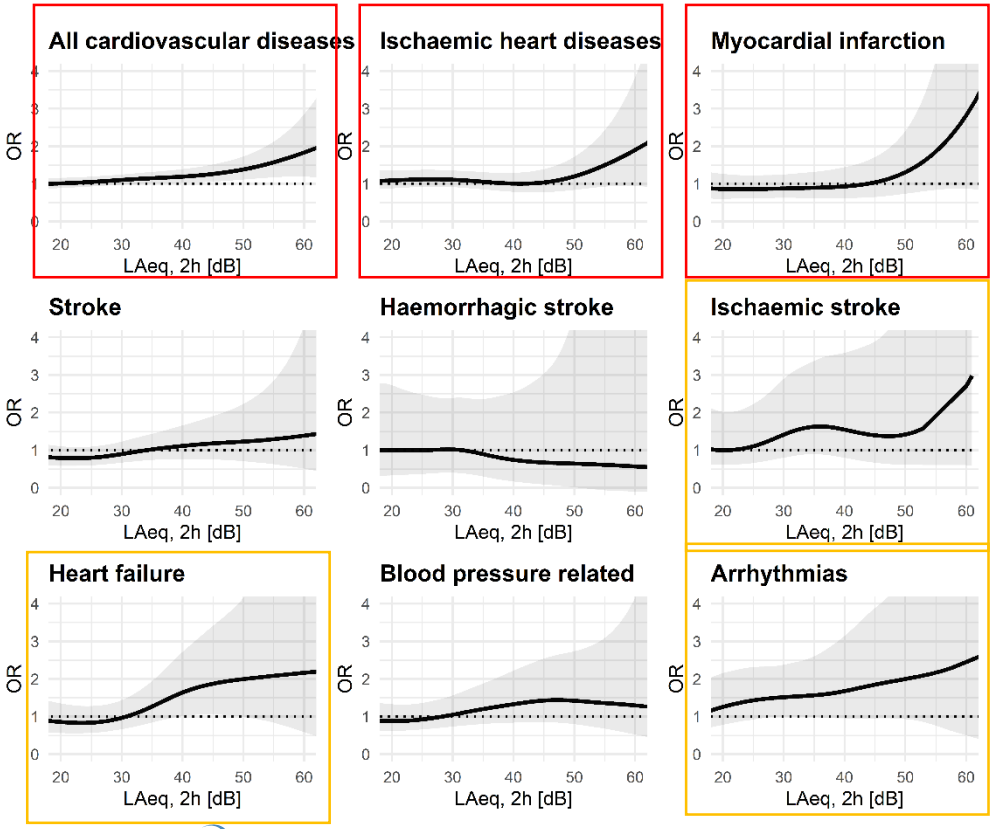
Can night-time aircraft noise trigger cardiovascular mortality?

Or cold, heat, air pollution?



Slide: Apolline Saucy

Nighttime deaths: noise exposure within 2 hours of death



- Continuous increase in risk for all CVD and arrhythmias
- Indications for a thresholds for ischaemic heart diseases, myocardial infarction and heart failure
- No association between nighttime noise and daytime deaths

Conditional logistic regression adjusted for NO2, temperature, precipitation, and holiday

Saucy et al, EHJ, 2021

SAPALDIA
Swiss study on Air Pollution and Lung Disease in adults

- **Outcome**
  Diabetes: 110 incident cases between 2001 and 2011 in 2'631 persons
  Depression: 410 incident cases between 2001 and 2011 in 4'581 persons
  (Respiratory diseases, arterial stiffness)

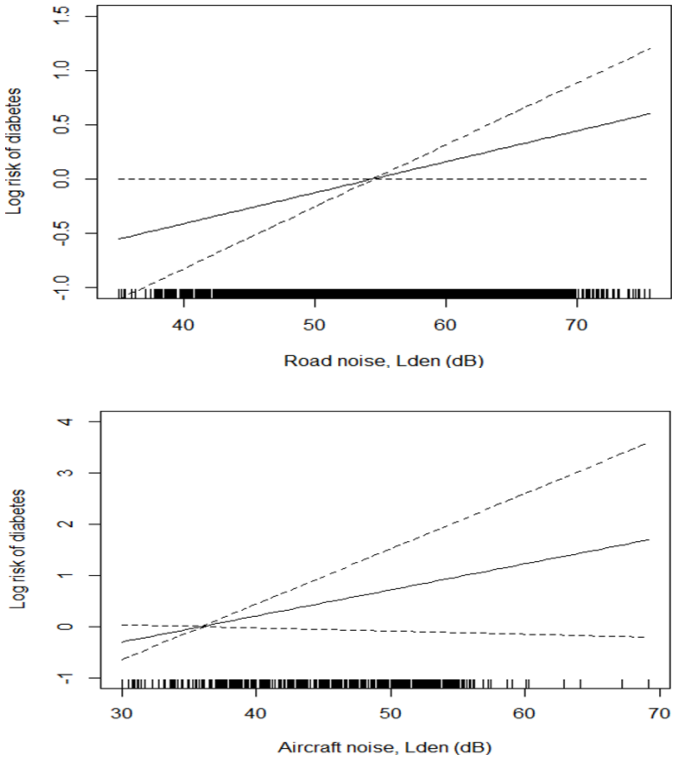
Diabetes

Source	Relative Risk per 10dB (%)	95% CI	
L_{den} road	1.35	1.02	1.78
L_{den} air	1.86	0.96	3.59
L_{den} railway	0.94	0.71	1.24

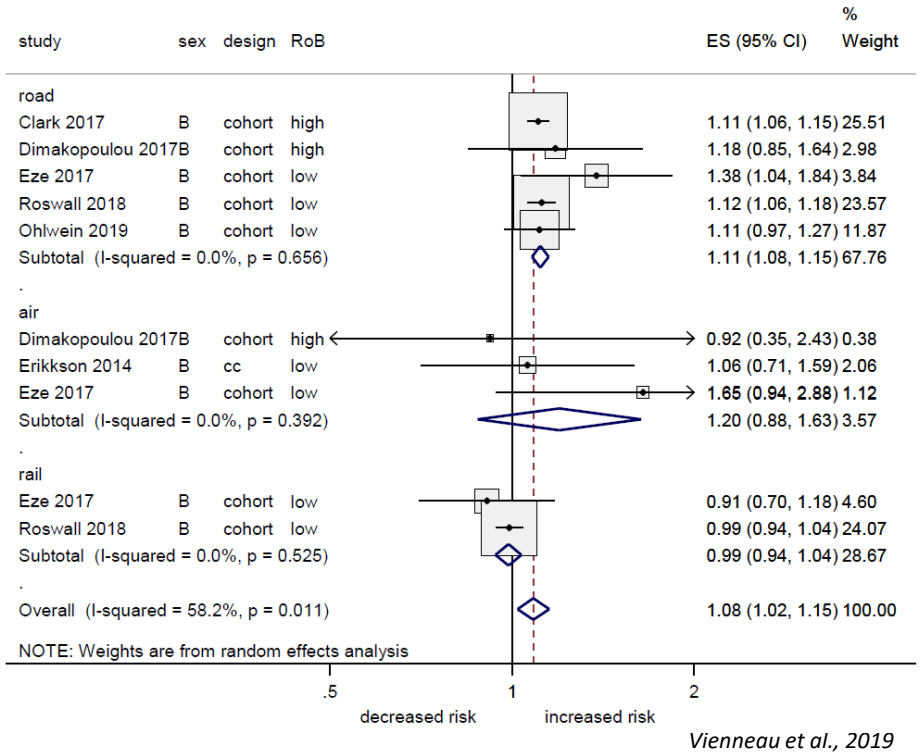
Eze et al. Int J Epidemiol, 2017

- **Statistical analysis**
  Multi-exposure model for Lden (road, rail, air) adjusted for many socio-demographic and lifestyle factors (e.g. smoking, alcohol, physical activity etc.) as well as air pollution.

Exposure-response

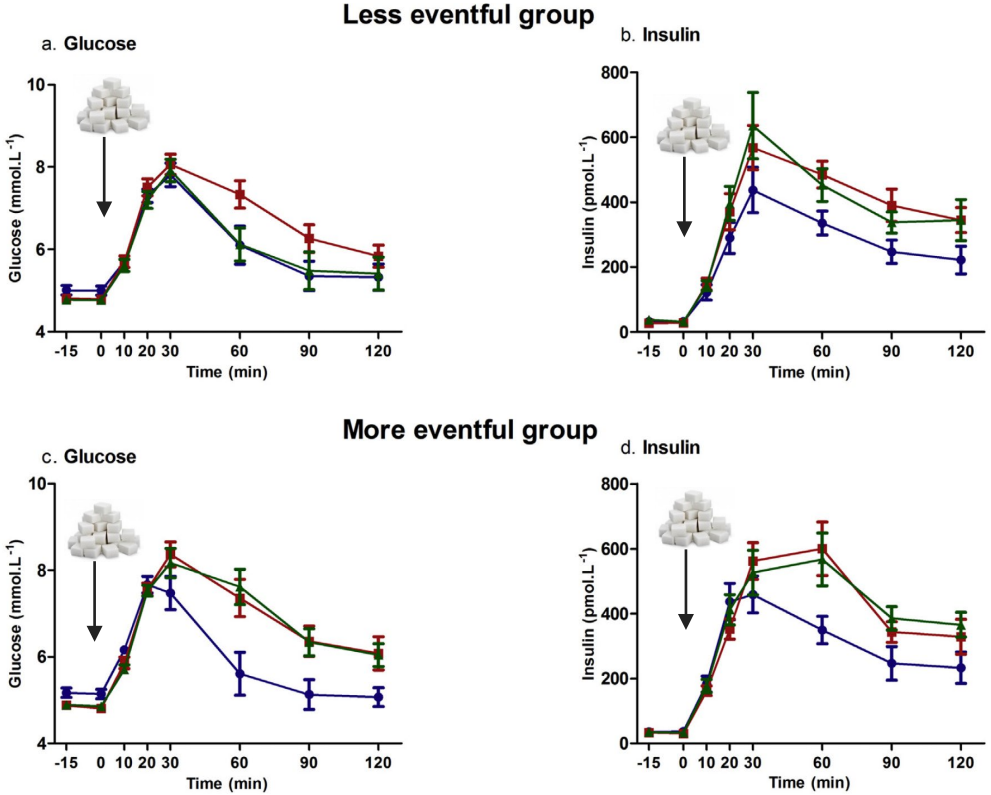


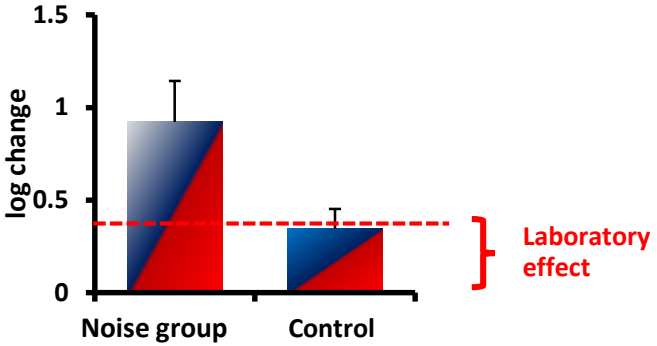
Meta-analysis



Vienneau et al., 2019

Randomized human experiment in the sleep laboratory: glucose response to a morning oral glucose tolerance test (OGTT)





Thiesse et al. Env Int, 2018

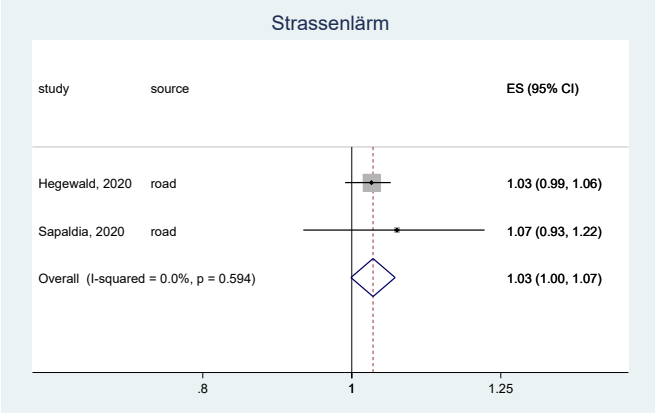
Depression

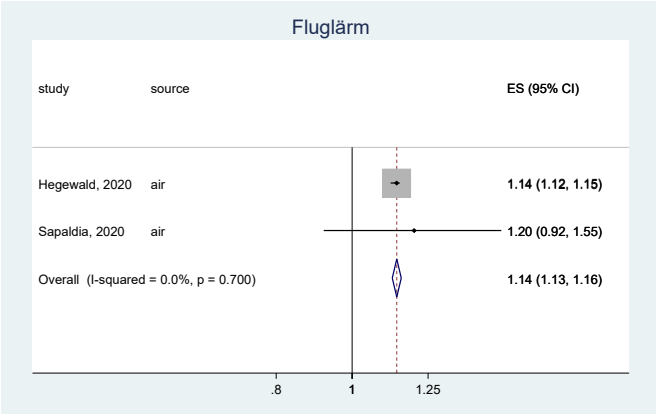
Sapaldia

Source	Relative Risk pro 10dB (%)	95% CI	
L_{den} road	1.07	0.93	1.22
L_{den} air	1.20	0.92	1.55
L_{den} railway	0.88	0.76	1.03

Eze et al. Environ Int, 2020

Meta-analysis





Community noise exposure above Lden of 70 dB(A) and Lnight of 60 dB(A) is associated with behavioural problems and cognitive development in a cohort of 3385 preschool children in Sao Paolo

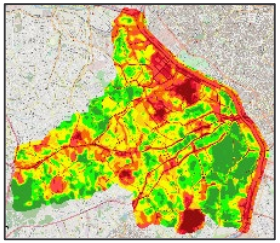
METHOD

São Paulo Western Birth Cohort (ROC)

Noise measurements in São Paulo

Land use regression model

Noise map

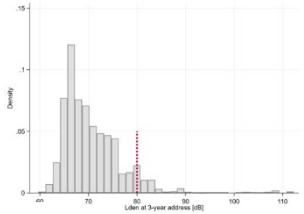


Behavioral Problems		Cognitive Development	
3 years	Strengths and Difficulties Questionnaire (SDQ)	3 years	PRIDI
6 years	Child Behavior Checklist (CBCL)	6 years	IDELA

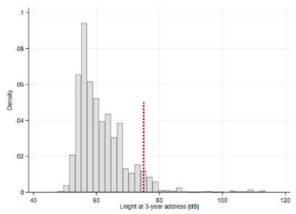
Multivariable cross-sectional and longitudinal regression models

Noise distribution

A Lden (mean=69 dB)



B Lnight (mean=60 dB)



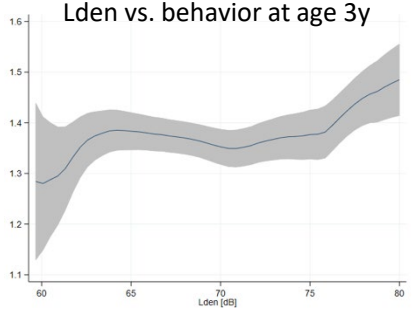
MEDICINA USP

University of Basel

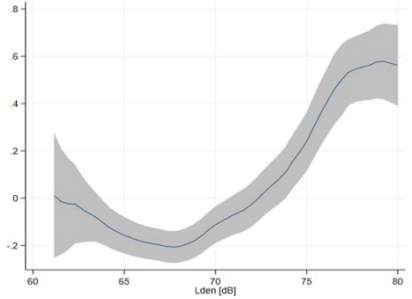
Swiss TPH
Swiss Tropical and Public Health Institute

OUTCOME

Lden vs. behavior at age 3y



Lden vs. behavior at age 6y



Raess et al, Env Int, 2021, https://doi.org/10.1016/j.envint.2021.1

Intermediate conclusions

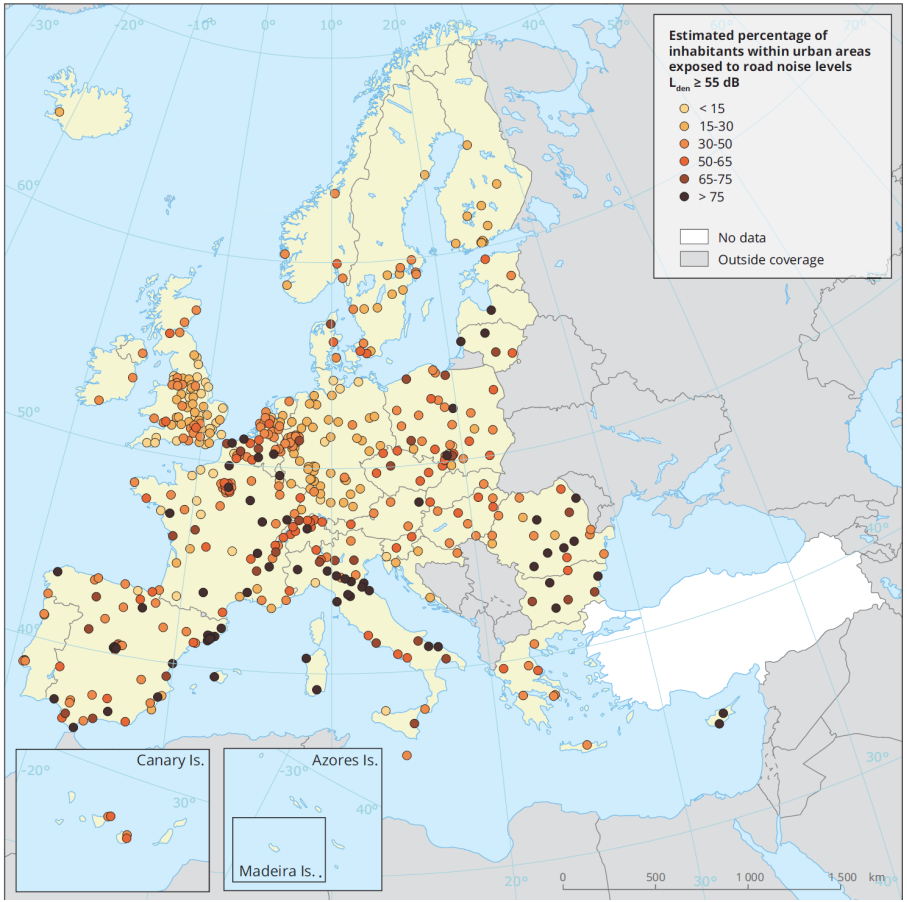
- In Europe, noise is the 2. most relevant environmental health burden after air pollution.
- Still relatively little research and little awareness (unless personally affected).
- Good evidence for effects on coronary heart diseases from chronic noise exposure.
- Substantial indications for other cardiovascular disease, diabetes, obesity, depression as well as behavioural problems and cognitive development in children.
- Indications for acute cardiovascular damage.
- Little habituation to noise from physiological point of view.
- Health effects occur also in people who are not noise annoyed.

Environmental noise in Europe — 2020

ISSN 1977-8449

25 1994-2019 European Environment Agency

Map 2.1 Estimated percentage of inhabitants within urban areas, exposed to road noise levels $L_{den} \geq 55$ dB in 2017



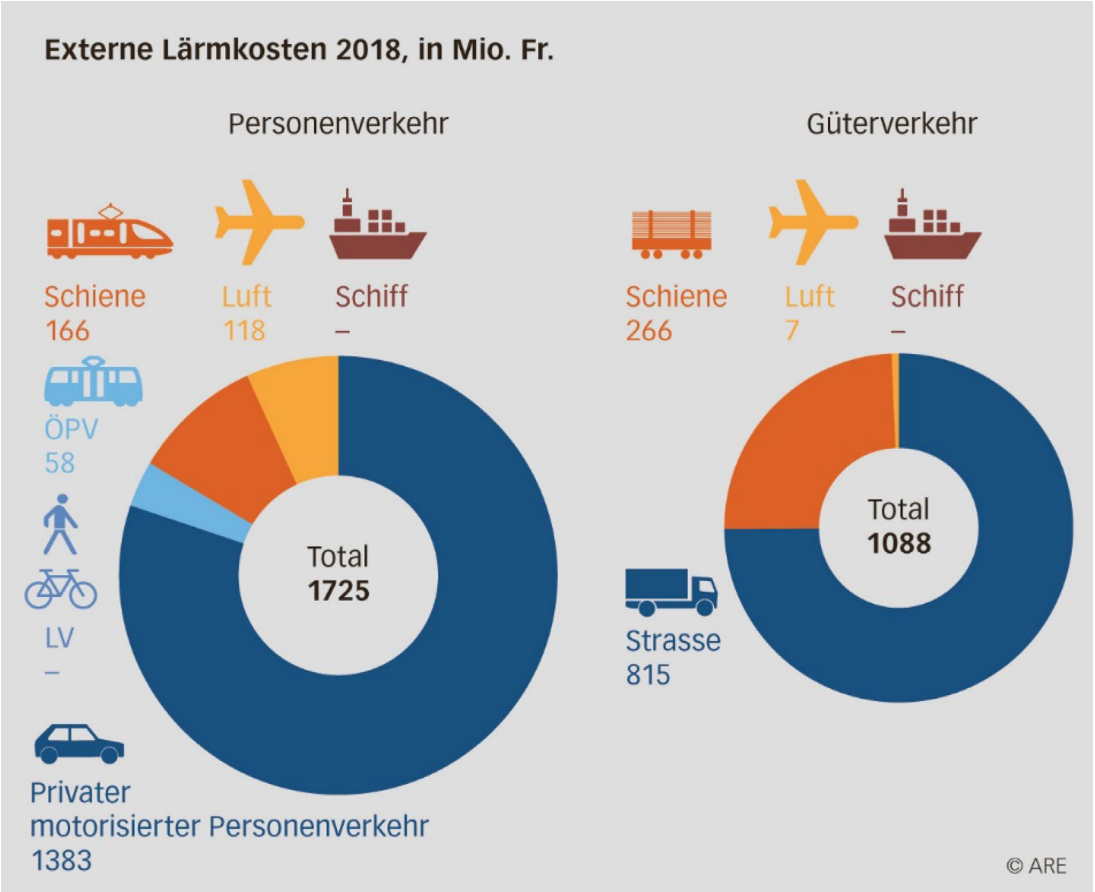
Health Impact in Europe

Table 3.5 **Estimated number of people suffering from various health outcomes due to environmental noise in 2017, EEA-33 (Turkey not included)**

		High annoyance	High sleep disturbance	Ischaemic heart disease	Premature mortality [a]	Cognitive impairment in children
Inside urban areas	Road	12 525 000	3 242 400	29 500	7 600	
	Rail	1 694 700	795 500	3 100	800	
	Air	848 300	168 500	700	200	9 500
	Industry	87 200	23 400	200	50	
Outside urban areas	Road	4 625 500	1 201 000	10 900	2 500	
	Rail	1 802 400	962 900	3 400	900	
	Air	285 400	82 900	200	50	2 900
	Total [b]	**21 868 500**	**6 476 600**	**48 000**	**12 100**	**12 400**

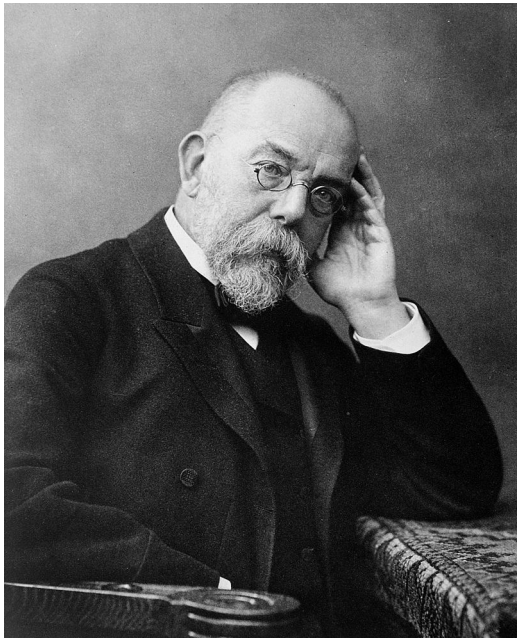
At least 20 % of the EU population live in areas where traffic noise levels are harmful to health. These significant health impacts are most likely to be underestimated, with new WHO evidence

External costs of noise



https://www.are.admin.ch/are/de/home/medien-und-publikationen/publikationen/verkehr/externe-kosten-und-nutzen-des-verkehrs-in-der-schweiz.html

Prevention and regulation

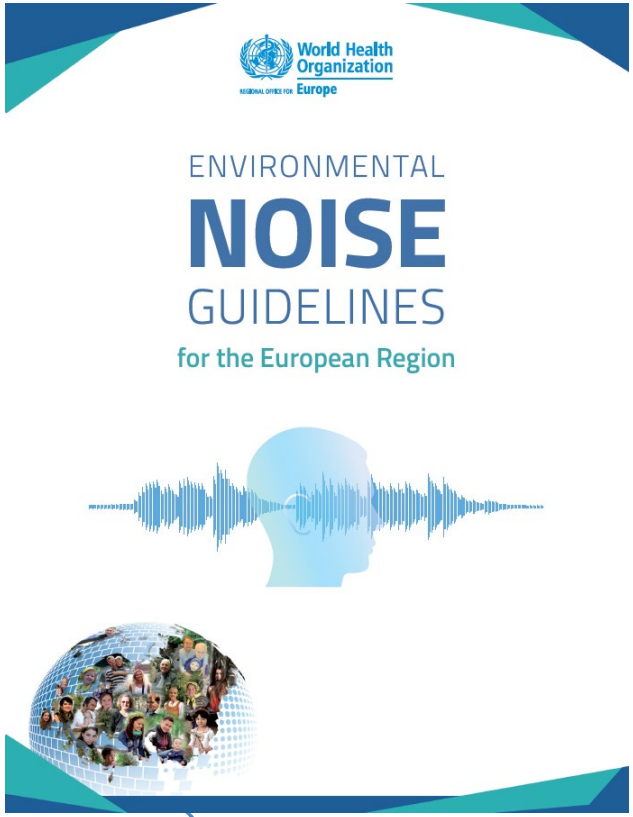


Source: de.wikipedia.org

One day, mankind will fight noise as relentlessly as Cholera and the Pest.

Robert Koch (1843 - 1910)

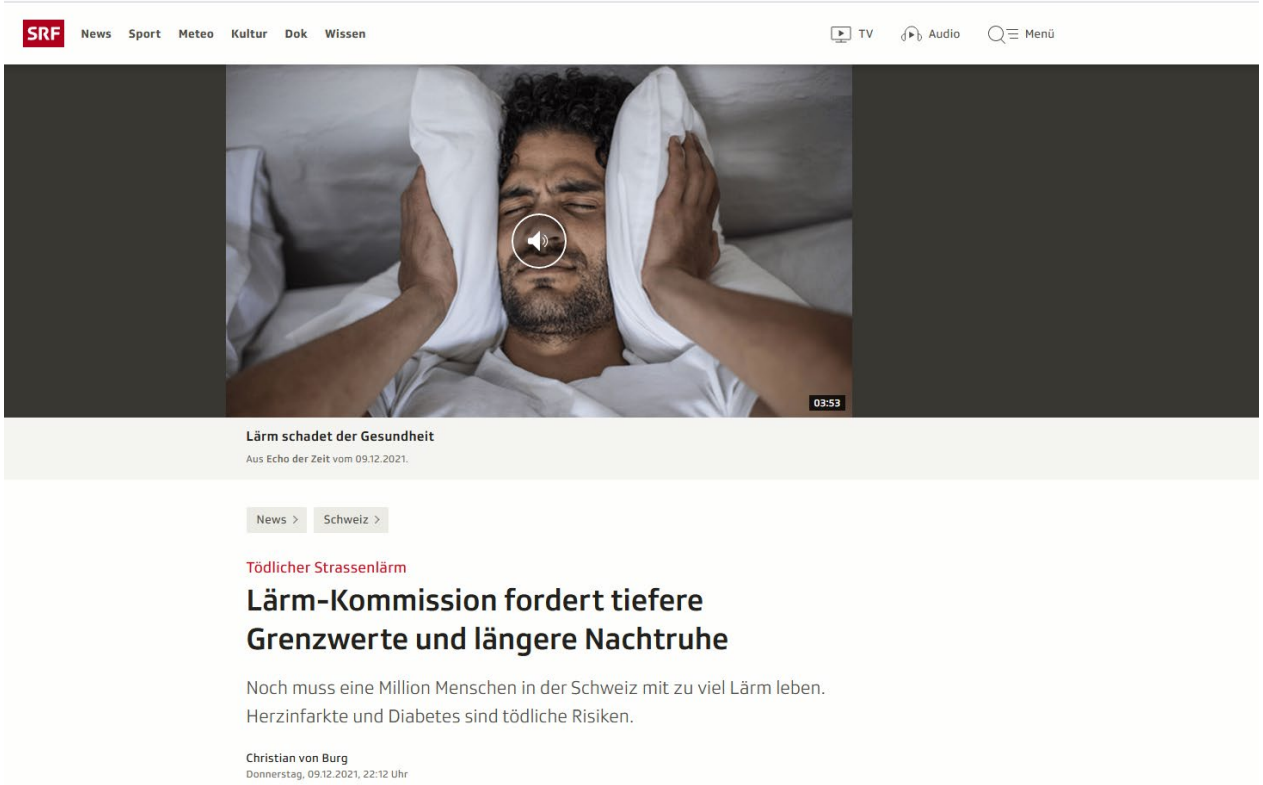
WHO noise guidelines for the European Region, 2018



Source	night	Lden
Road	45 dB	53 dB
Railway	44 dB	54 dB
Aircraft	40 dB	45 dB
Wind turbine	-	45 dB

Swiss regulatory limits:
night: 45-60 dB
Day: +10 dB

Federal Noise Abatement Commission has proposed new noise limits in 2021



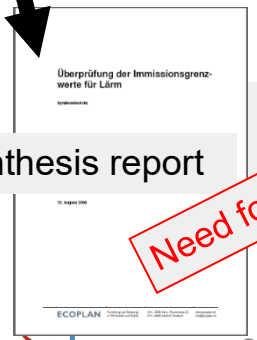
A long journey…

Swiss noise ordonnance (LSV): 1987)
(Limits road rail: 1987, aircraft: 2001)

2008: EKLB/BAFU initiiert

"Preliminary study to review the immission limit values for noise"

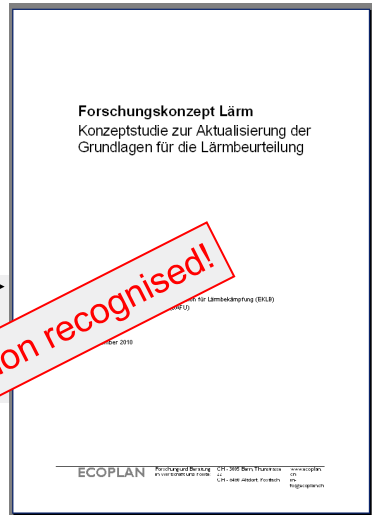
"Input papers"



2009: Synthesis report

Need for action recognised!

2010: Conzept study with work packages + financial needs



2010: Research concept EKLB

2011: No funding through UVEK ressources

Sinergia application 2013

SiRENE-Studie
2013-2020

2014-2018

Legal basis

- Federal Constitution Art. 74 - Environmental protection

  [1]The Confederation shall issue regulations on the protection of humans and their natural environment from **harmful** or **annoying** effects.

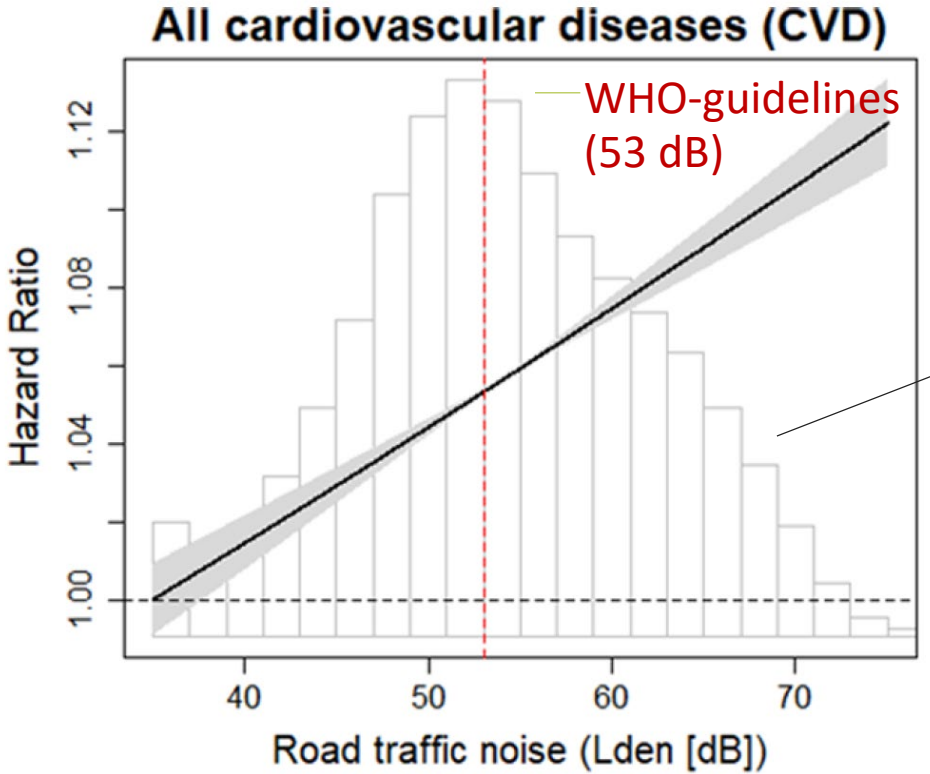
- Environmental law Art. 15 - ambient limit values for noise and vibrations

  The limit values for noise and vibrations shall be set in such a way that, according to the state of **scientific knowledge or experience**, exposure below these values do not **significantly** disturb **the well-being of the population.**

- Environmental law Art. 13 – ambient limits

  [2]It shall also take into account the effects on **vulnerable groups of people,** such as children, the sick, the elderly and pregnant women.

Deriving limits: the challenge



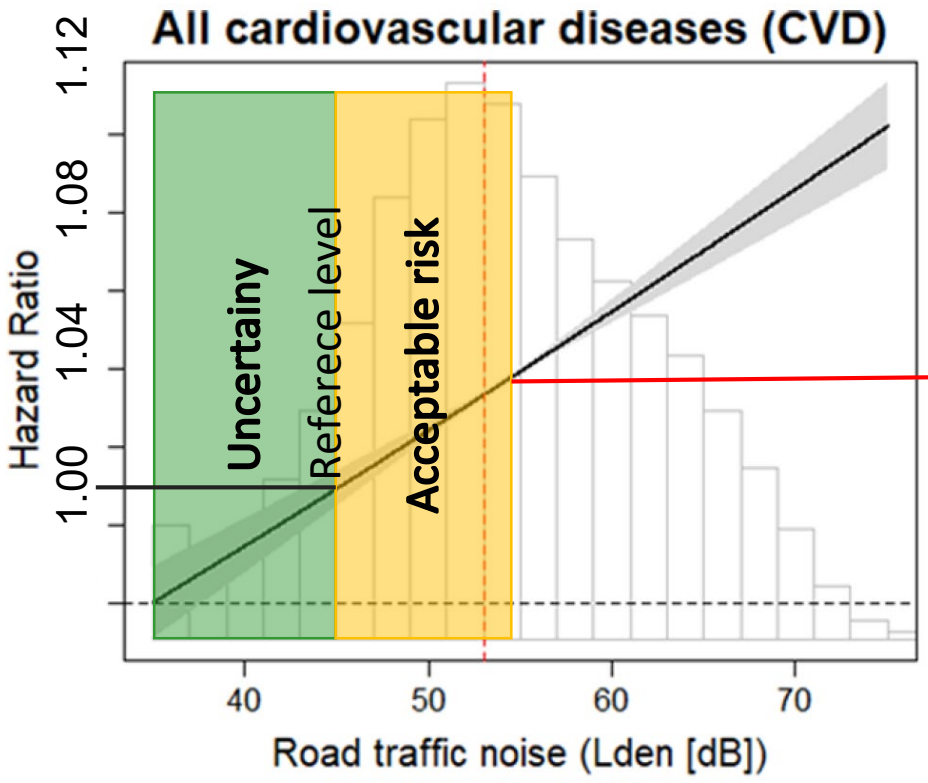
Non-parametric exposure-response curve

Histogram: Distribution of road traffic noise in CH

Threshold?

Vienneau et al, 2022
(https://doi.org/10.1016/j.envint.2021.106974)

General approach



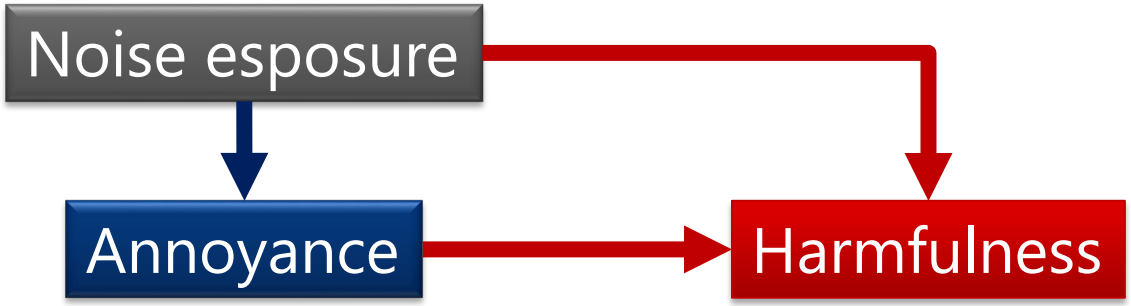
Same approach as WHO

Limit

Vienneau et al, 2022
(https://doi.org/10.1016/j.envint.2021.106974)

Methods

- **Science-based** and objective derivation with the same approach as the WHO in the development of the "Environmental Noise Guidelines“, 2018.
- Separate assessment of **road, rail and aircraft noise**.
- **Subjectively perceived** noise effects are relevant to health and have the same weight as **somatic** health effects**.**



Deriving scientific evidence

- Evidence evaluation criteria:
  - Causal relationship plausible from a pathophysiological point of view, evidence evaluation criteria WHO.
  - Solid exposure-response relationships exist.
  - In addition to international studies, there is at least one good-quality study from Switzerland.
  - Results from Swiss studies do not contradict the results from international meta-analyses (and vice versa).

- Derivation of exposure-response relationships for each outcome:
  - Meta-analysis of international data (50% weight)
  - Swiss study data (50% weight)

Accepted risks

Nuisance (self-reported)

- Noise annoyance
- Sleep disturbance

Diseases

- Cardiovascular system
- Diabetes

Accepted proportion of affected people:

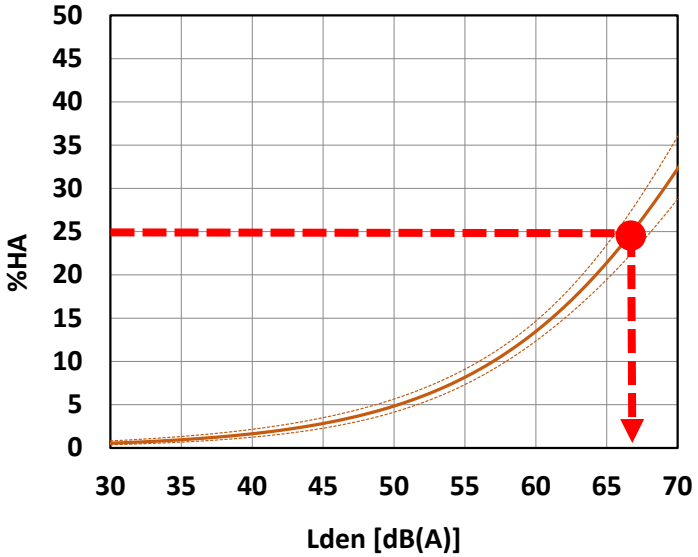
- 25% highly annoyed
- 15% highly sleep disturbed

Accepted relative excess risk:

- 5% ischemic heart disease incidence
- 2.5% cardiovascular mortality
- 20% diabetes incidence

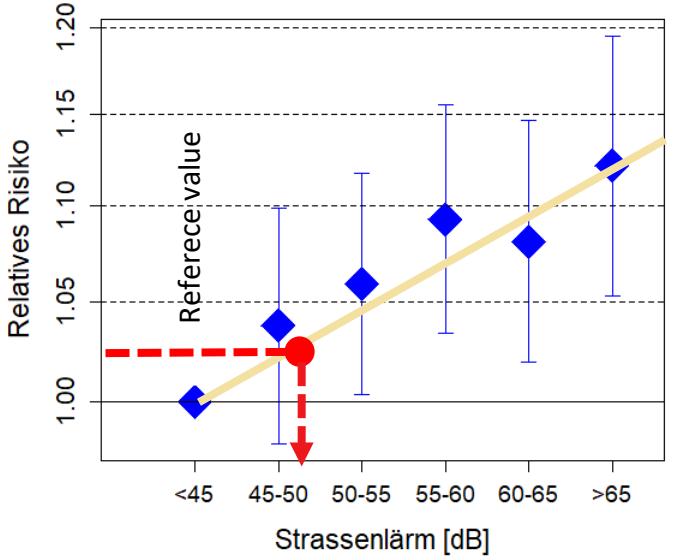
Definition of thresholds

Road traffic: 25% HA



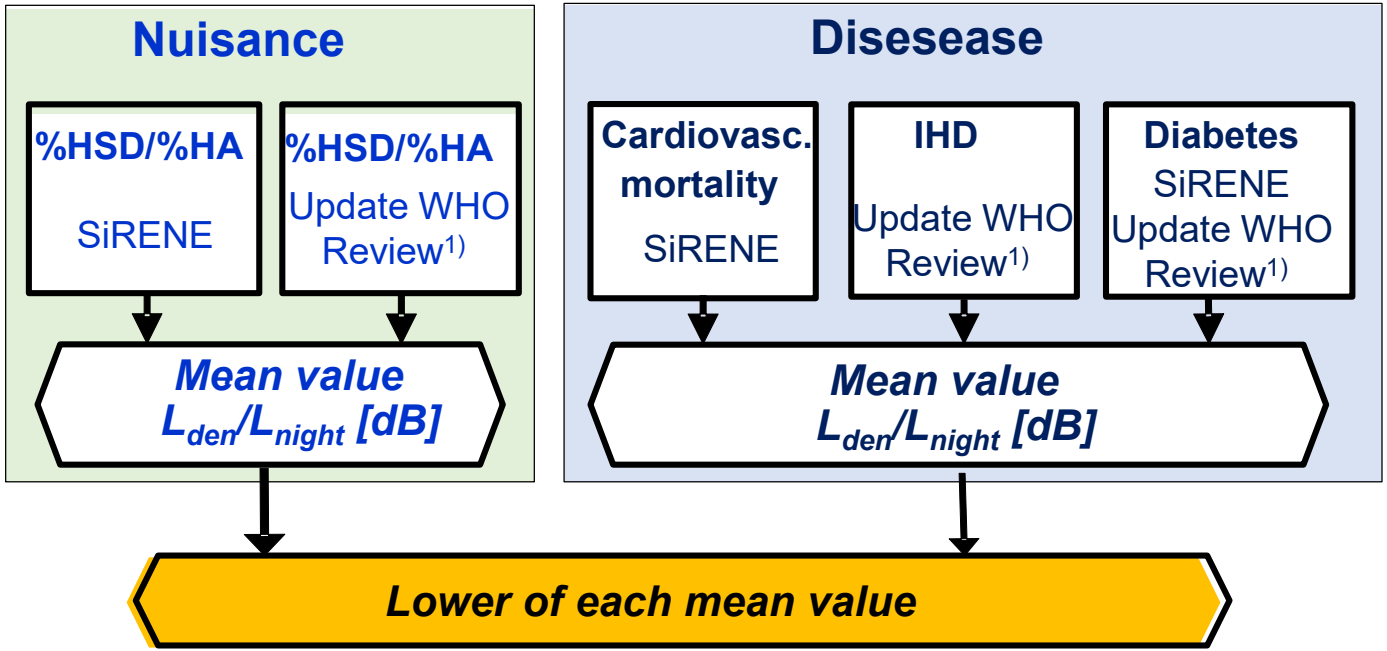
Brink et al, 2019
(https://doi.org/10.1016/j.envint.2019.01.043)

Road traffic:
2.5% increase in CVD mortality



Heritier et al, 2017
(https://doi.org/10.1007/s10654-017-0234-2)

Evidence synthesis



1) Vienneau et al., 2019. https://edoc.unibas.ch/70857/

Overview Regulatory limits

	CH day	CH night	WHO Lden	WHO night
Road	60	52	53	45
Railway	59	56	54	44
Aircraft	54	43*	45	40

Relevant effects

Nuisance

Adverse effects

Nuisance and adverse effects

*Night hours aircraft (flight curfew: 0.00-5.00):

22.00-23.00: 52 dB

23.00-24.00: 49 dB

05.00-06.00: 49 dB

06.00-07.00: 52 dB

Additional recommendations

- Application
  Focus on residential; more flexible for rooms without long-term residential purpose (office, hotel)
- Point of measurement
  Loudest point on facade ➔ Pressure on mitigations measures at source
- Time periods
  Extension of the night period to 9 hours (22-07 h) ➔ Protection of sleep
  Additional single hour limit between 06 and 07 o'clock for aircraft noise
- Uniform protection of residential areas
  Same limits in sensitivity areas II and III
- No corrections due to little traffic
  → Road and railways noise

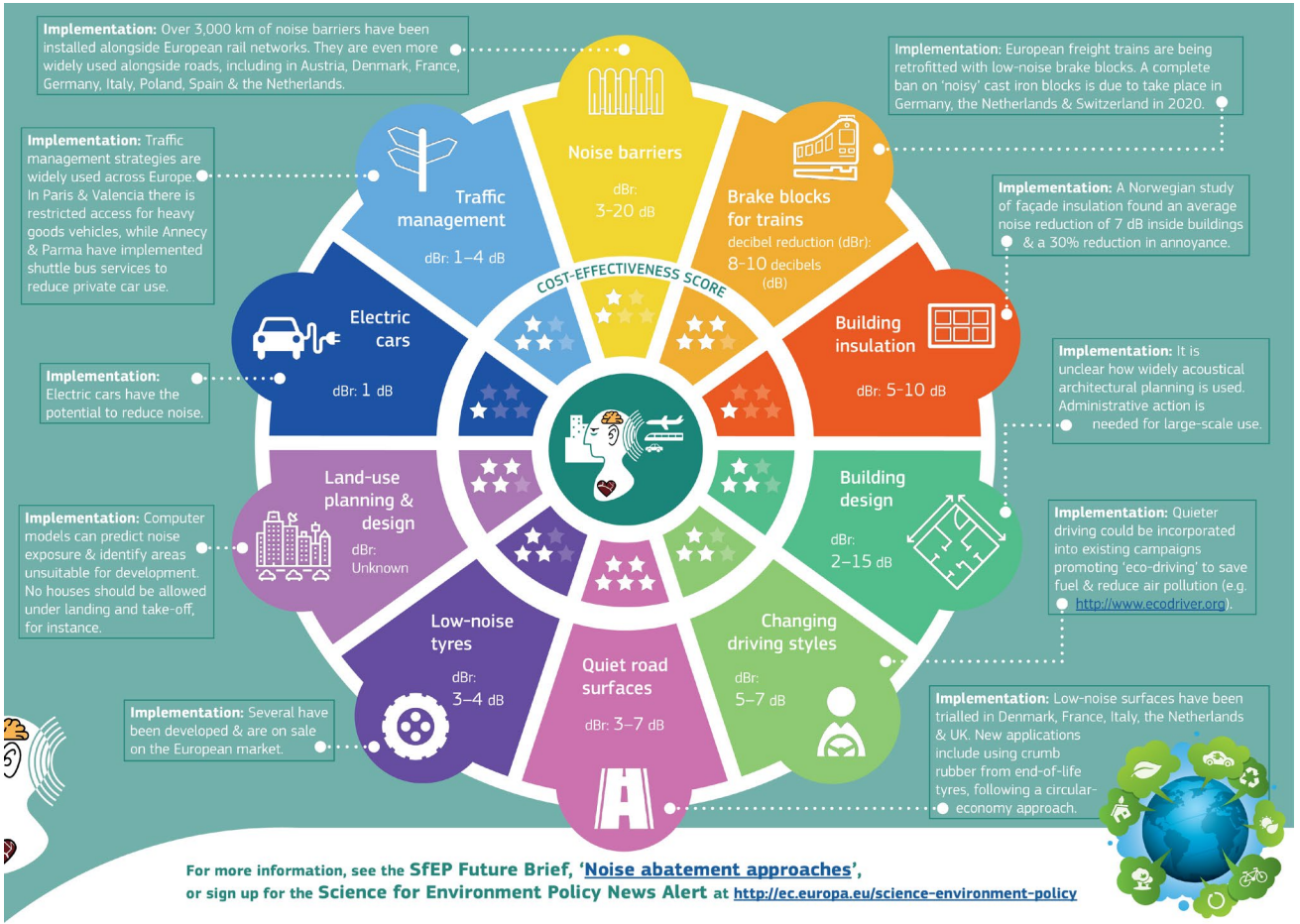
Summary of proposed new noise guidelines

- The recommendation is based on the current state of scientific knowledge.
- The proposed limit values protect the population better from noise.
- The health consequences of traffic noise cause CHF 2.8 billion in external costs every year. Investments in noise protection are worthwhile.
- Noise abatement at the source is central.

The existing limits for traffic noise underestimate the negative effects of noise on the population and no longer meet the requirements of the Environmental Protection Act.

➔ Report is with the Federal Council

Noise mitigation at the source



Swiss TPH

Source: Timo Essner

Thank you for your attention

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