

The impacts of night flights on health

UECNA Online Seminar

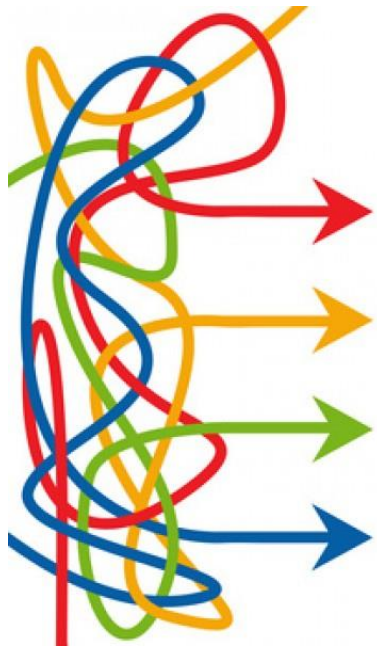
21st October 2021

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Agenda



1. Stress-related health effects of aircraft noise
2. WHO: Environmental Noise Guidelines & DALYs
3. Aircraft-noise induced sleep disturbances
4. Long-term effects of nocturnal aircraft noise
5. Exposure response relationships for sleep disturbance
6. The case of Frankfurt:
 - Effects of night flight ban, introduced in 2011

What are the health effects of noise?

Auditory effects

- hearing impairment



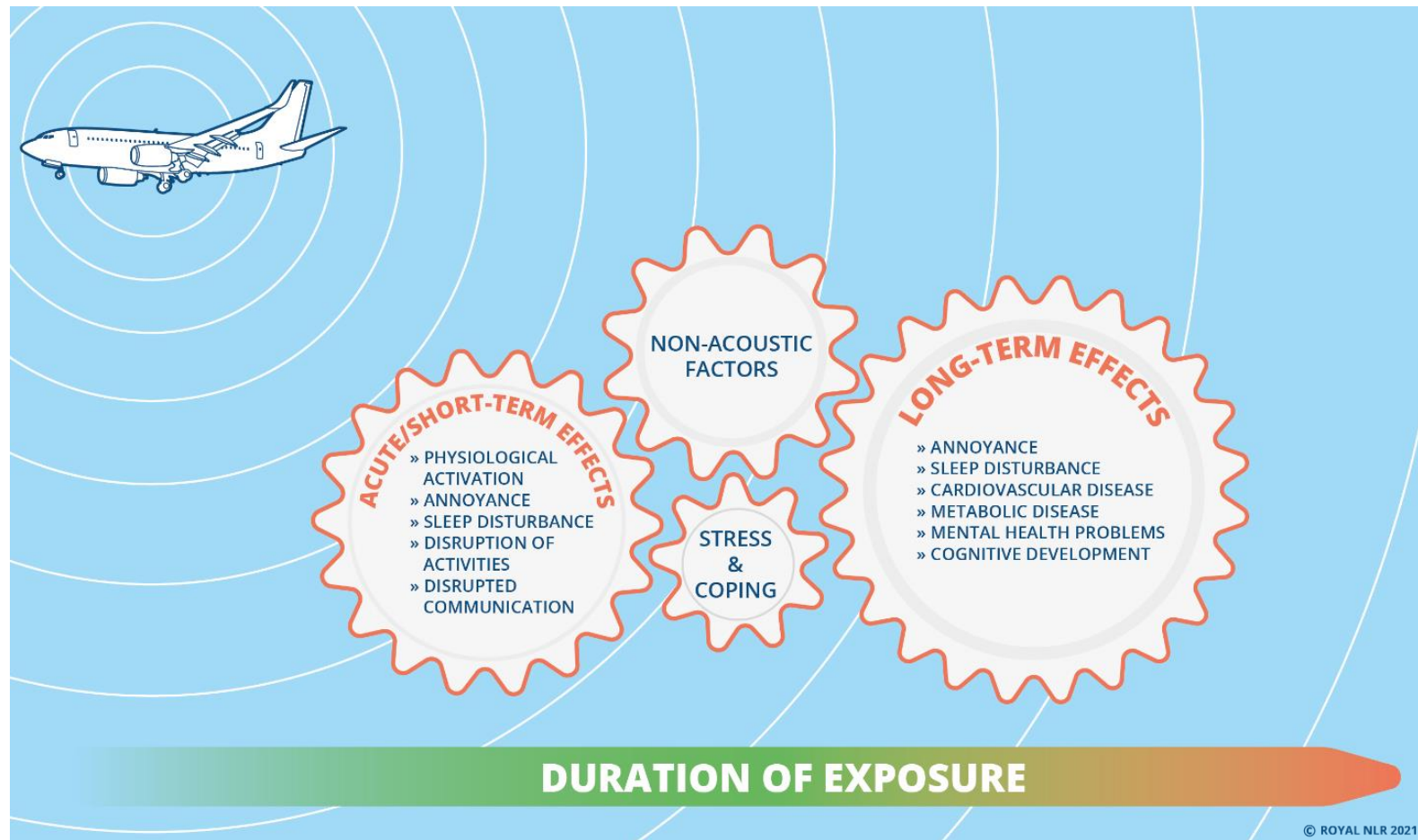
Non-auditory effects

- stress-related effects
outside the hearing system

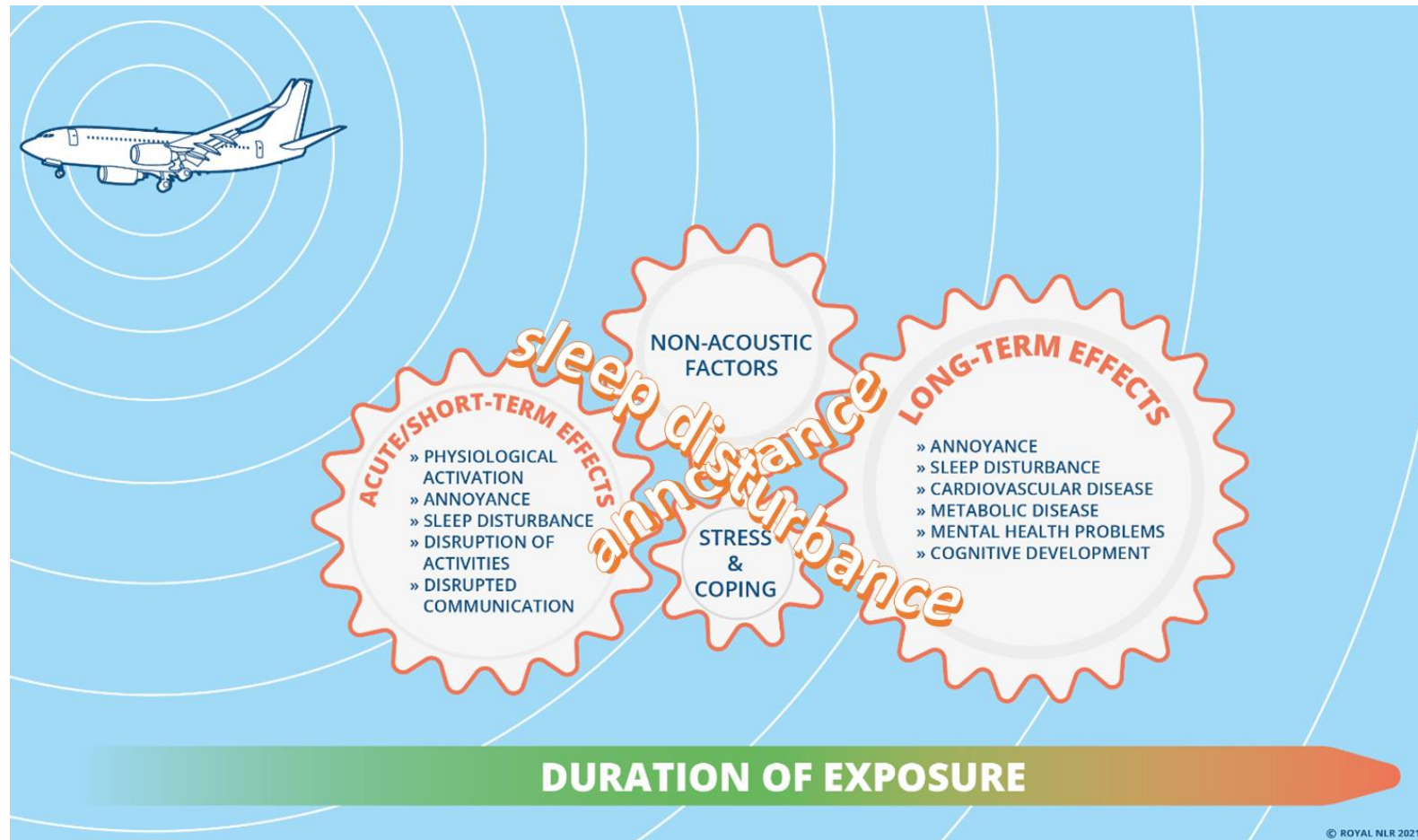


M. Basner, W. Babisch, A. Davis, M. Brink, C. Clark, S. Janssen, S. Stansfeld: Auditory and non-auditory effects of noise on health. The Lancet 383 (2014) 1325–1332.

Aircraft noise is an environmental stress factor

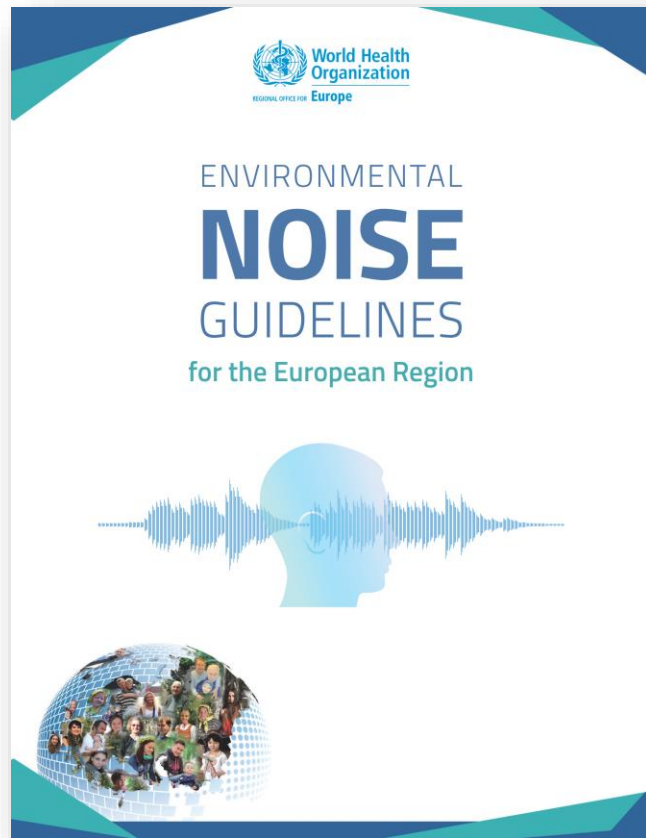


Aircraft noise is an environmental stress factor



WHO

Environmental Noise Guidelines 2018



Critical health outcomes

- Annoyance
- Sleep disturbance
- Cardiovascular diseases
- Cognitive impairment
- Hearing impairment & tinnitus



WHO Guideline
exposure level

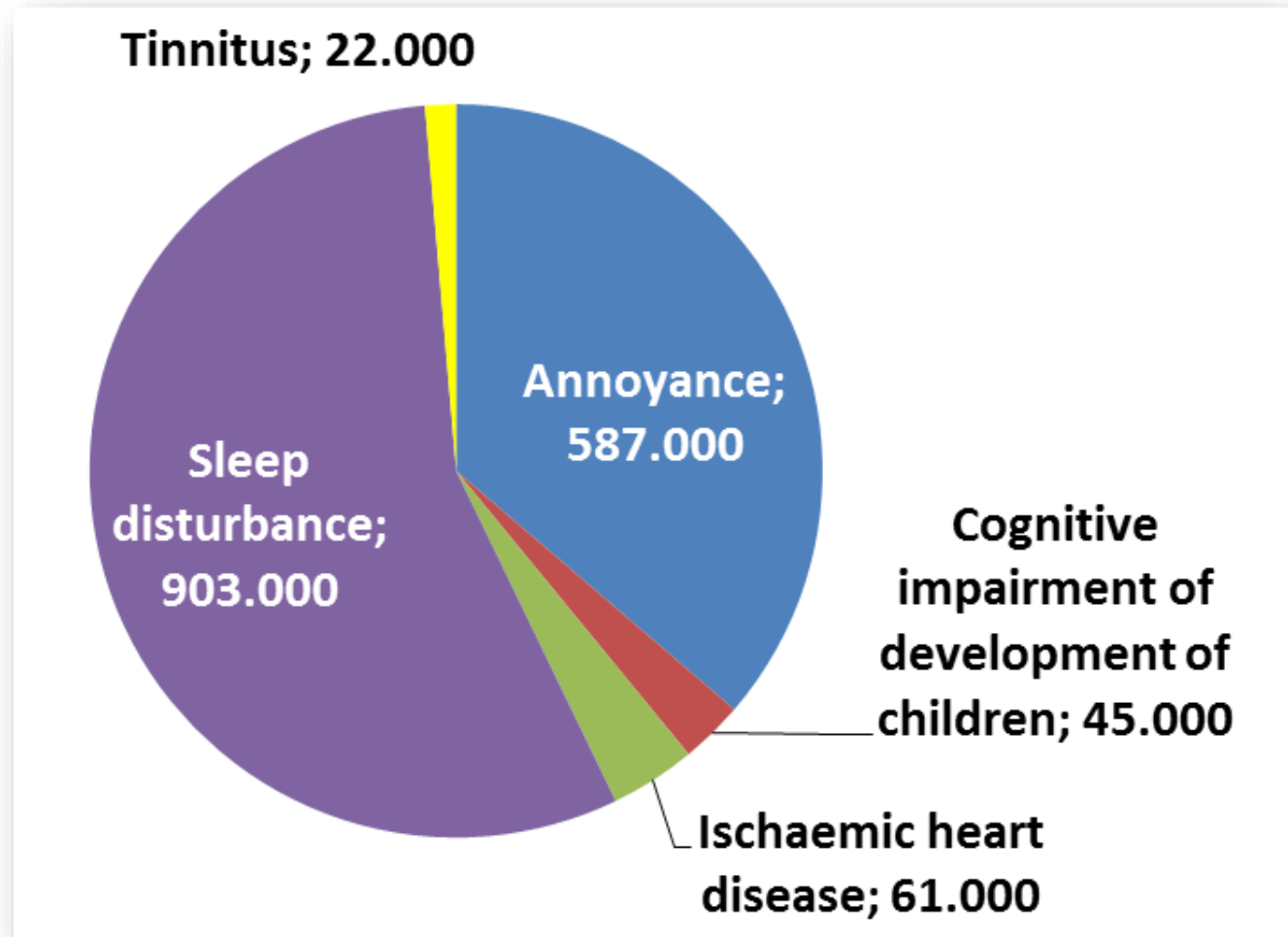
$L_{\text{den}} = 45 \text{ dB}$

$L_{\text{night}} = 40 \text{ dB}$

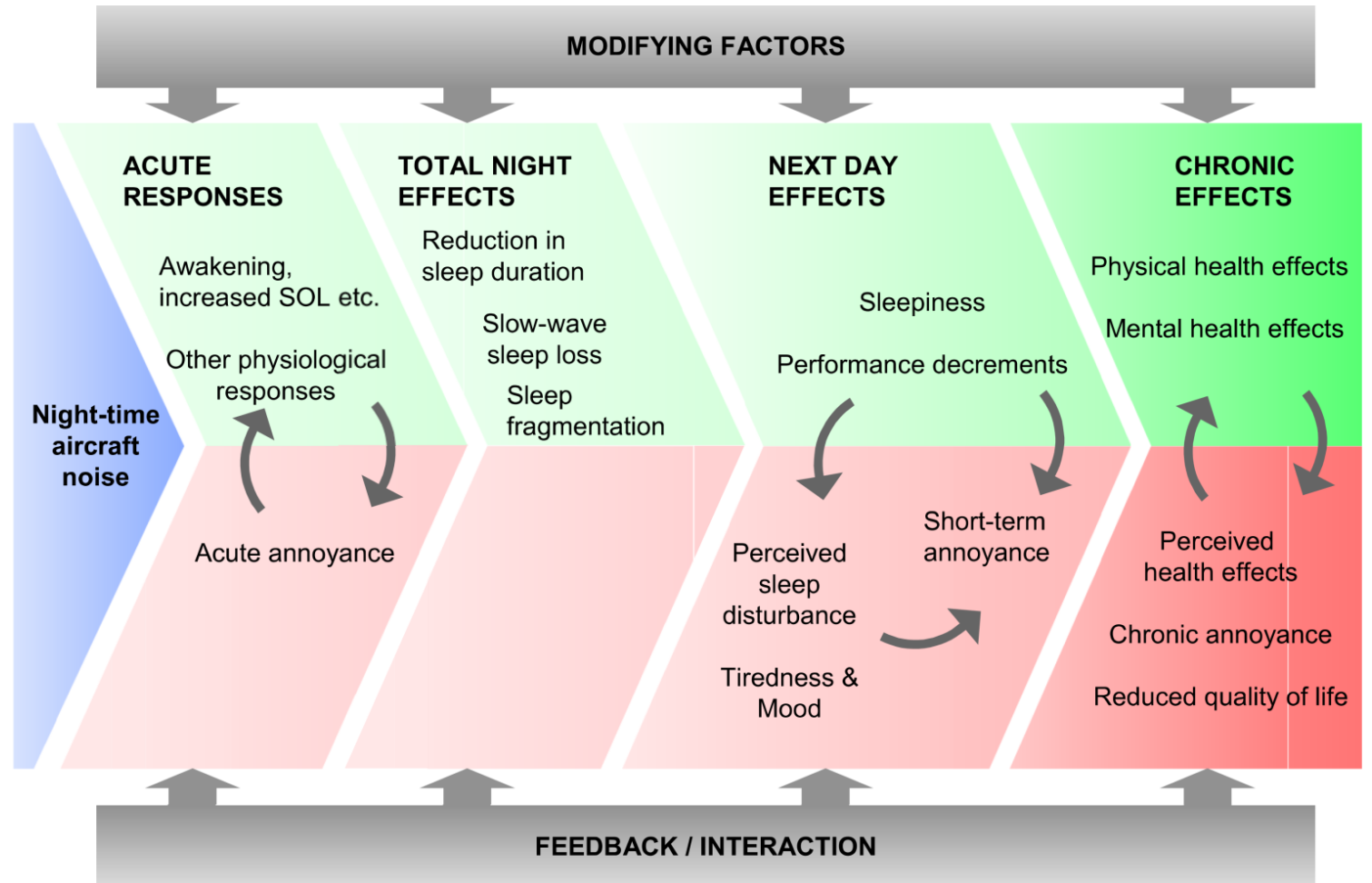
WHO (2011): Environmental Burden from Environmental Noise

DALYs lost:

Healthy (disability-adjusted) life years lost per year
in Western Europe due to transportation noise



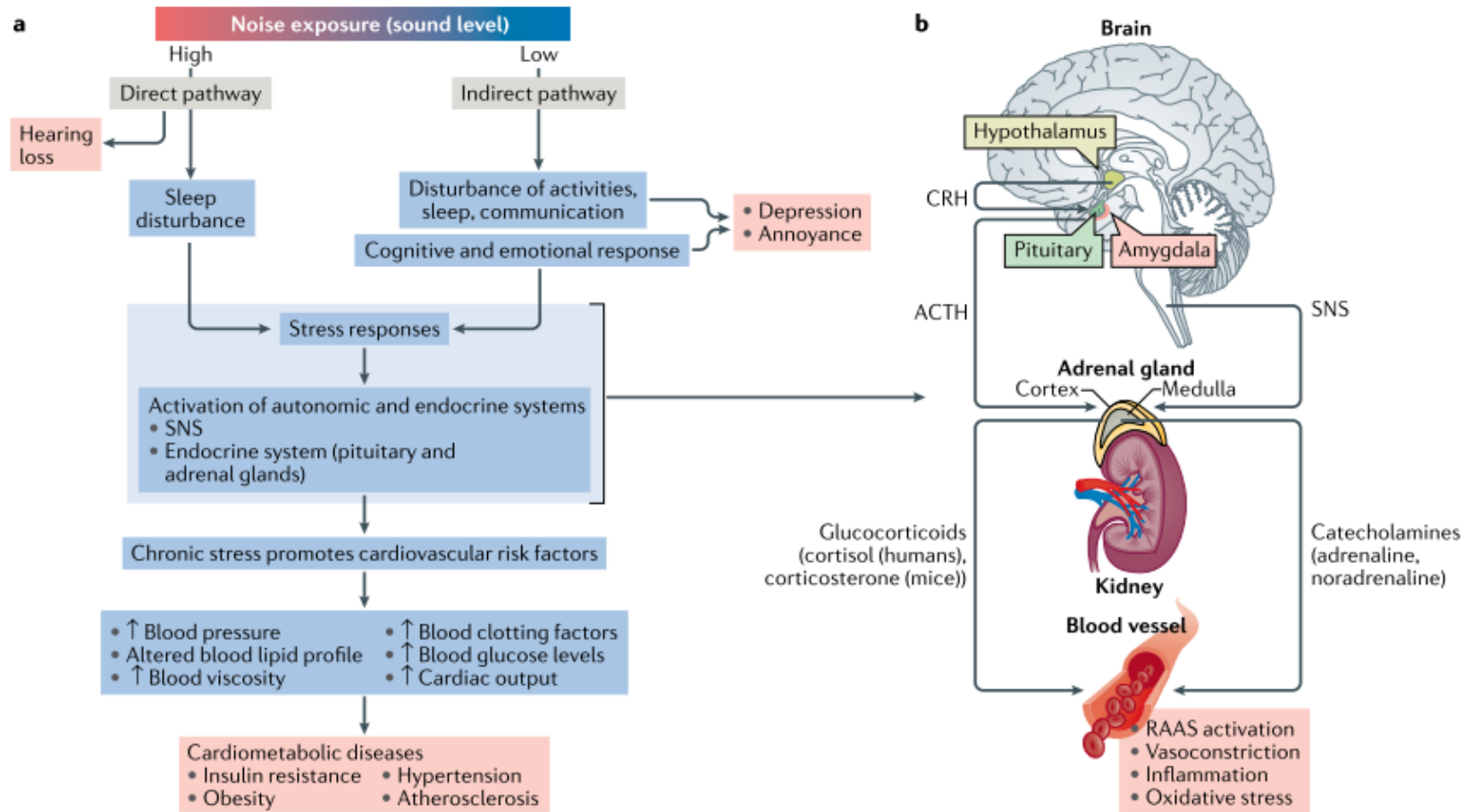
Impact of aircraft noise at night-time



Source: Porter, N.D., Kershaw, A.D. & Ollerhead, J.B. (2000). Adverse effects of night-time aircraft noise. R&D report 9964. London (UK): Civil Aviation Authority. - Modifiziert

Long-term effects of
nocturnal aircraft noise:

(Physiological)
noise–stress concept
and the adverse
health consequences
in humans

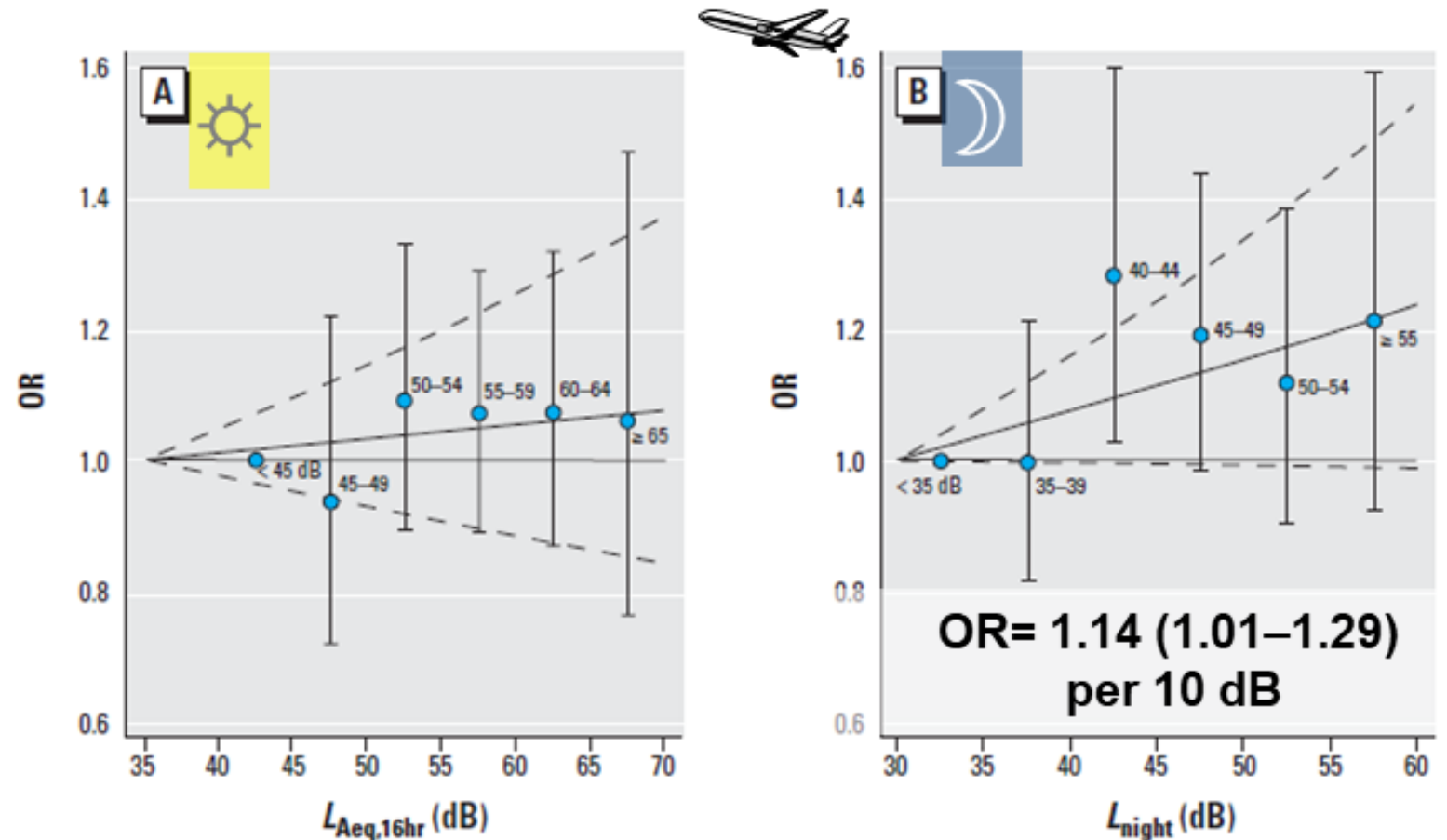


Source: Münzel, T., Sørensen, M. & Daiber, A. (2021). Transportation noise pollution and cardiovascular disease. *Nature Reviews Cardiology*, 18, 619-636.
<https://doi.org/10.1038/s41569-021-00532-5>

Long-term effects of
nocturnal aircraft noise:

HYENA study:

Aircraft noise at
night-time
increases the risk
of hypertension



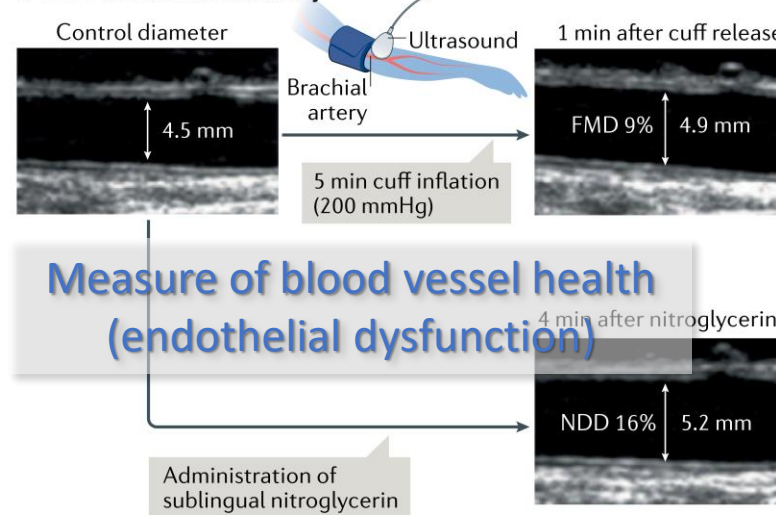
Source: Järup, L., Babisch, W., Houthuijs, D., Pershagen, G., Katsouyanni, K., Cadum, E., Dudley, M.L., Savigny, P., Seiffert, I., Swart, W., Breugelmans, O., Bluhm, O., Selander, J., Haralabidis, A., Dimakopoulou, K., Soutzi, P., Velonakis, M., Vigna-Tagliani, F., on behalf of the HYENA study team (2008). Hypertension and Exposure to noise near airports: the HYENA study. *Environmental Health Perspectives*, 116, 329-333.

Long-term effects of
nocturnal aircraft noise:

Physiological
measurements of
health effects of
nocturnal aircraft
(and railway) noise

Source: Münzel, T., Sørensen, M. & Daiber, A. (2021).
Transportation noise pollution and cardiovascular disease.
Nature Reviews Cardiology, 18, 619-636.
<https://doi.org/10.1038/s41569-021-00532-5>

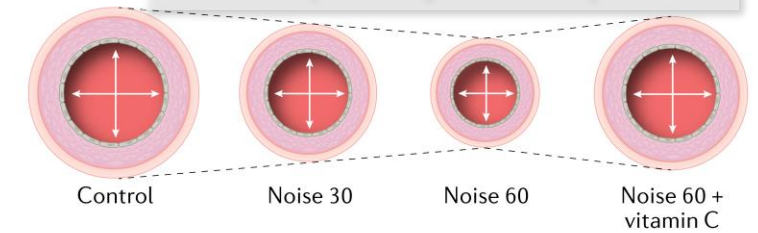
a FMD of the brachial artery



Measure of blood vessel health
(endothelial dysfunction)

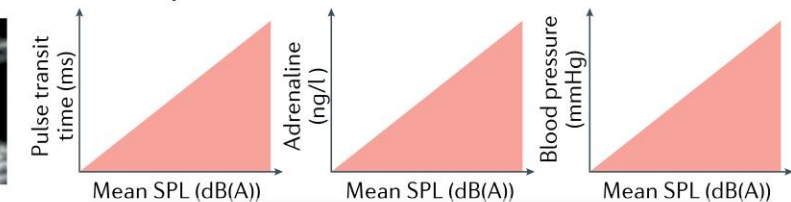
Administration of
sublingual nitroglycerin

b Adverse vascular effects of night-time noise



Vasodilatation (widening of
vessels) is impaired by noise

c Night-time noise increases arterial stiffness, sympathetic activity and blood pressure



Increase of adrenaline release

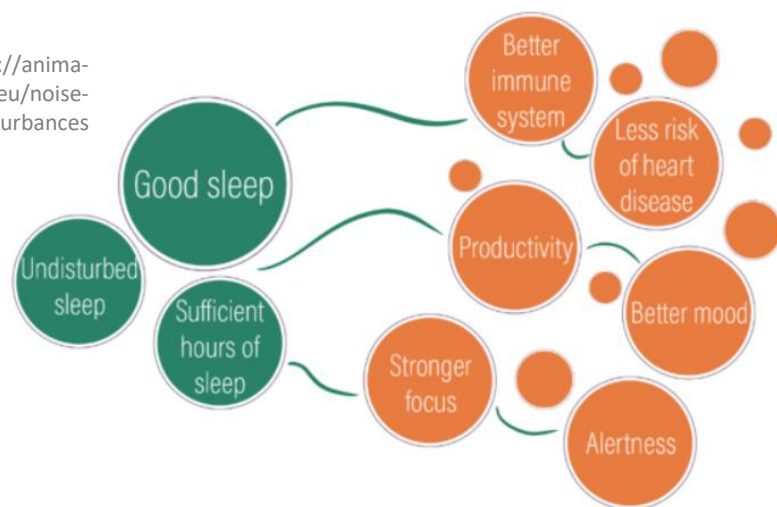
Exposure to aircraft noise at night increases

- sympathetic activation physiological stress response
- blood pressure risk factor for heart diseases
- arterial stiffness subclinical parameter for atherosclerosis
- markers of oxidative stress and inflammation risk factors of metabolic diseases

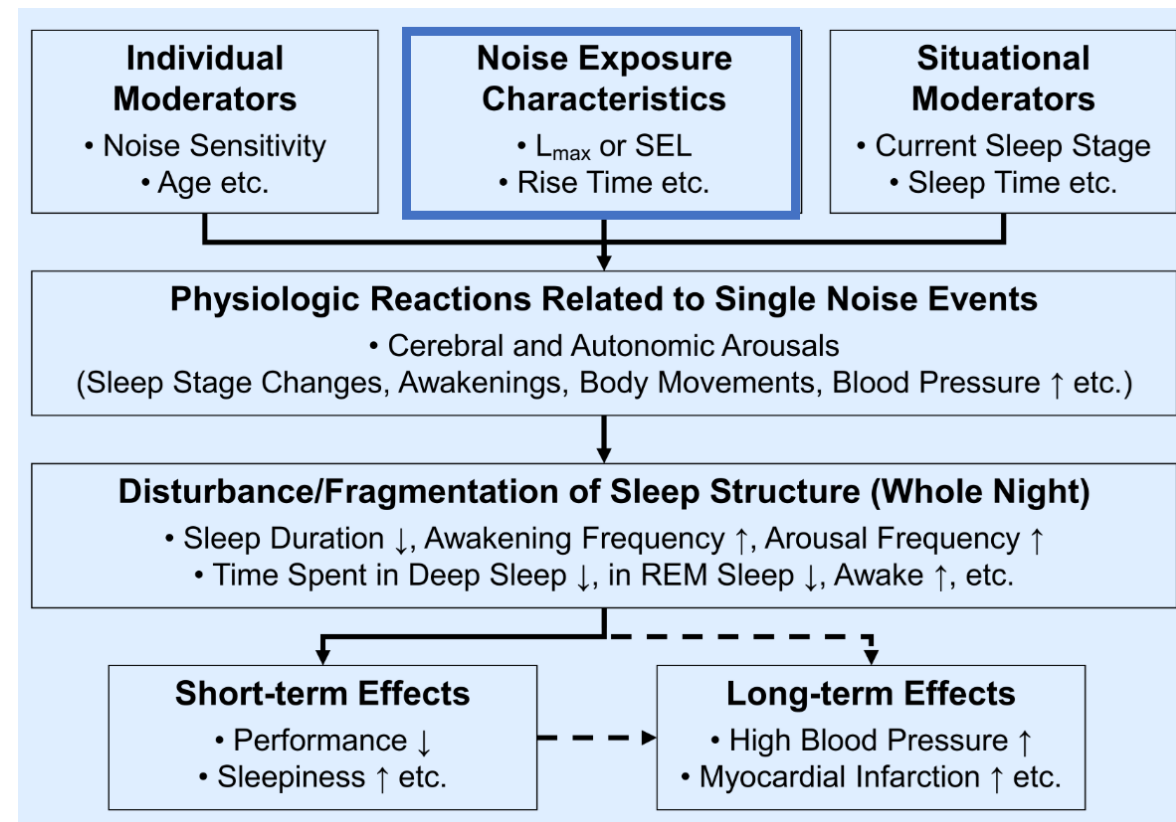
Noise effects on sleep



<https://anima-project.eu/noise-platform/sleep-disturbances>



- **Noise** has been shown to
 - fragment sleep,
 - reduce sleep continuity, and
 - reduce total sleep time



Source: Basner, M. & McGuire, S. (2018). WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep. International Journal of Environmental Research and Public Health, 15(3), 519. doi:10.3390/ijerph15030519.

Assessment of physiological and self-reported sleep disturbance

%HSD –
reported sleep
disturbances

Example:

In the **last 12 months** aircraft noise has disturbed you

- when falling asleep?
- when sleeping in the night?
- when awakening in the early morning?

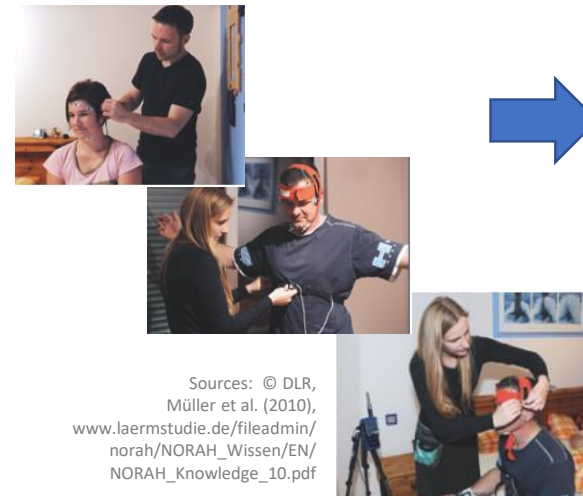
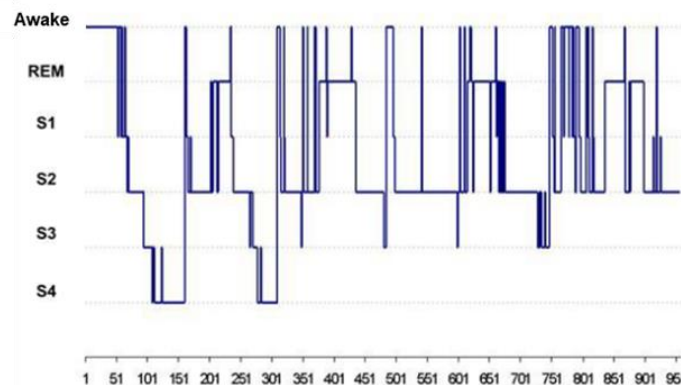
- 1) Not at all
- 2) Slightly
- 3) Moderately
- 4) Very
- 5) Extremely

*HSD
highly sleep
disturbed*

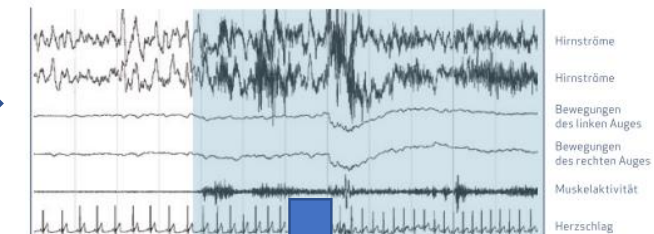
**p (additional
awakenings)**

sleep stage change
to awake or S1
in a 90 s time
window following
noise event onset

In 3 – 4 consecutive nights



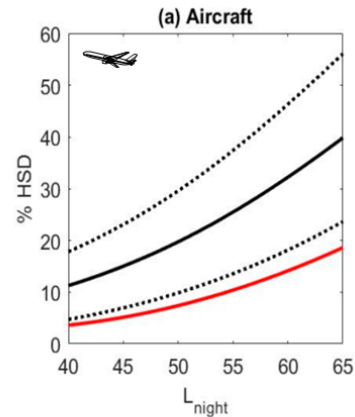
Sources: © DLR,
Müller et al. (2010),
www.laermstudie.de/fileadmin/norah/NORAH_Wissen/EN/NORAH_Knowledge_10.pdf



Physiological signals of
awakenings that will be
related to noise events

Exposure-response functions for the aircraft noise impact on sleep

%HSD –
reported sleep
disturbances



Black:
Basner & McGuire (2017)
WHO review

Red:
Miedema & Vos (2007)
EU re-analysis

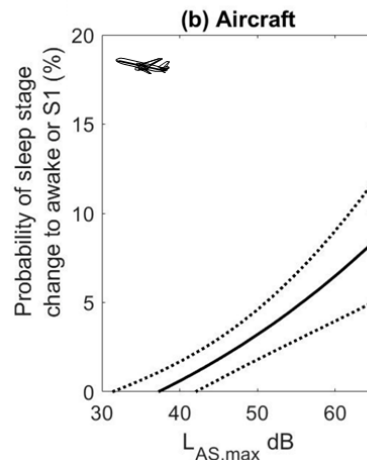
→ L_{night}

$$L_{\text{night}} = 38.3 \text{ dB}$$



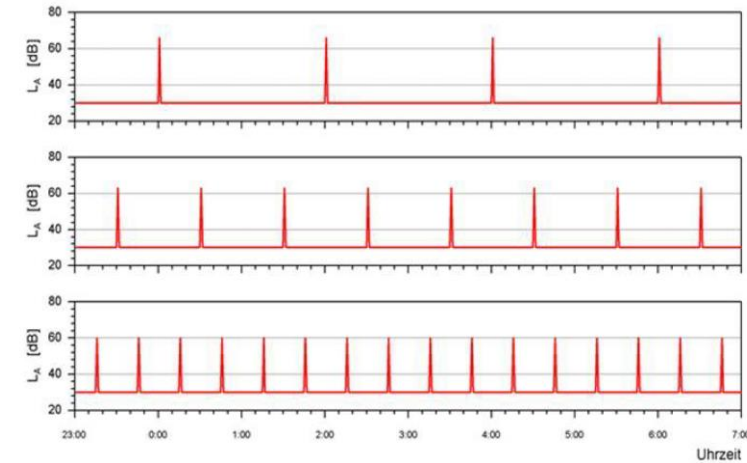
p (additional
awakenings)

sleep stage change
to awake or S1
in a 90 s time
window following
noise event onset



Basner & McGuire (2017)

→ $L_{\text{AS,max}}$
per event



4 x 66 dB(A)

8 x 63 dB(A)

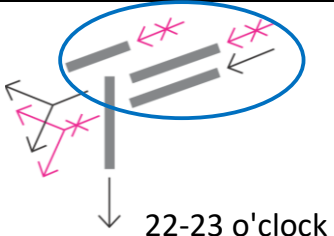
16 x 60 dB(A)

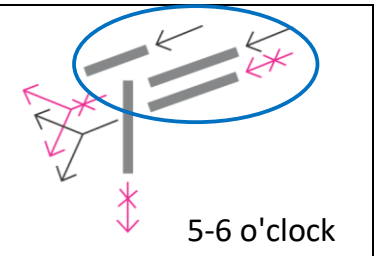
The case of Frankfurt Airport:

New runway and implication of a night flight ban

- October / November 2011 New (4th) runway Northwest
Night curfew: 11pm – 5am (mediation night)
- 2015 / 2016: Noise respite in shoulder hours of mediation night in order to prolong the noise relief to 7 hours

Westerly mode of operation

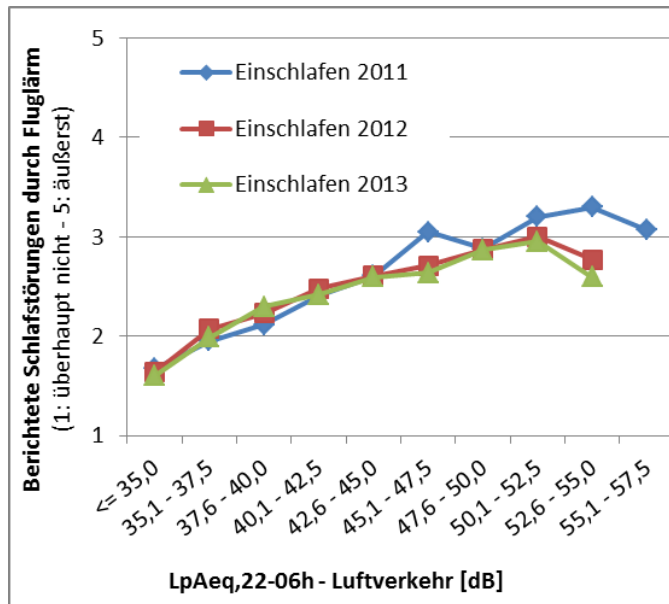
|  22-23 o'clock | Approaches 22-23h/5-6h, approaches & departures 23-5h | | | |
|--|---|---------|--------------------------|---------|
| | Runway | 22-23h | 23-5h | Relief |
| | Northwest (25R) | Respite | Ban on scheduled flights | 7 hours |
| | Center (25C) | Respite | | 7 hours |
| | South (25L) | | Respite | 7 hours |



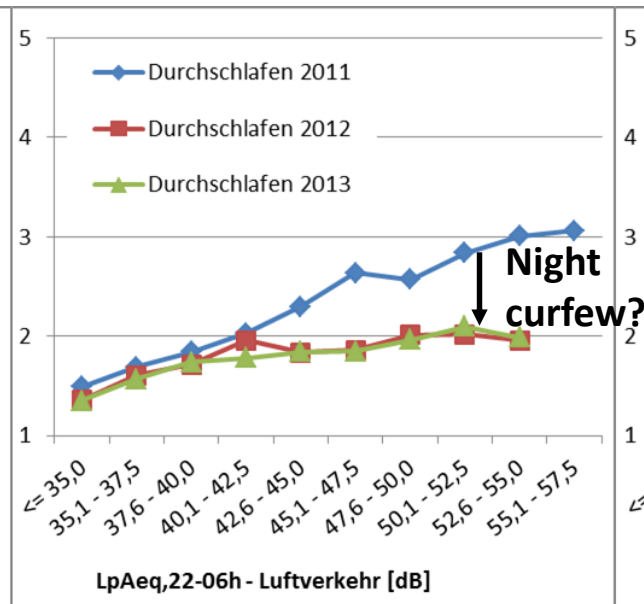
The case of Frankfurt Airport: Self-reported sleep disturbance during night decreased after implementation of night flight ban

Long-term sleep disturbance ...

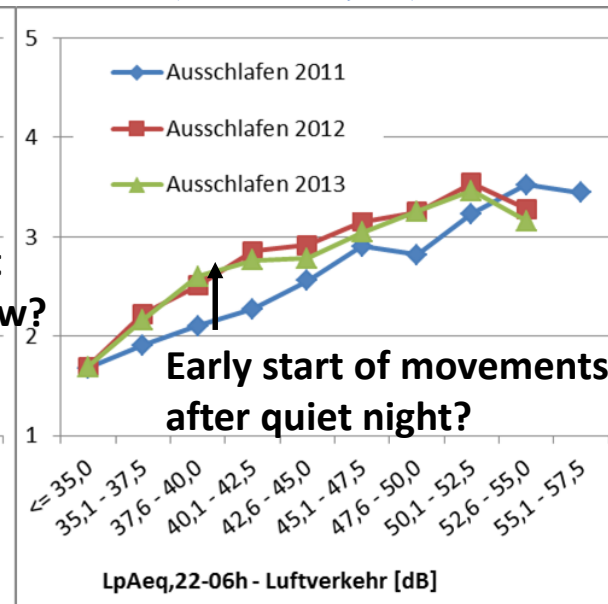
when falling asleep
(*Einschlafen*)



during the night
(*Durchschlafen*)



in the early morning
(*Ausschlafen*)



Thinking about
the last 12 months,
aircraft noise has
disturbed me ...

- (1) not at all
- (2) slightly
- (3) moderately
- (4) very
- (5) extremely

... disturbed

The case of Frankfurt Airport: New runway and implementation of a night flight ban

- Higher self-reported short-term aftereffects of SD in early morning

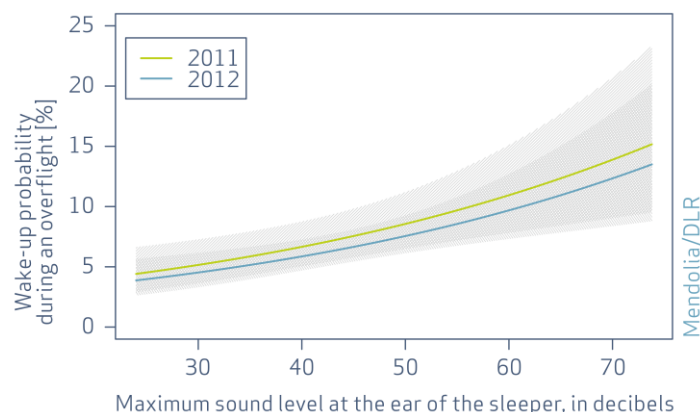
Sleepiness in the morning after rising



1 → fully awake
8 → very tired, major problems staying awake, fighting against sleep

- Almost no differences before/after implementation of night flight ban in **physiological sleep quality**

Aircraft noise-associated wake-up probability



None of these six investigated sleep characteristic values showed significant differences between the years or the groups.

| | 2001: Sleep time: 10/10.30 p.m. to 6/6.30 a.m. | 2012: Sleep time: 10/10.30 p.m. to 6/6.30 a.m. | 2012: Sleep time: 11/11.30 p.m. to 7/7.30 a.m. |
|---|--|--|--|
| Total sleep duration | 7:06 hours | 7:08 hours | 7:07 hours |
| Time between going to bed and falling asleep | 13.9 minutes | 14.5 minutes | 13.1 minutes |
| Sleep efficiency (proportion of sleep to time in bed) | 90% | 90% | 91% |
| Duration of waking after falling asleep | 36.7 minutes | 34.4 minutes | 33.8 minutes |
| Difference between planned and actual end of sleep | 3.3 minutes | 5.4 minutes | 5.7 minutes |
| Waking proportion in percent between 4.30 a.m. and planned end of sleep | 14% | 14% | 12% |

The case of Frankfurt Airport:

Self-reported sleep disturbance during night decreased after implementation of night flight ban

The case of Frankfurt Airport: Summary of the effects of the night flight ban as assessed in the NORA study (www.laermstudie.de)

- The night flight ban implemented in 2011 after years of debates about this noise abatement measure comprises the time period from 11pm to 5am.
- For that time period, NORA survey participants (2011-13) reported less sleep disturbance during the night after the implementation of the ban. In that sense, the ban was successful.
- No effect of the night flight ban was seen for the late evening when going to bed and falling asleep. This might be because the night flight ban starts at 11pm when most people have already gone to bed.
- A slight increase after the implementation of the flight ban was seen for self-reported sleep disturbance in the early morning, probably because the night flight ban ends already at 5am.
- The physiological sleep parameter for the whole night did not change significantly after the implementation of the night flight ban. On the other hand, the implementation of the night flight ban followed an airport expansion (opening of a new runway). It cannot be ruled out that the night flight ban has compensated the potential adverse impacts of the airport expansion on sleep. (Overall, the sleep quality did not get worse.)
- An additional survey revealed that the noise respite of one additional hour either in the evening (10-11pm) or in the early morning (5-6am) introduced in 2015 had only marginal effects on the annoyance in the late evening and early morning. The changes in the hourly noise levels ($L_{Aeq,1h}$) at the home address of participants were too low, and the participants did not perceive the changes. However, although the participants partly criticized this noise respite measure („Laermpause“) as tokenism, they spoke for maintaining the measure („*Better than nothing*.“).
- Overall, the results indicate that the success of the implementation of noise abatement measures in terms of an improvement of residents' health and quality of life could be improved by an appropriate accompanying communication with residents and, ideally, engagement of exposed communities in such noise abatement strategies.



Thank you for your attention

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