



Public Health
England

Quantifying noise-induced sleep disturbance – recent evidence

Dr Benjamin Fenech

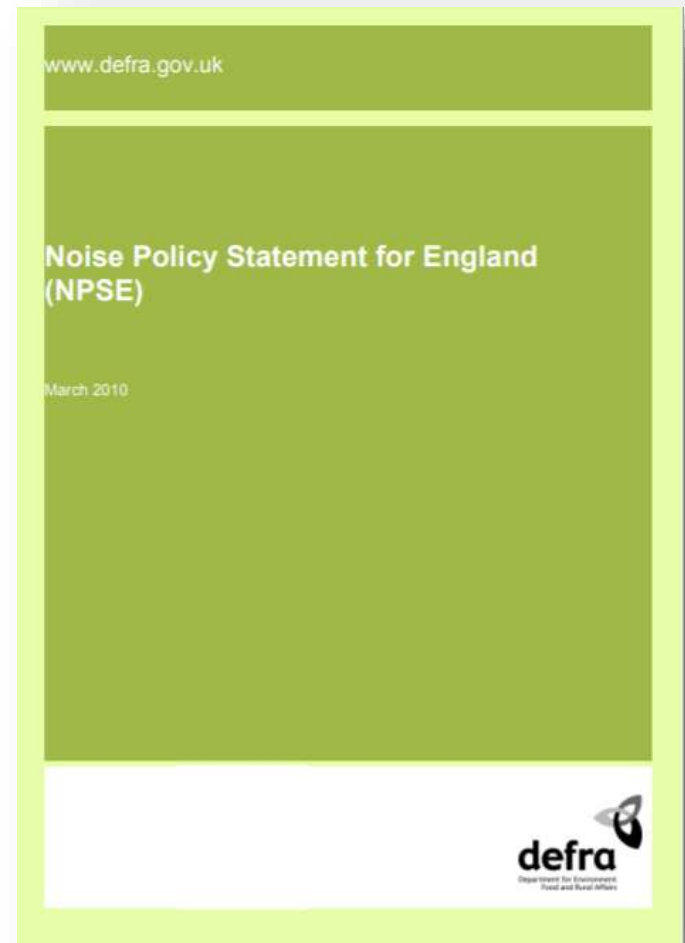
Principal noise and health specialist

Environmental Hazards and Emergencies

Centre for Radiation Chemical and Environmental Hazards

Context

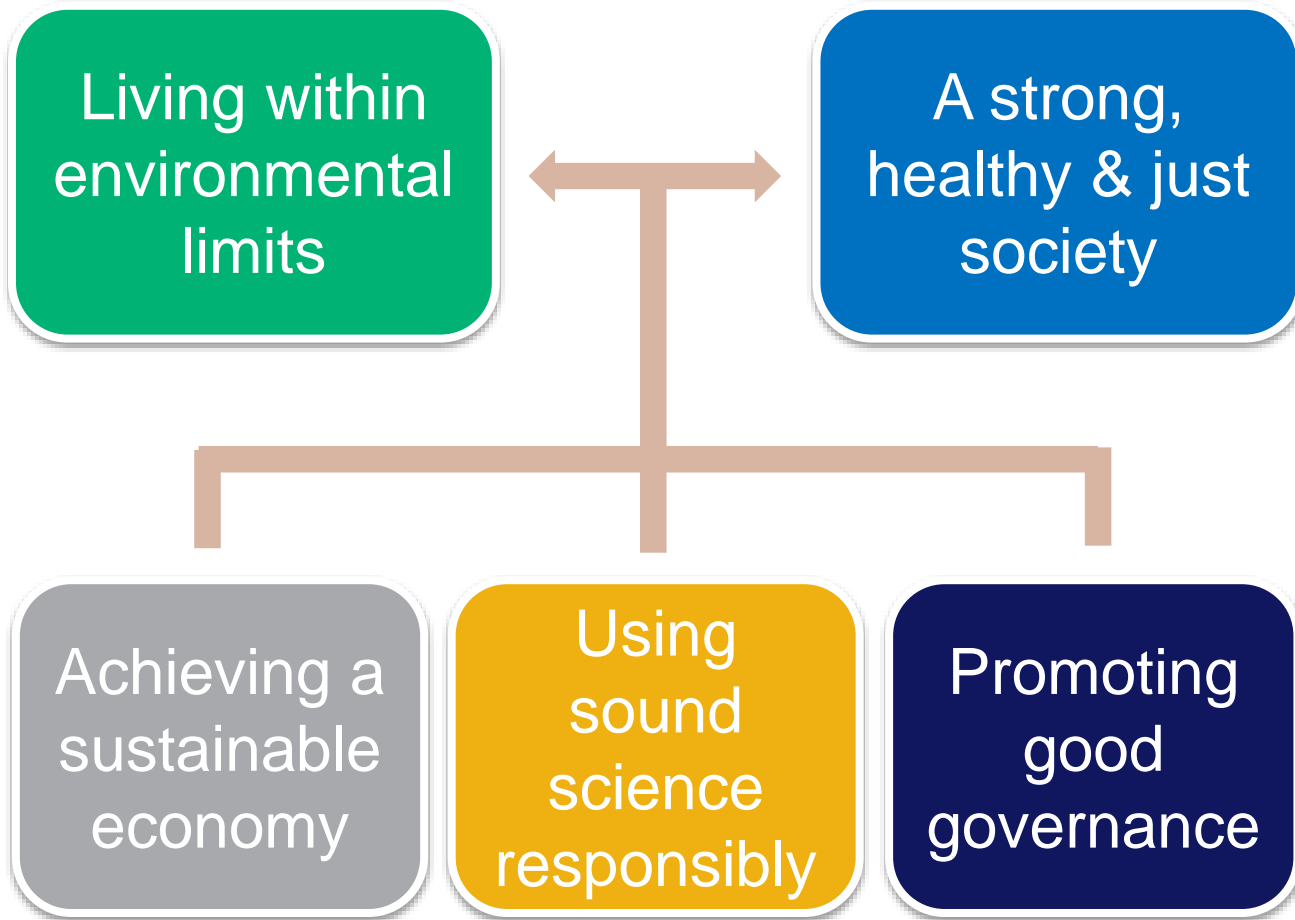
*“Promote good health and a good quality of life through the effective management of noise **within the context of Government policy on sustainable development.**”*



<https://www.gov.uk/government/publications/noise-policy-statement-for-england>

Sustainable development

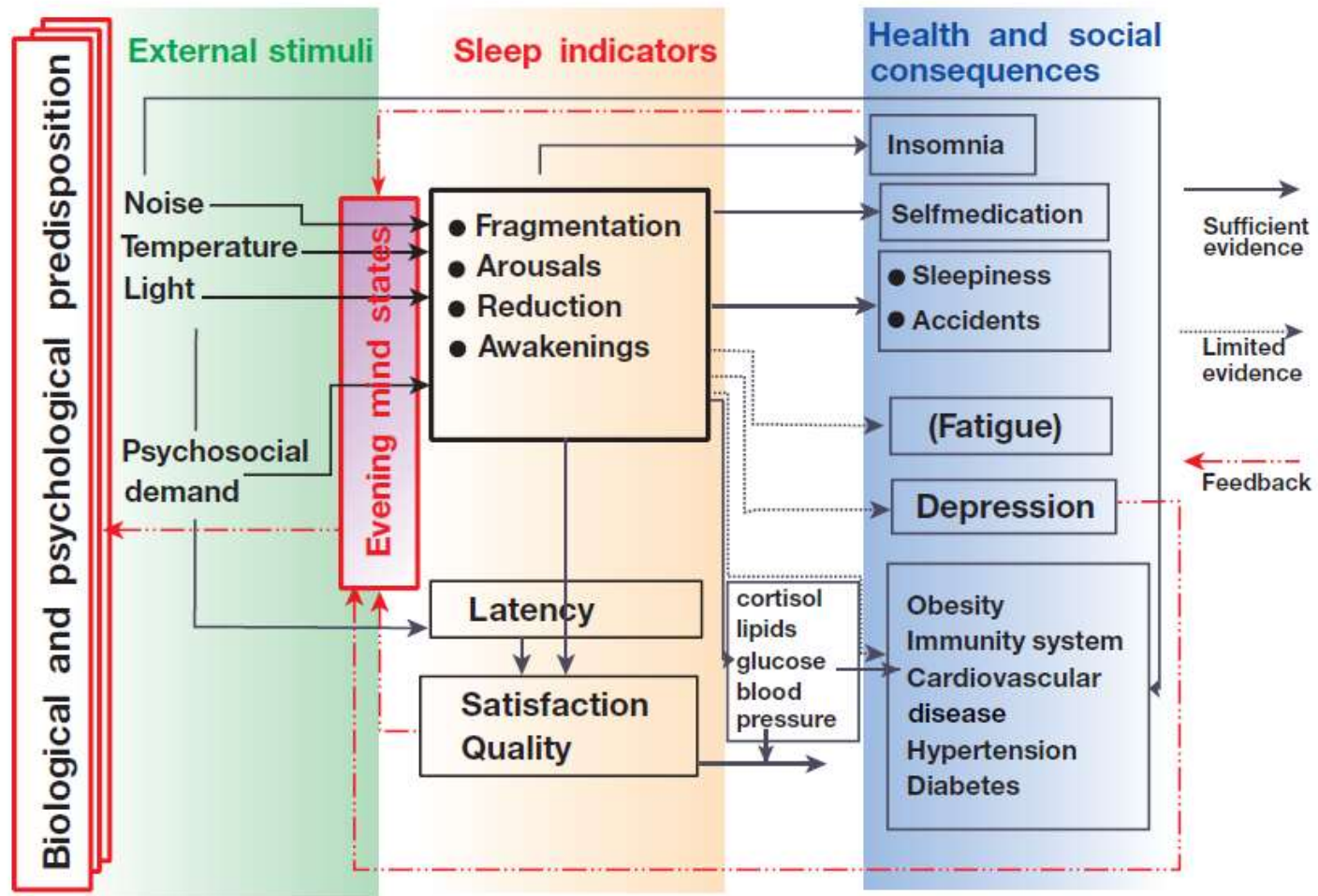
| |
|--|
| to improve our |
| Meeting the diverse |
| Building a strong |
| Ensuring policy is |
| Actively promoting effective participative systems of governance in all levels of society – engaging people's creativity, energy and diversity |
| public attitudes and values |
| incentivised |



adapted from
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/323193/Guiding_principles_for_SD.pdf

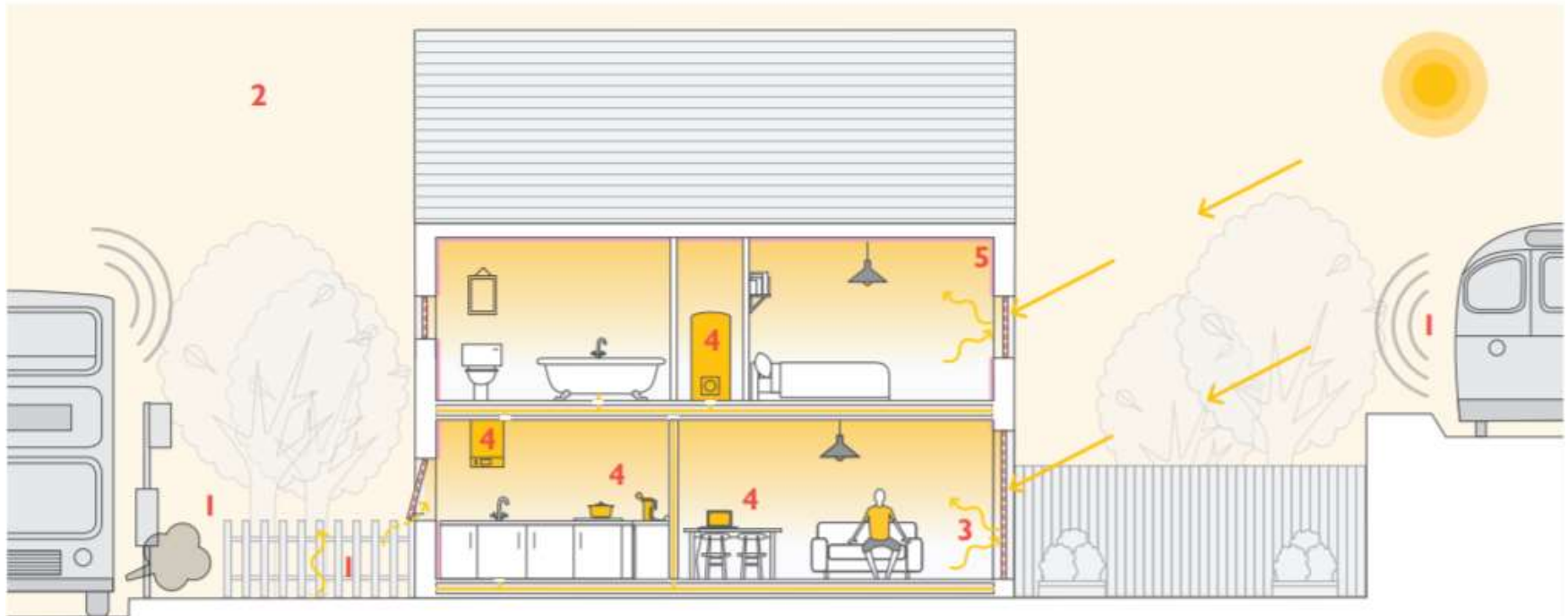
Sleep and health

Fig.2.1
Expert view on the relations
between sleep and health



WHO, Bonn, 26-01-2004

The bigger picture



Cumulative effects

1. Site context

External pollution, noise and excessive noise may prevent occupants from opening their windows.

Surrounding hard surfaces will absorb heat and release this during the night.

2. External temperature

On a warm, still day when external temperatures are high, fresh air may not provide enough of a cooling effect to address overheating.

3. Solar gains

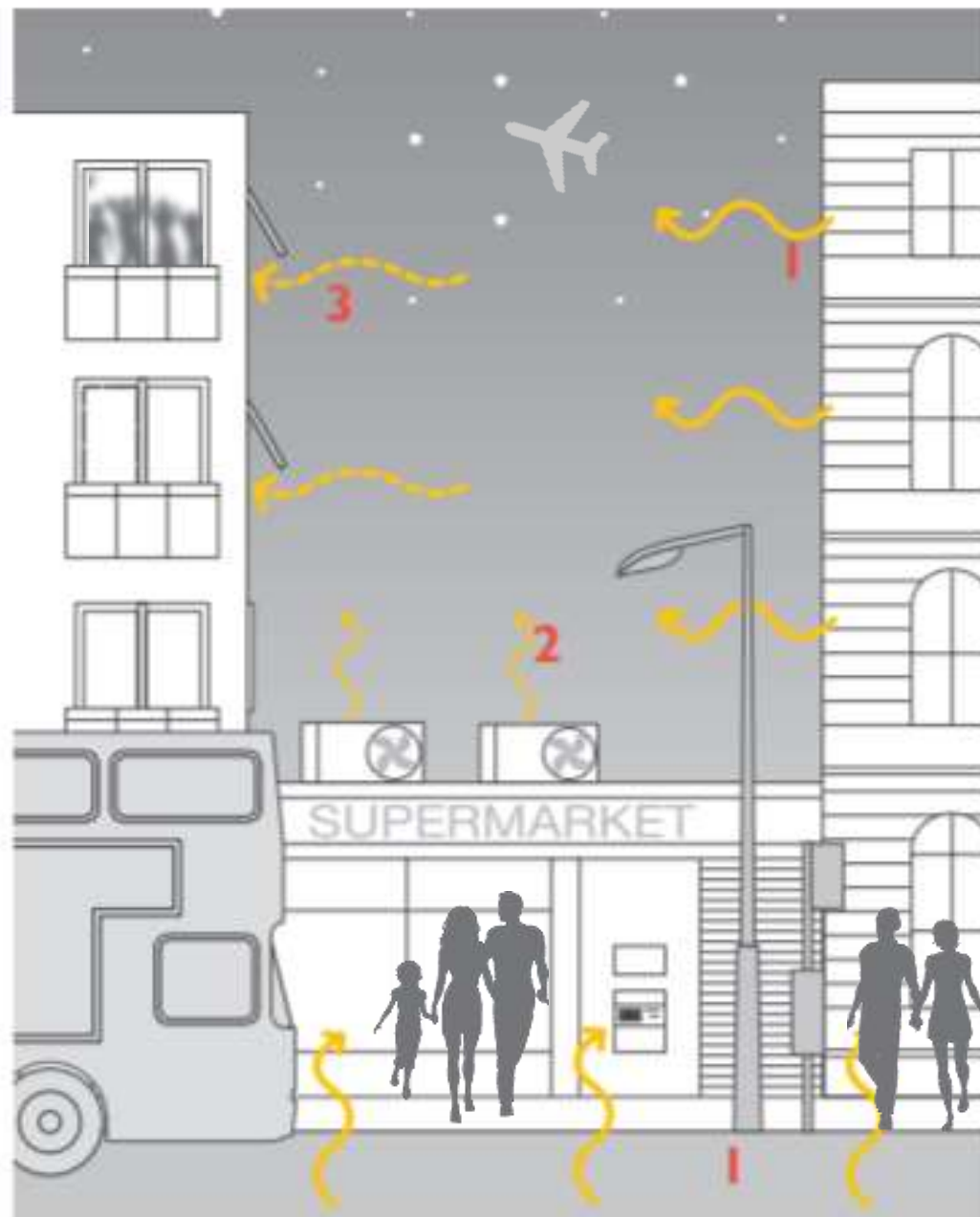
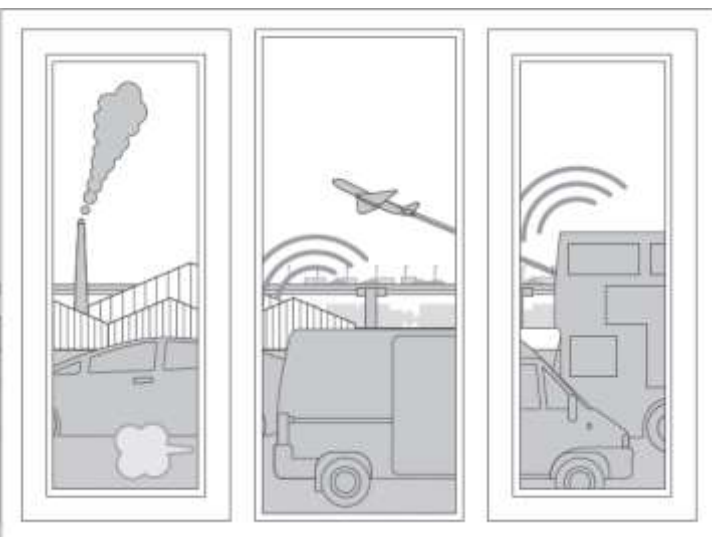
Double-glazed windows with a low-e coating prevent heat from escaping. Houses with unshaded west-facing glass will suffer from higher levels of solar gain in the warmer part of the day.

4. Internal gains

Electrical appliances, occupant activities such as cooking, and building services, e.g. boiler and hot water storage, all have the potential to radiate heat that may contribute significantly to the increasing internal temperatures.

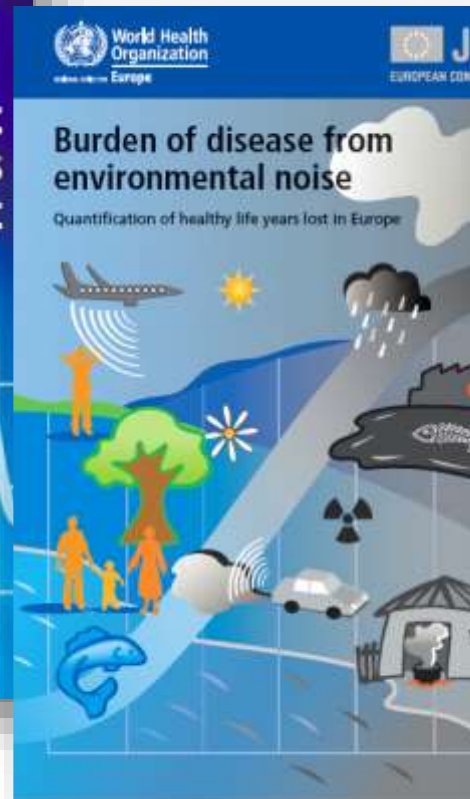
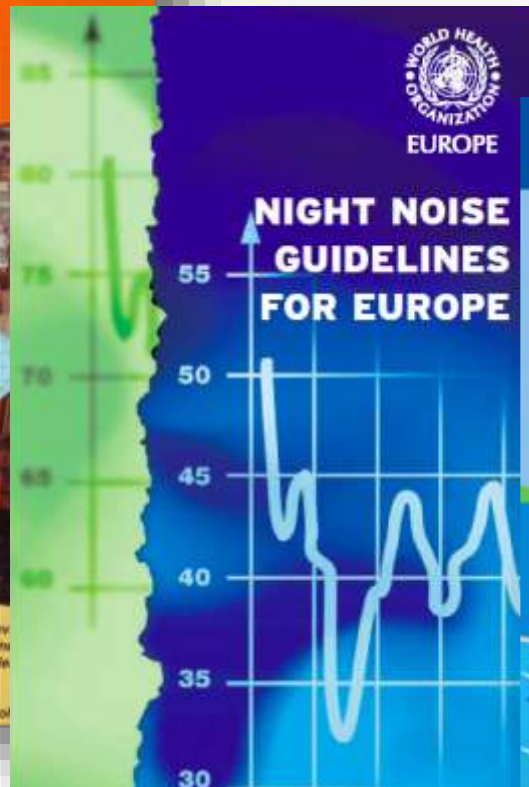
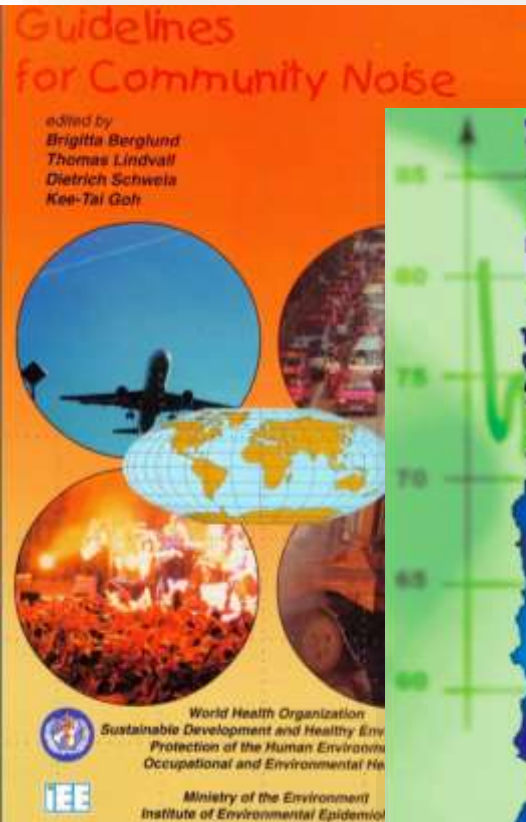
5. Building design

Modern homes have increased levels of insulation and airtightness, resulting in more heat being retained within the homes. This means any built-up heat in the homes will have to be actively removed.



adapted from NHBC Foundation NF44, 2012

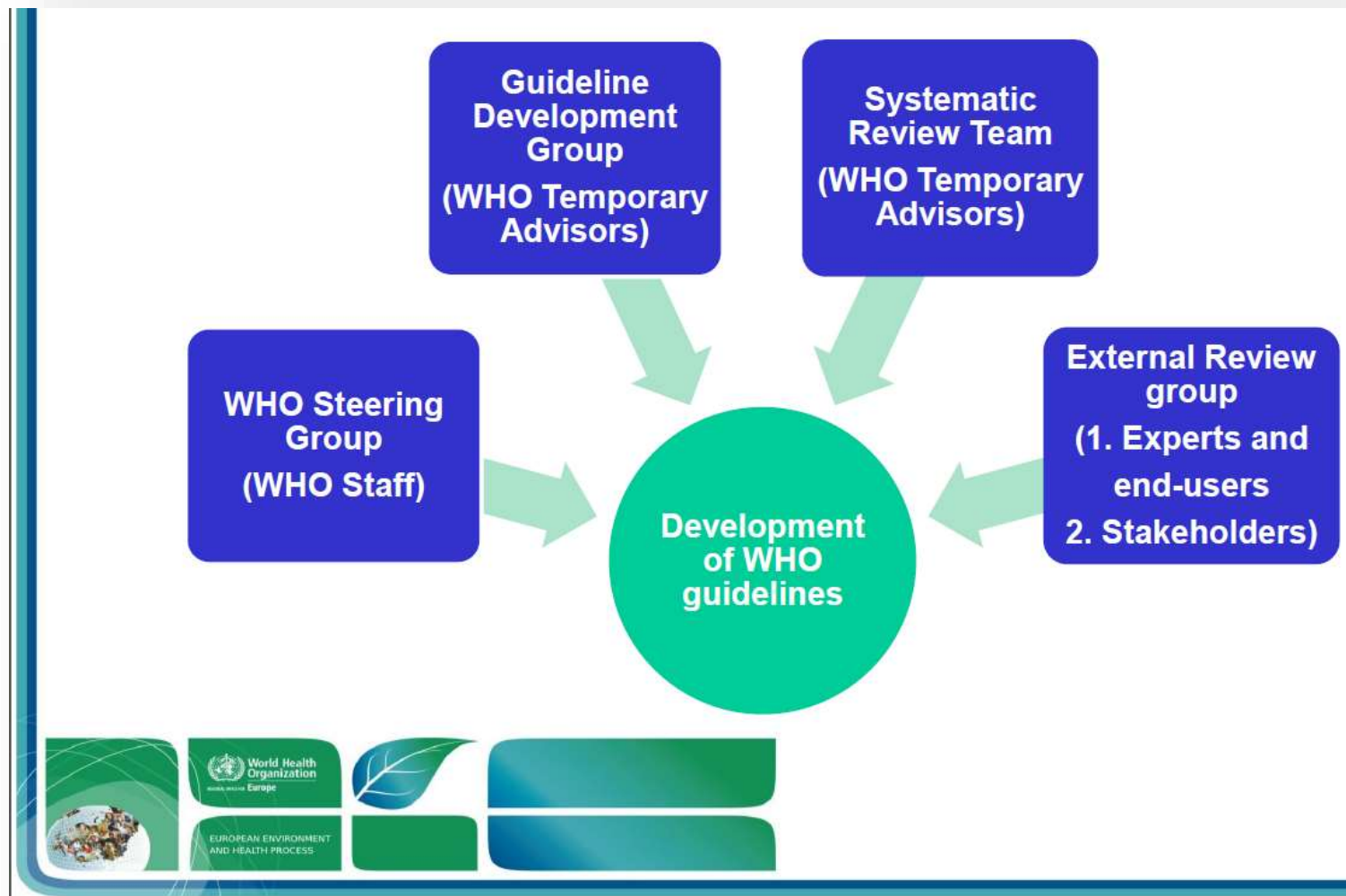
WHO Guidance




WHO Environmental
Noise Guidelines for
the European region

2018?

Development of WHO Guidelines




WHO-commissioned systematic reviews

**International Journal of
Environmental Research
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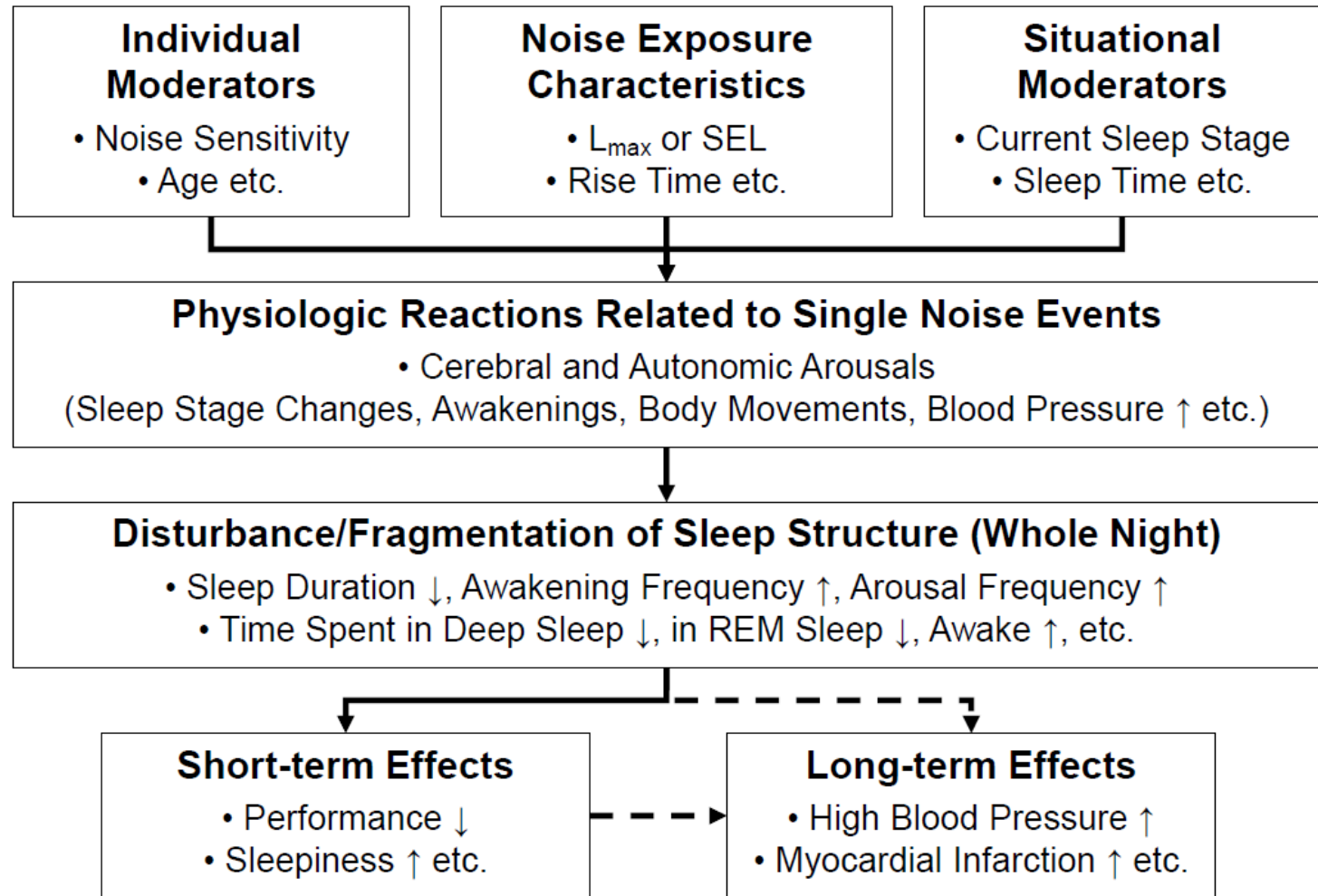
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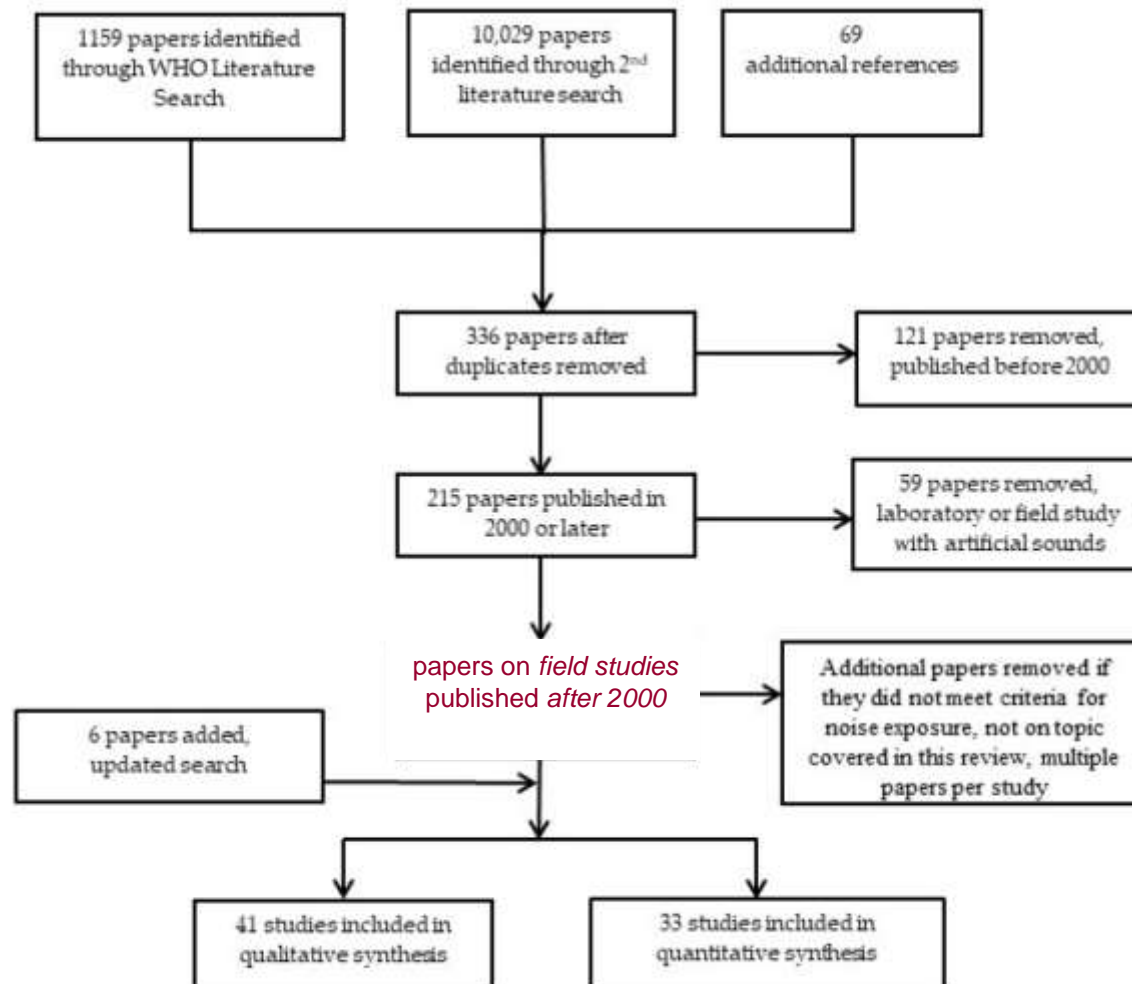
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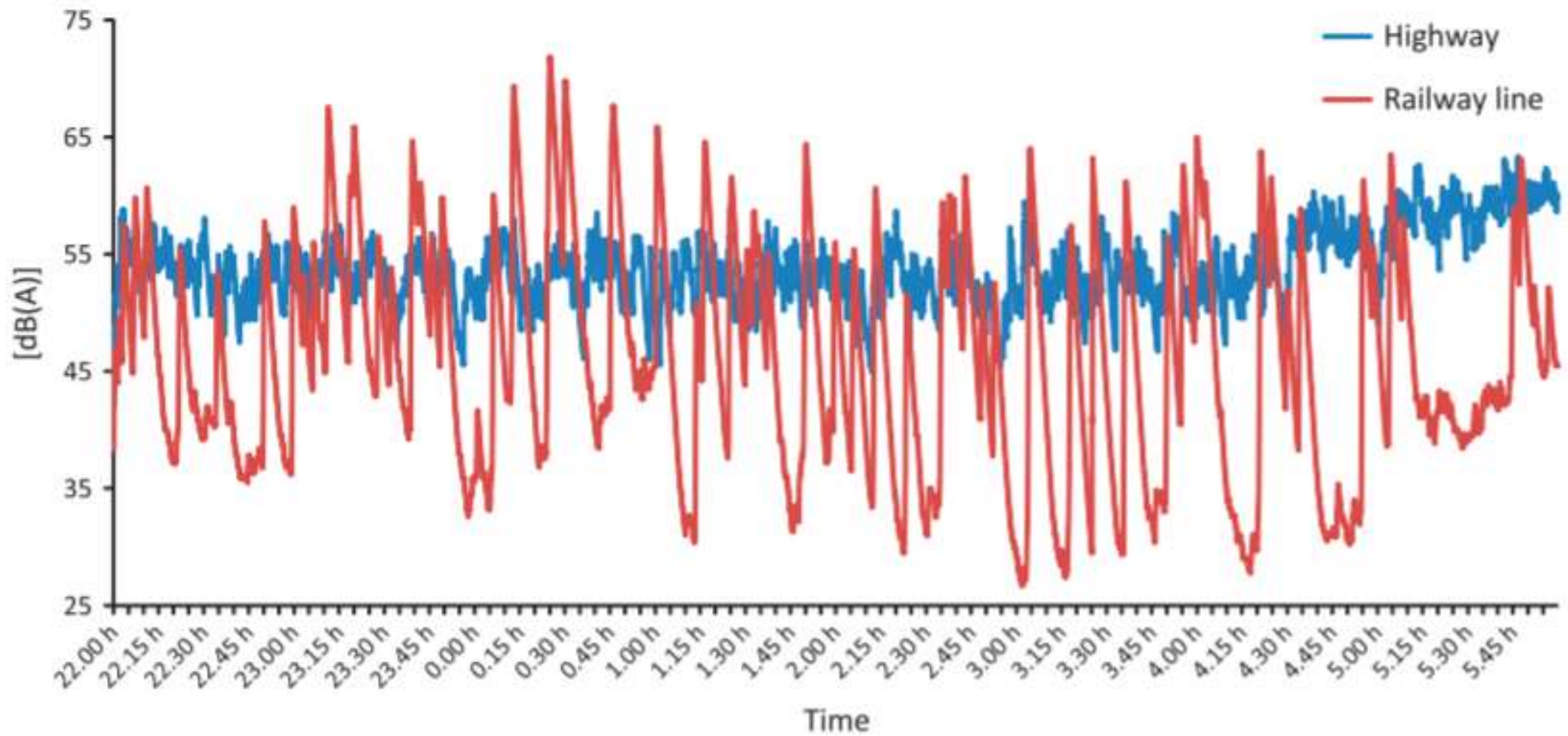
Effects of noise on sleep



Literature screening

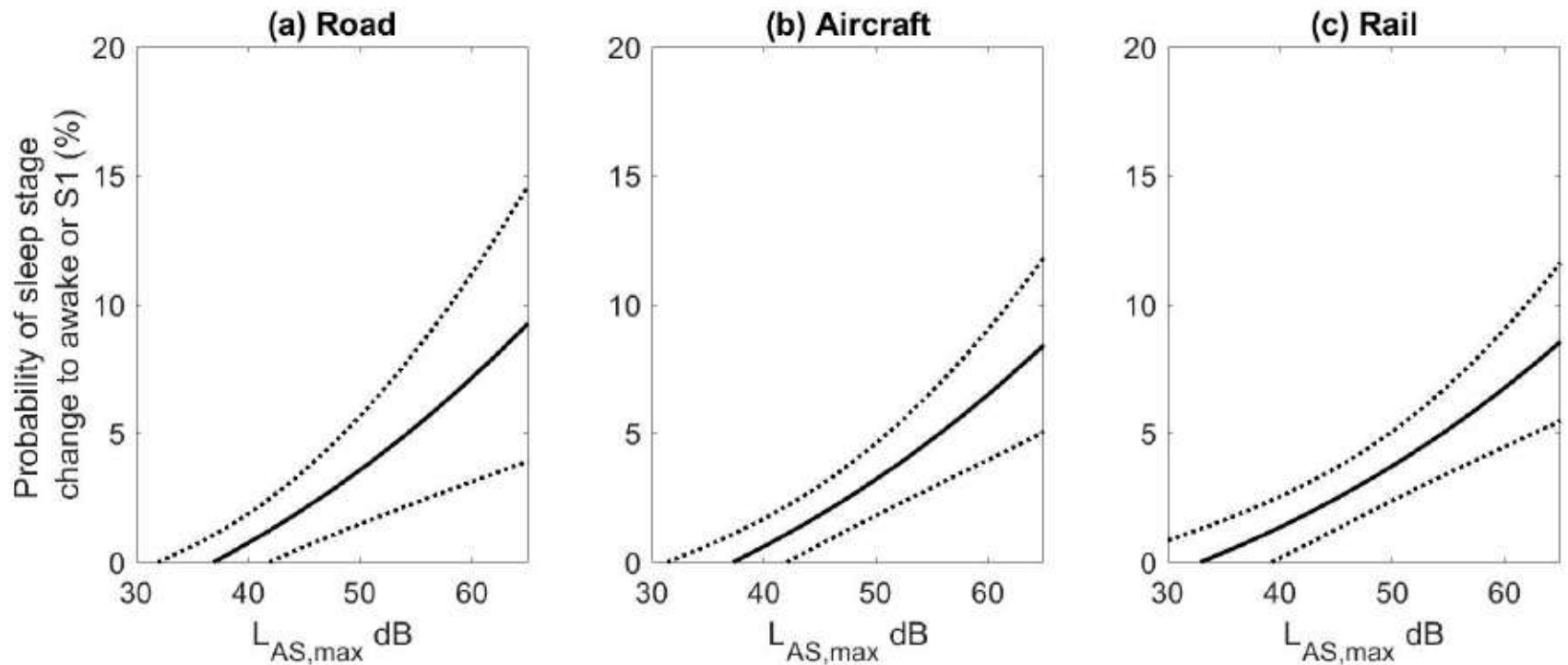


Metrics

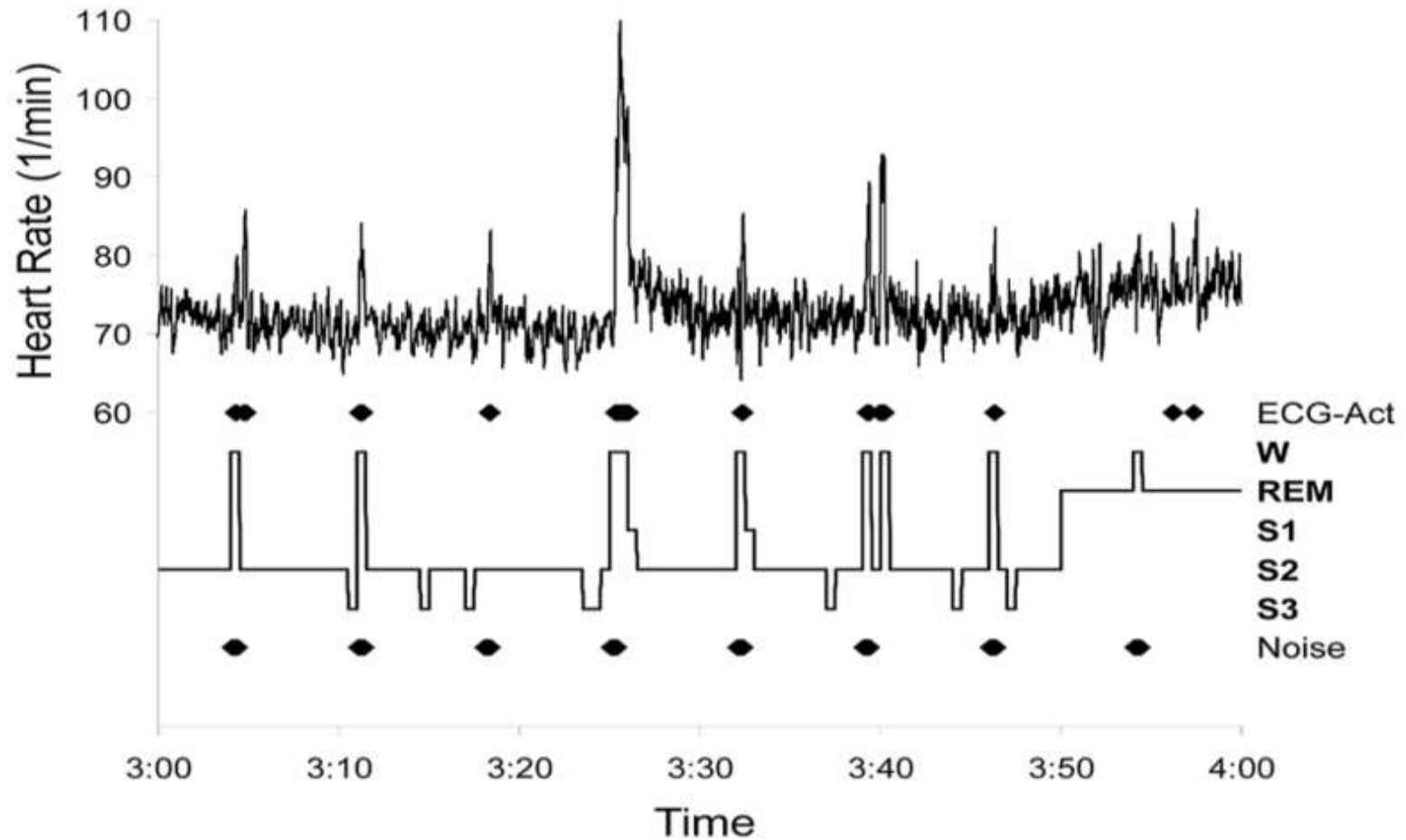


Journal of Exposure Science and Environmental Epidemiology (2016), 575 – 585

Cortical awakenings



Vegetative vs cortical arousals



Habituation

“Subjects exposed to noise usually habituate....

*Habituation is a reasonable mechanism that preserves energy resources. However, **habituation is not complete**, i.e., subjects continue to react to noise events even after several years of noise exposure. ... Unfortunately, little is known about individual differences in the ability to habituate to noise and potential predictors.*

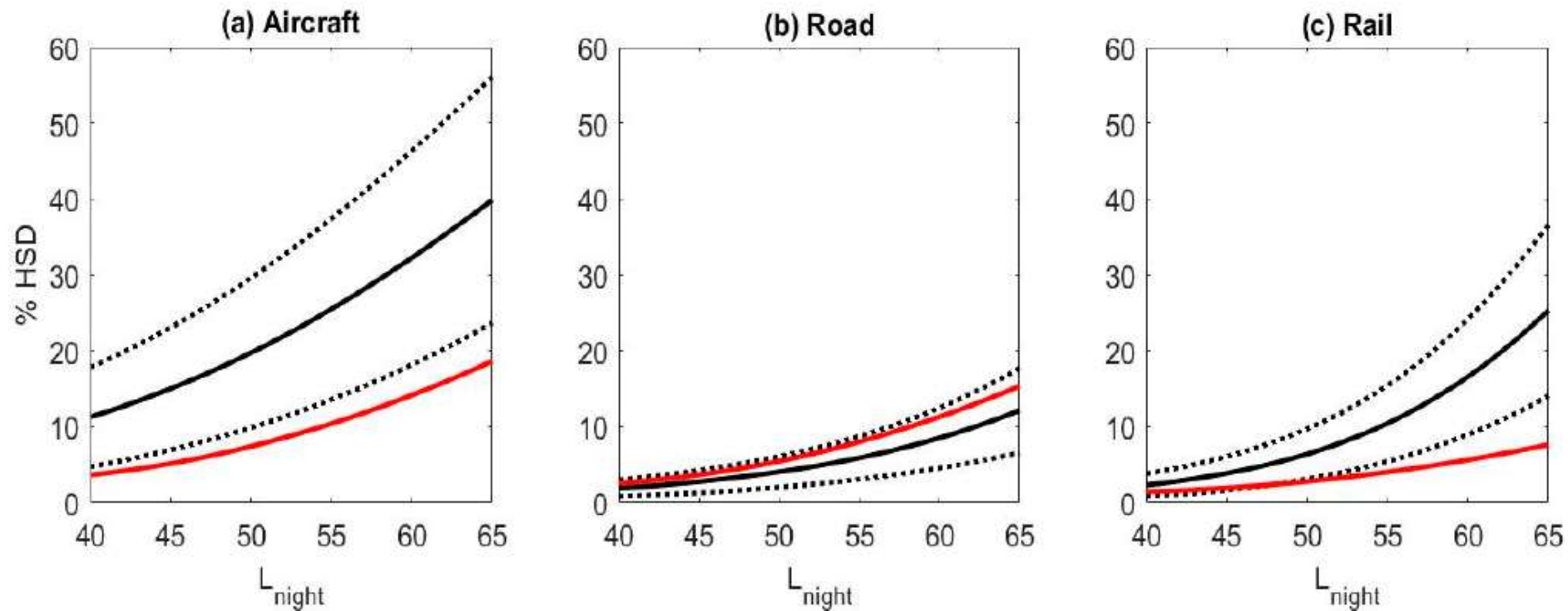
*Importantly, **activations of the vegetative nervous system habituate to a much lesser degree to noise compared to cortical arousals**. It is also possible that exposed subjects become more sensitive to the effects of noise on sleep. This sensitization may be related to, e.g., individual changes in noise exposure, or changes in media coverage.”*

Int. J. Environ. Res. Public Health 2018, 15, 519

Self reported sleep outcomes

| | Number of Studies | | Odds Ratio per 10 dBA | 95% Confidence Interval |
|-----------------------|-------------------|--------|-----------------------|-------------------------|
| Aircraft Noise | | | | |
| Falling Asleep | 6 | 6,368 | 2.00 | 1.68–2.41 |
| Awakenings | 5 | 4,054 | 1.72 | 1.31–2.27 |
| Sleep Disturbance | 1 | 2,309 | 2.05 | 1.64–2.56 |
| Combined Estimate | 6 | | 1.94 | 1.61–2.33 |
| Road Noise | | | | |
| Falling Asleep | 8 | 10,212 | 2.63 | 1.86–3.73 |
| Awakening | 8 | 10,177 | 1.75 | 1.24–2.47 |
| Sleep Disturbance | 3 | 9,901 | 2.21 | 1.52–3.20 |
| Combined Estimate | 12 | | 2.13 | 1.82–2.48 |
| Rail Noise | | | | |
| Falling Asleep | 4 | 6,520 | 2.57 | 1.87–3.53 |
| Awakening | 3 | 5,311 | 2.54 | 1.49–4.33 |
| Sleep Disturbance | 2 | 1,809 | 4.10 | 0.69–24.41 |
| Combined Estimate | 5 | | 3.06 | 2.38–3.93 |

Self-reported sleep disturbance



Quality of the evidence

| Sleep Outcomes | Noise Source | Number of Participants (Studies) | Quality of Evidence | Noise Metric | Odds Ratio per 10 dBA Increase (95% CI) |
|---|--------------|----------------------------------|---|----------------------------|---|
| Cortical awakenings in adults | Road | 94 (2) | ⊕⊕⊕○ Moderate | Indoor L _{AS,max} | 1.36 (1.19–1.55) |
| | Rail | 33 (1) | ⊕⊕⊕○ Moderate | Indoor L _{AS,max} | 1.35 (1.21–1.52) |
| | Aircraft | 61 (1) | ⊕⊕⊕○ Moderate There was evidence of dose-response | Indoor L _{AS,max} | 1.35 (1.22–1.50) |
| self-reported sleep disturbance in adults | Road | 20,120 (12) | ⊕⊕⊕○ Moderate | Outdoor L _{night} | 2.13 (1.82–2.48) |
| | Rail | 7133 (5) | ⊕⊕⊕○ Moderate | Outdoor L _{night} | 3.06 (2.38–3.93) |
| | Aircraft | 6371 (6) | ⊕⊕⊕○ Moderate There was evidence of dose-response | Outdoor L _{night} | 1.94 (1.61–2.33) |

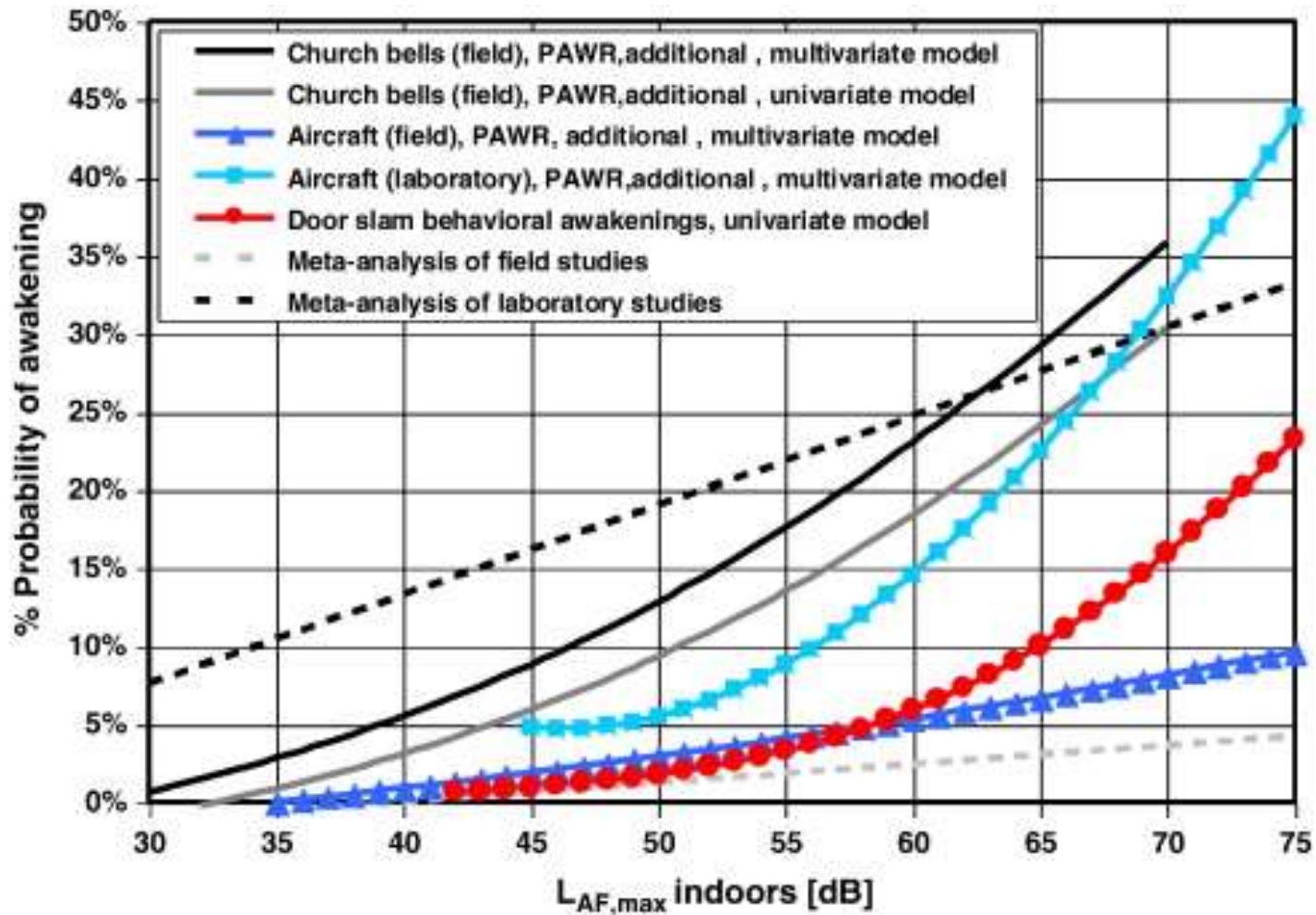
Quality of evidence

| Quality of Evidence | Definition | Examples of When This is the Case |
|---------------------|--|---|
| High | Further research is very unlikely to change our confidence in the estimate of effect | Several high-quality studies with consistent results |
| Moderate | Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate | One high-quality study or several studies with some limitations |
| Low | Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate | One or more studies with severe limitations |
| Very Low | Any estimate of effect is very uncertain | No direct research evidence One or more studies with very severe limitations |

Quality of the evidence

| | | | | | |
|--|-------------------------|---|--|--|------------------|
| motility (adults) | Road, Rail, Aircraft | 1320 (8) | ⊕⊕○○ Low | L _{Amax} and L _{Aeq} | Not estimated |
| Self-Report and children Children | Road, Rail, Aircraft | 1754 (4) | ⊕○○○ Very Low Inconsistency in results, small | Varied across studies | Not estimated |
| Self-Reported Sleep Disturbance in Adults | WT noise | 3971 (6) | imf ⊕○○○ Very low | Outdoor A-weighted SPL | 1.60 (0.86–2.94) |
| All Sleep Outcome Measures | hospital noise | 964 Adults/67 Children (13 Adults/4 Children) | es Inconsistency in results and imprecision due to small sample sizes | Varied across studies | Not estimated |

Other sources of noise



Science of the Total Environment 409 (2011) 5210–5220

Closing remarks

- Quality of evidence for non-transport sources of sound
- Noise-induced sleep disturbance of relatively constant (but relatively high) noise levels – cortical awakenings, falling asleep....
- Noise-induced sleep disturbance and indoor temperature, indoor air quality...
- Noise-induced sleep disturbance in the elderly, those with pre-existing health conditions...