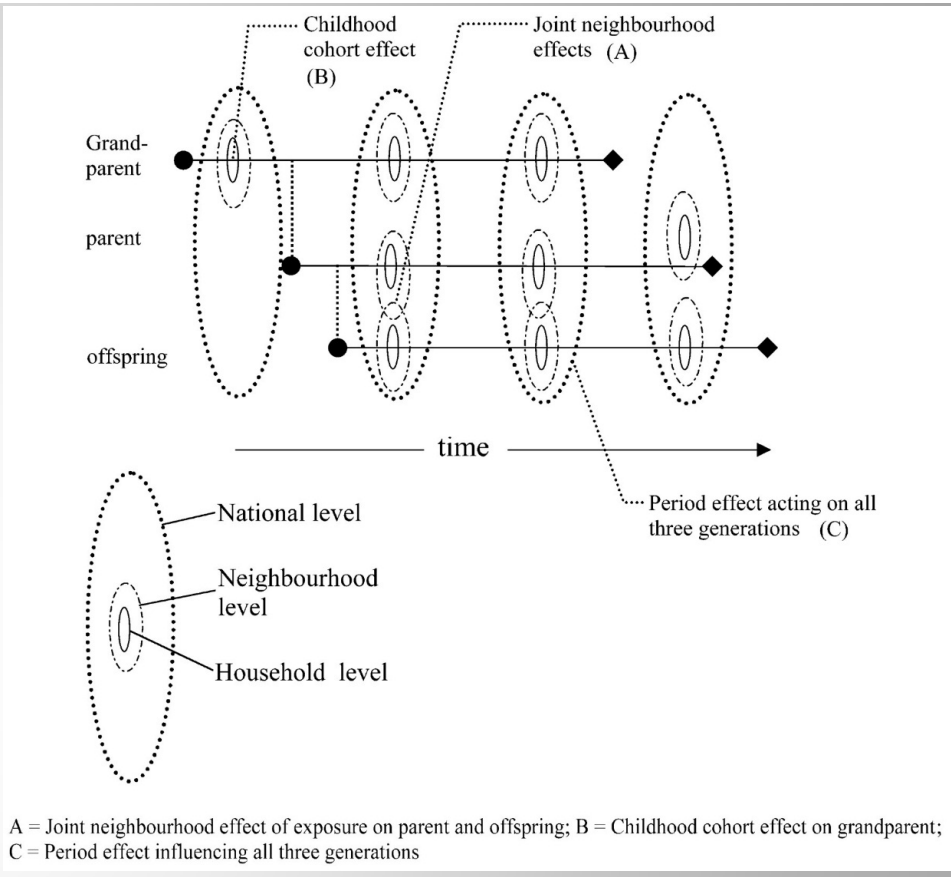


A = Joint neighbourhood effect of exposure on parent and offspring; B = Childhood cohort effect on grandparent;
C = Period effect influencing all three generations

Systematic reviews in noise epidemiology. Limitations and chances from a Public Health view

Peter Lercher

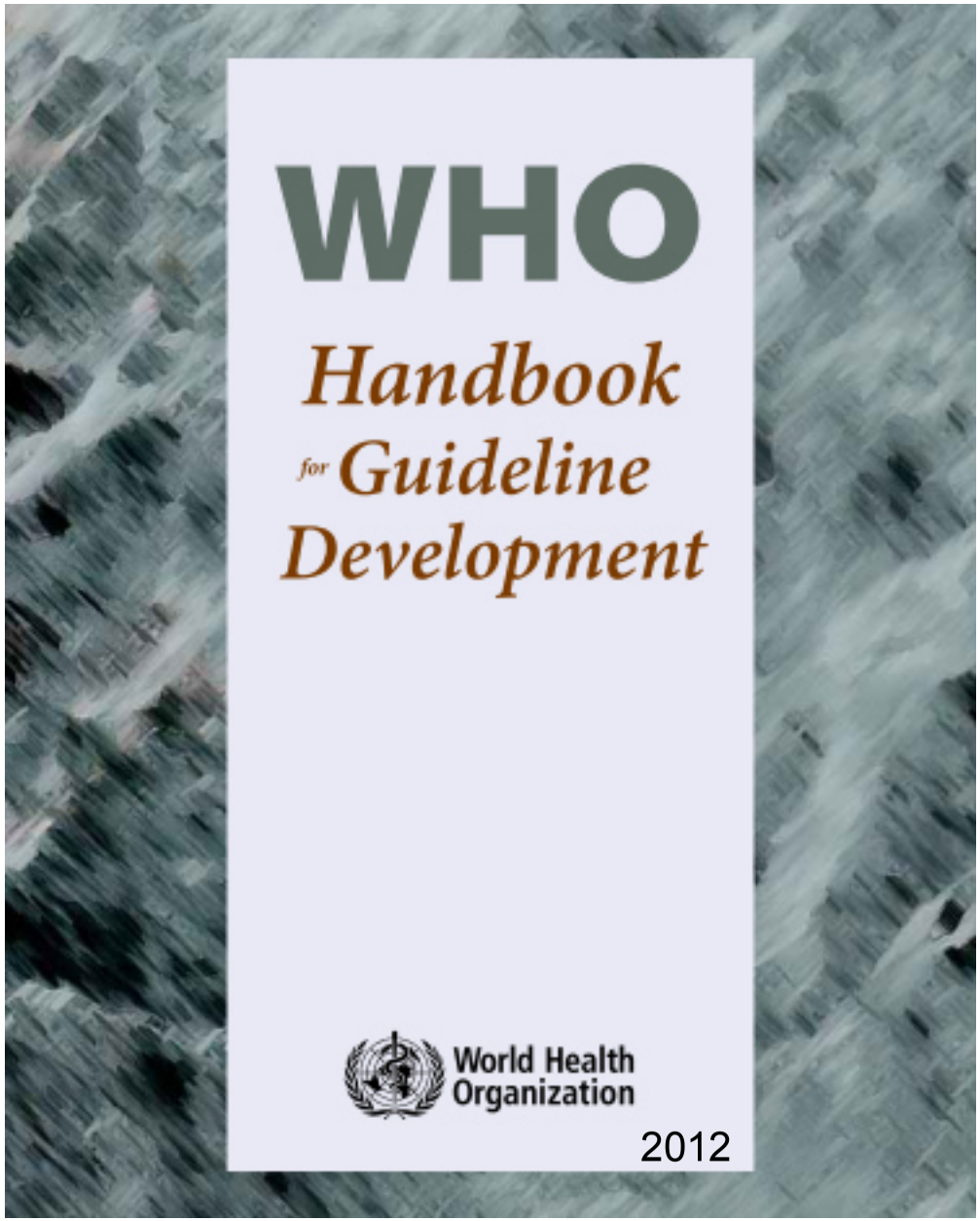
Medical University Innsbruck

Internoise 2016, Hamburg, 21.-24.8.2016

Evidence reviews as essential tool for guideline development and public health policy

- The Burden of Disease (BoD) concept requires the quantification of the relative importance of environemtal health determinants (noise , air pollution, green space etc.)
- Hitherto, the effects of noise were not included in the BoD calculations – as - strong methodological requirements were set for the assessment of the evidence base (GRADE assessment) by the WHO-steering committee.
- In its normative and standard-setting work, WHO has committed itself to follow the GRADE guidelines in their future work – as the Burden of Disease from Environmental Noise assessment* was not yet based on the GRADE guidelines

*Fritschi L, Brown L, Kim R. Burden of Disease from Environmental Noise—Quantification of Healthy Life Years Lost in Europe. WHO 2011.



http://www.who.int/kms/guidelines_review_committee/en/

Why has it taken so long to include noise in a BoD assessment and why is a valid assessment still an ongoing challenge

- The medical model does not fully fit with the stress and context driven causal pathways through which the expected health effects of noise are expected to occur
- The physical description of the noise is only a surrogate indicator of the perceived psychosocial stress moderated or mediated by the personal vulnerability under the specific environmental conditions and coping options of the human receptor.
- In the stress conceptualization of potential health effects elicited by noise – a much larger heterogeneity is expected to result from population studies across various geopolitical and socio-cultural backgrounds compared with air pollution effects - which follow closer the medical model with its toxicology based physiological mechanisms
- Additional heterogeneity of the noise effects is expected due to different environments, building structures and housing, coping opportunities and background prevalence of health and disease in the respective study populations

The dilemma with evidence reviews: who will be satisfied?

- Results of evidence reviews represent the best available knowledge across different environments and are a proper basis for BoD assessment at larger (supra-national) scales
- It provides the required input for evidence based environmental health policy
- However, the **average results** of a systematic review may be difficult (or even inappropriate) to apply under contextually different local circumstances, where environmental health impact assessment (EHIA) takes place
- In the referred WHO guideline handbook this is also acknowledged: “Recommendations **can be** implemented in, and adapted to, local settings and contexts”
  Who will take over this additional task?
- In addition, the main exposure response information comes from single transportation sources, while in EHIAs the typical scenario is a combination of sound sources accompanied by other environmental exposures – like air pollution, vibration – but also contexts with social and safety issues
- No data are available for other relevant sound sources: noise from industrial (windfarms are now included) and general sources (e.g. supermarkets, noise in buildings)

What is needed ?

- Appropriate health models accounting for the much larger size of environmental determination of the health effects within a stress based model of noise effects – compared with the classical medical model that follows toxicology principles – like air pollution – and allowing integration by accounting for both approaches
- An improvement in sound exposure assessment which resembles better the neurophysiologic representation in the peoples mind*
- The evidence base should consider potential moderation and mediation of environmental and social factors and context constellations
- Therefore, we need more Epi-studies which provide such information to feed evidence reviews – currently, such information is rarely available – but sometimes simply hidden in the archives and not analyzed
- Following, examples are shortly outlined to underline the relevance of these issues which are often responsible for the actual size and severity of adverse effects of noise which may be amenable to preventive action at smaller scale - if sufficiently considered.

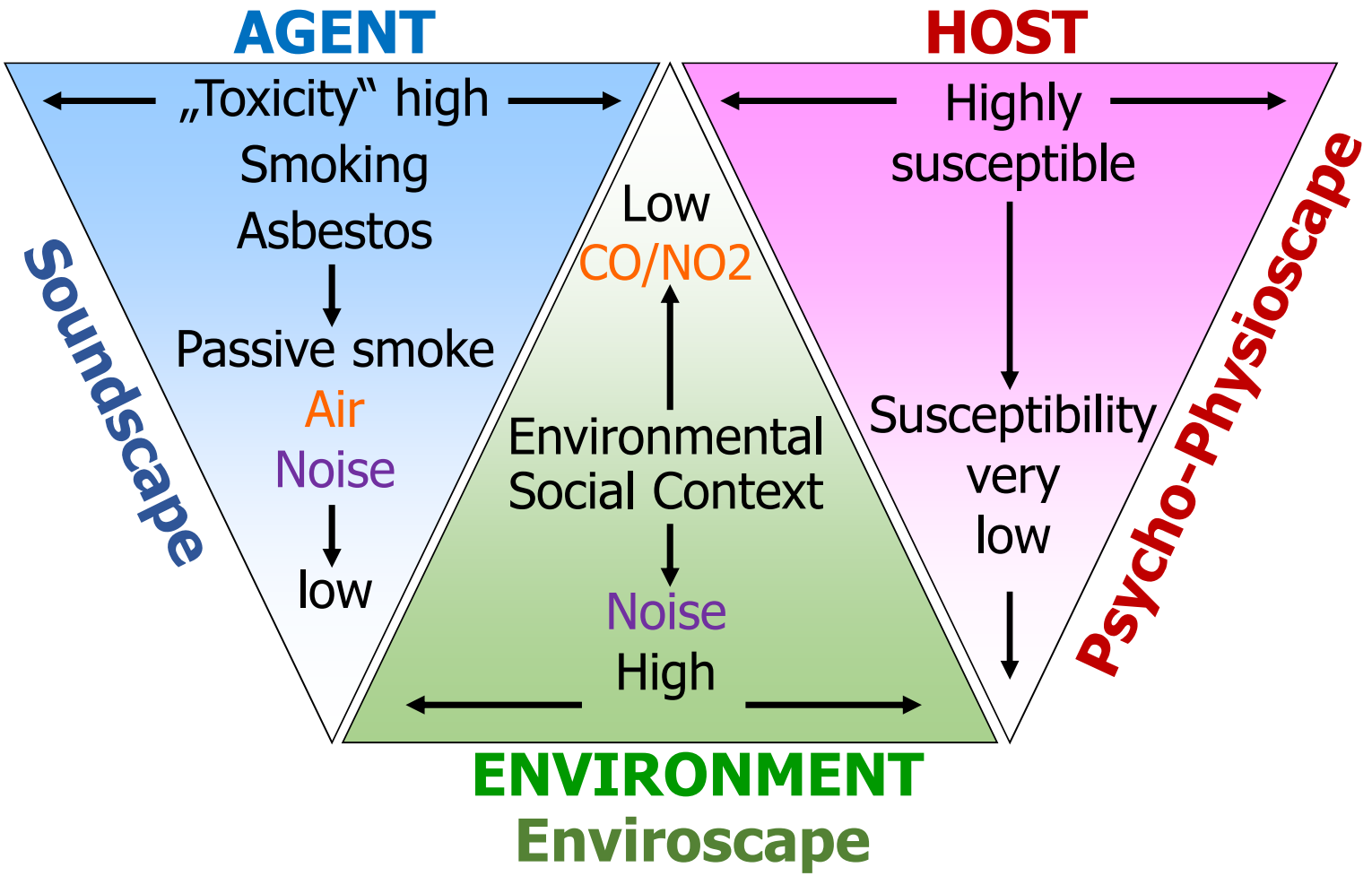
*Visit the session on „noise exposure assessment for health studies“

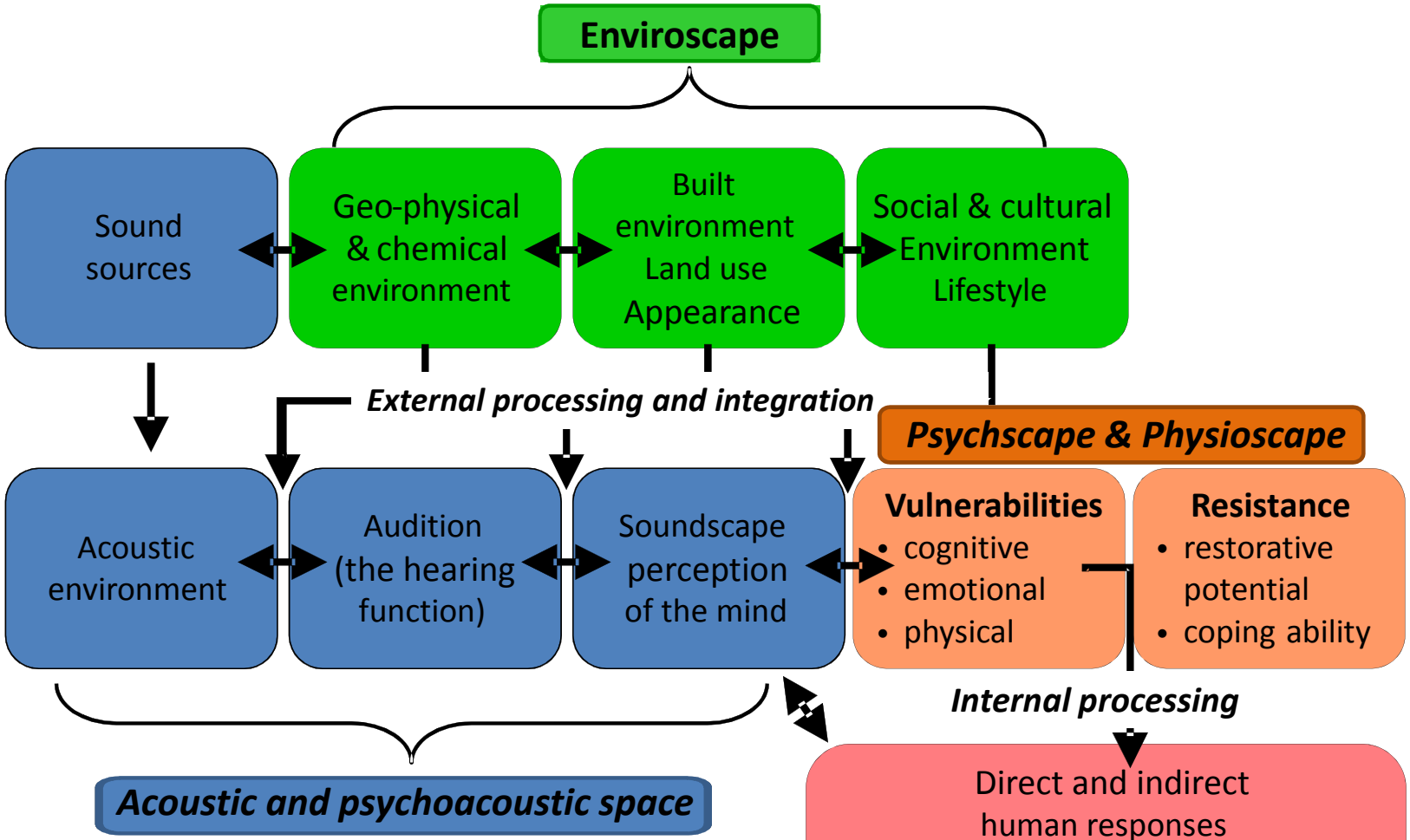
The needs for future studies

BEYOND THE TOXICOLOGY MODEL: INTEGRATING HEALTH MODELS

The „epidemiologic triad“ as guide to integrated assessment

when subject and environmental context matters a lot





The soundscape perspective

linking the Enviro- with the Socio-Psycho-Physioscape

Involved theoretical concepts

	Stress Perspective	Coping Perspective	Restoration Perspective
Theoretical Premise	Heavy demands can undermine adaptation.	Readily available resources support adaptation.	Adaptation requires periodic restoration.
Practical Premise	Interventions can eliminate or mitigate demands.	Interventions can ensure the availability of resources.	Interventions can enhance opportunities for restoration.

From Hartig, Bringslimark & Patil (2008); Hartig (2008)

The needs for future studies

RESPONSE ORIENTED EXPOSURE ASSESSMENT

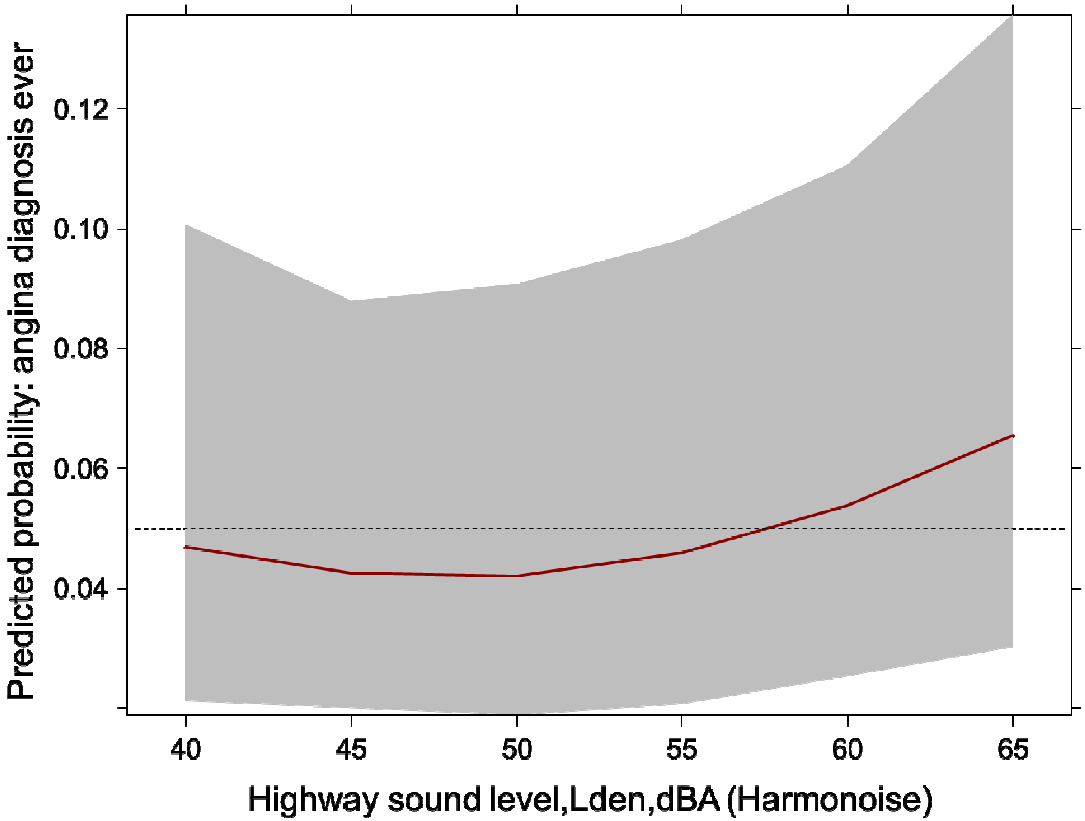
Critical evaluation of noise indices and propagation modeling*

- From exposure modeling validation to exposure effect modeling evaluation
  - Typically only the intrinsic sound models are evaluated – but not whether different models show different results on exposure response curves
  - Be cautious about land-use regression models in noise epidemiology
  - GRADE has not yet established criteria for quality assessment of exposure assignments
- Consideration of special noise exposure characteristics
  - Threshold level of human response is lowered by strong fluctuations or emergence
  - Low frequency sound: 59% of Dutch households close to motorways show dBC-A levels ≥ 15 dB[+]
  - Sharpness/roughness containing and modulated sounds are another neglected issue
- Consideration of combined noise exposure (mixed source exposure)
  - in Germany 33% of people are exposed to 2 or 3 sources - 11% even to 4 or 5 sound sources
- Consideration of noise exposure in combination with other agents
  - E.g. Sørensen found the strongest association with ischemic stroke for a combination of high noise and high NO2

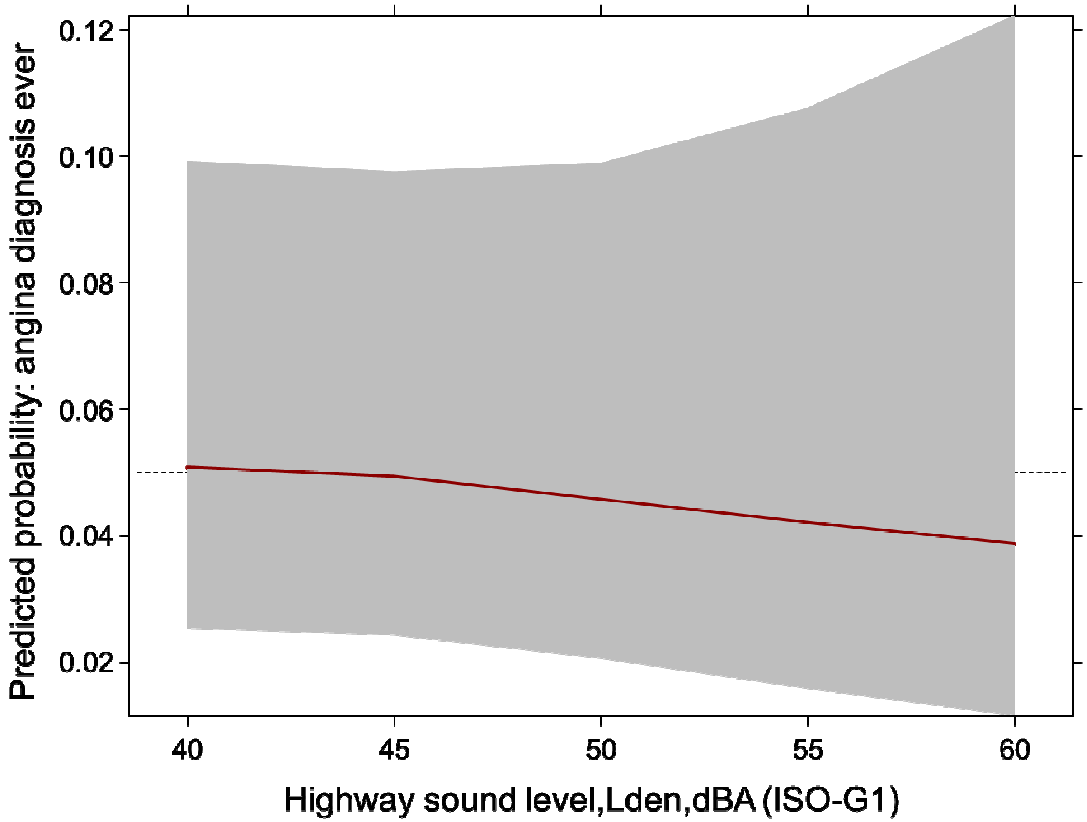
[+] Schreurs et al. , Acoustics `08
Baliatsas C et al. Sci. Total Environ 2016

*Visit the session on „noise exposure assessment for health studies“

Effect of different sound modeling procedures



Harmonoise propagation modeling



Improved ISO propagation modeling

Heimann et al. 2007 and Lercher P, unpublished

Evaluation of low frequency noise impact from motorways in the Netherlands

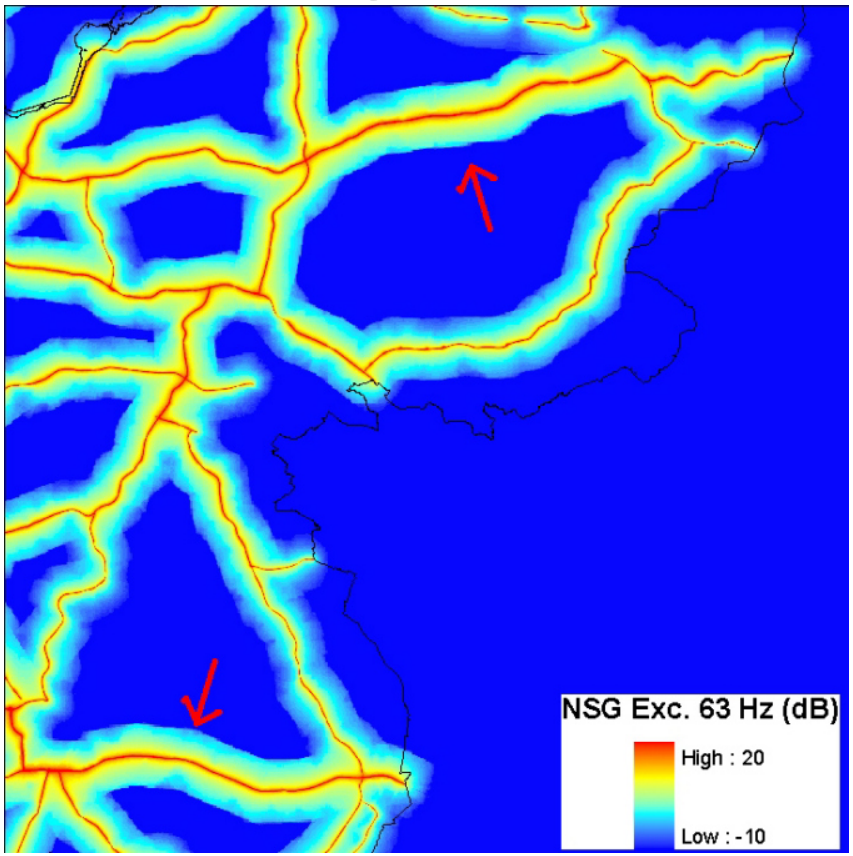


Fig. 6. Noise Map of roads with large Amounts of Heavy Vehicles

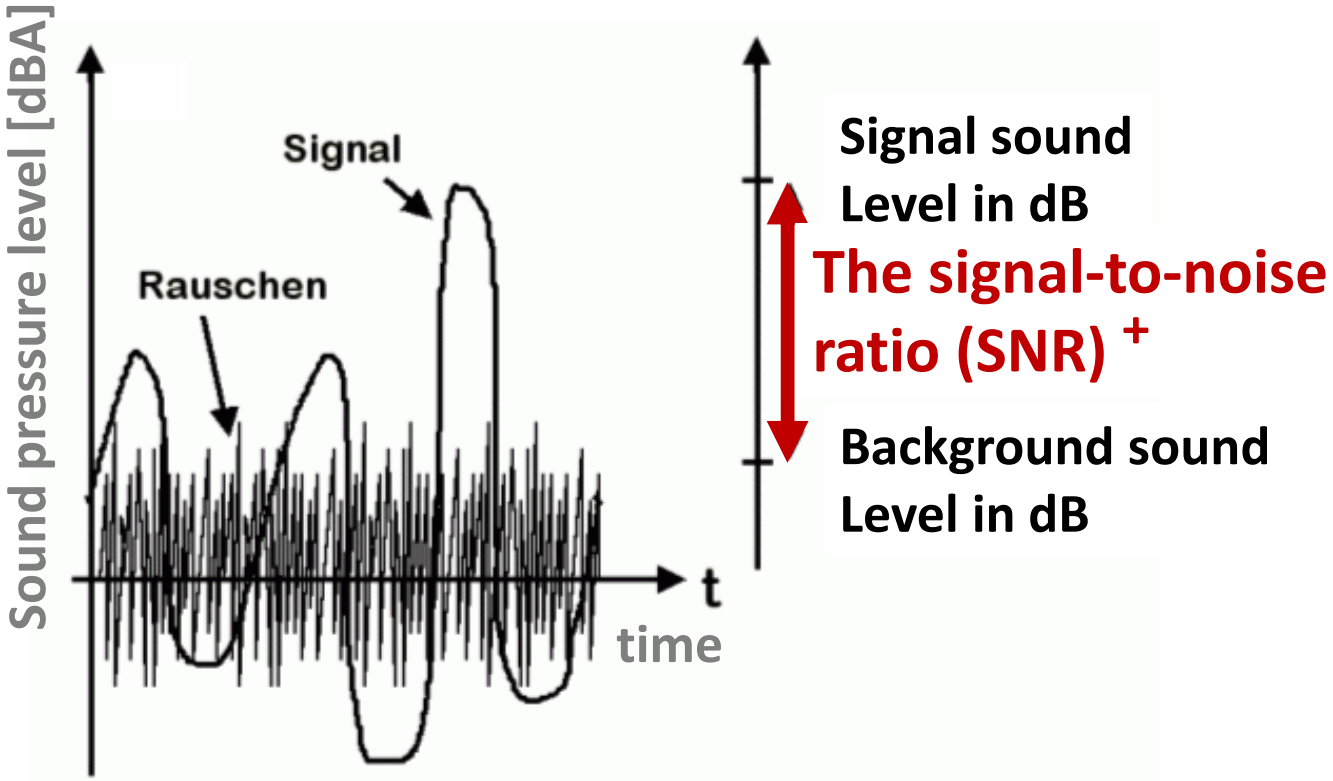
Guideline	Number of households (Mio)	Total percentage of households
NSG* guideline 63 Hz	3.00	43
NSG* guideline 125 Hz	5.60	79
dBC-A ≥ 15 dB	4.20	59
dBC-A ≥ 20 dB	0.64	9

* the LF-guideline according to the Dutch Association for Noise Annoyance (NSG)

Quelle: Schreurs et al. , Acoustics `08

The signal-to-noise ratio (SNR)

is the main determinant of the autonomic reaction[+]

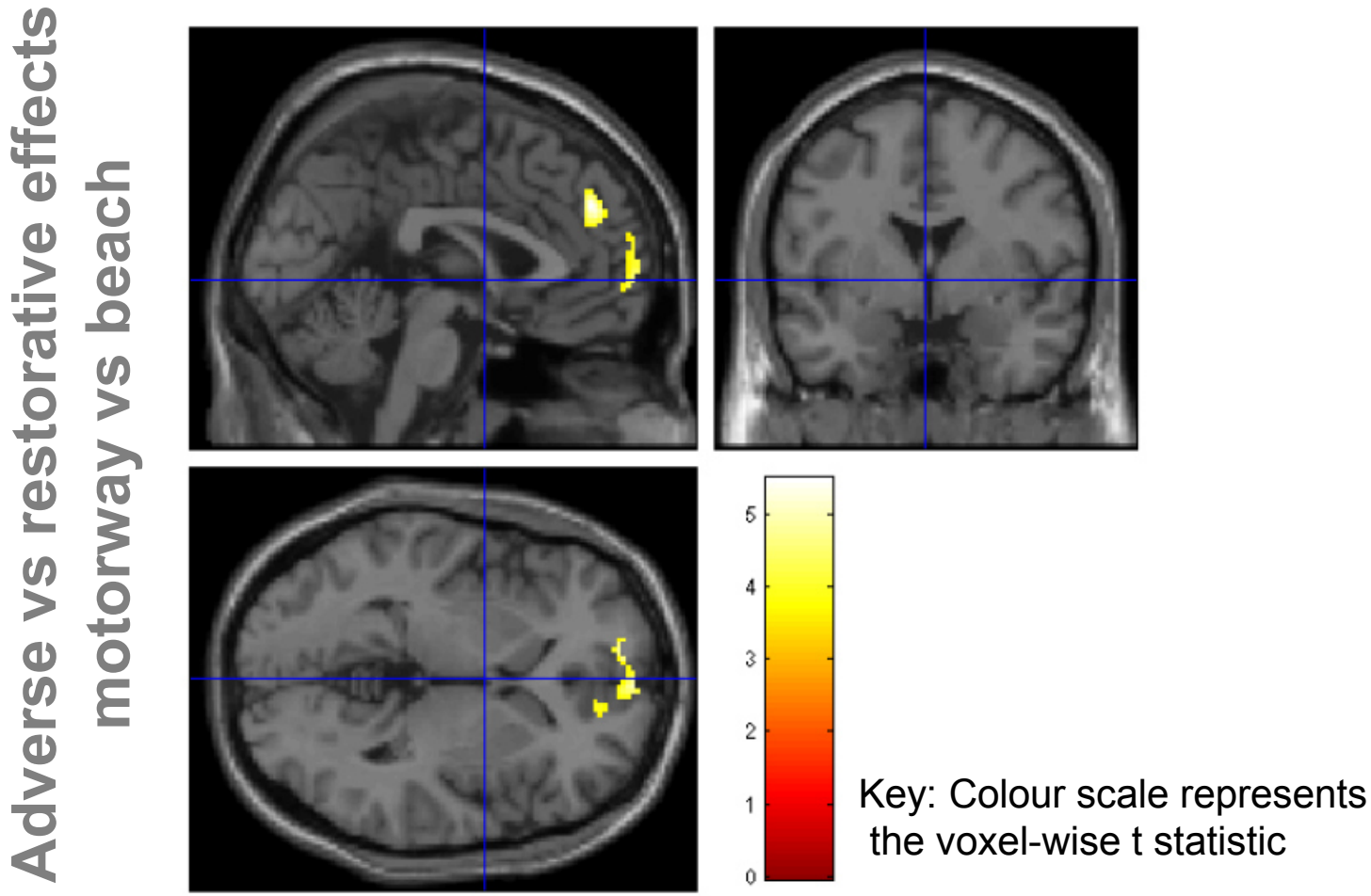


[+]Rule of thumb

A 10 dBA-difference[°] is able to elicit autonomic reactions

° Chang SS et al. 2015 conformed neglected earlier research (Klosterkötter 1977) down to 35 dBA*

* It is long known that exposure in lower sound level areas (<50dBA) will elicit stronger annoyance: as reaction is directly proportional to perception and not to sound intensity



Watts et al. 2009 utilized an experimental design by which it has been possible to isolate visual (landscape) effects in modulating the response to auditory inputs. **The A-weighted levels in both cases is exactly 65 dB(A)** Specifically it has been shown that responses in the medial prefrontal cortex are linked directly to activity in the auditory cortex under tranquil conditions (beach) but not under non-tranquil conditions (motorway).

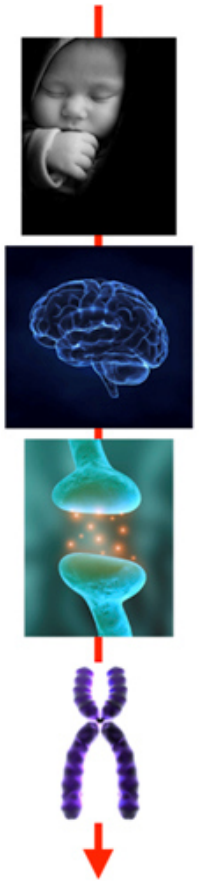
The needs for future studies

MORE CONSIDERATION OF MODERATION BY PERSON AND CONTEXT

Person-Environment-Relations

The study rationale

- **The existence of differential susceptibility/resilience to social and physical environments at different systemic levels** (Reiss et al. 2013, Boyce 2016)
- **The possible combined/synergistic effects of the social and physical environment** (Appleton et al. 2016)
- **Note: This knowledge is often required to appropriately implement preventive actions**



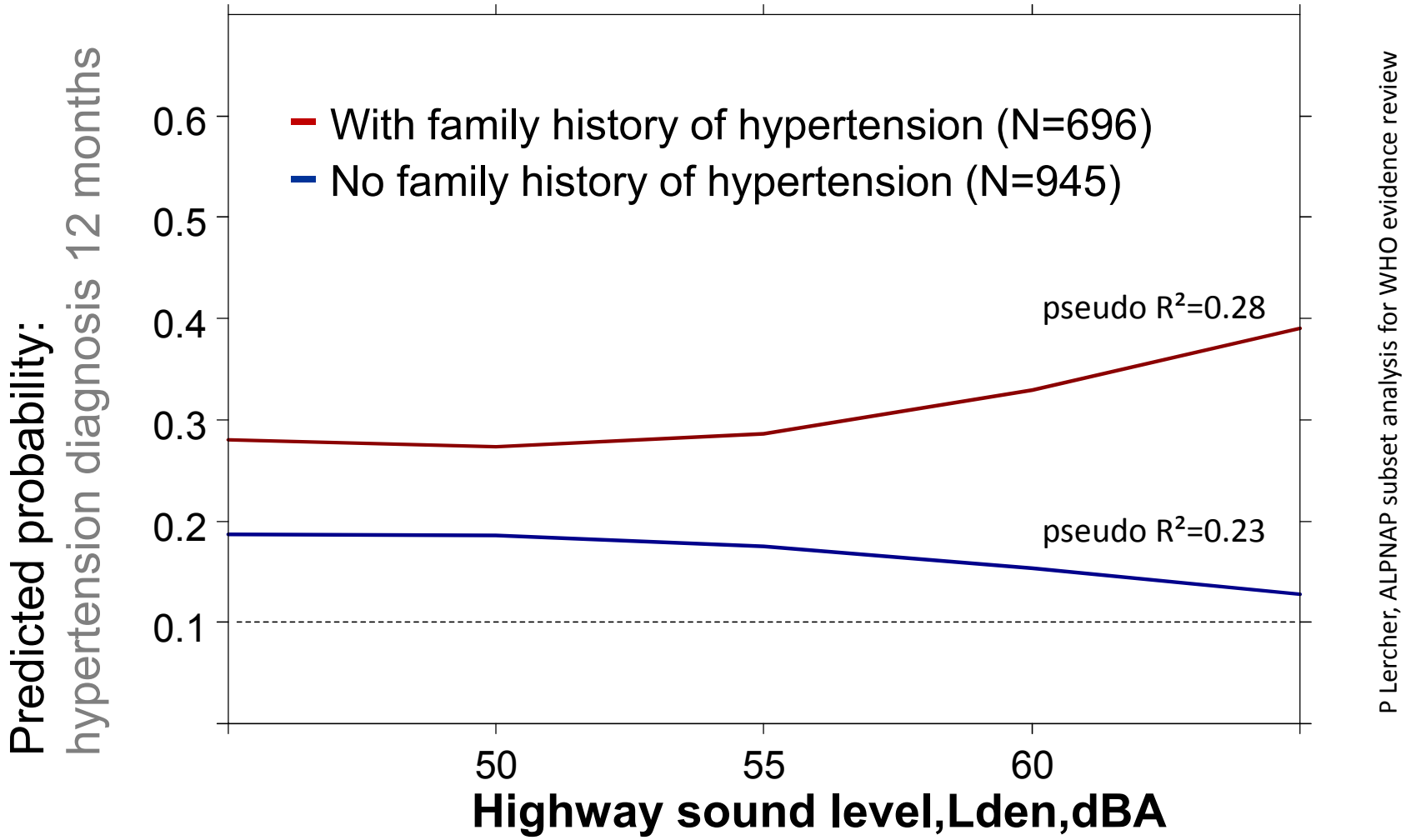
Early experience and behaviour

Autonomic regulation, Serotonin/Dopamin etc.

Synaptic functions Suppression/modulation/ resilience

Epigenetic regulation and Gene-environmental interactions

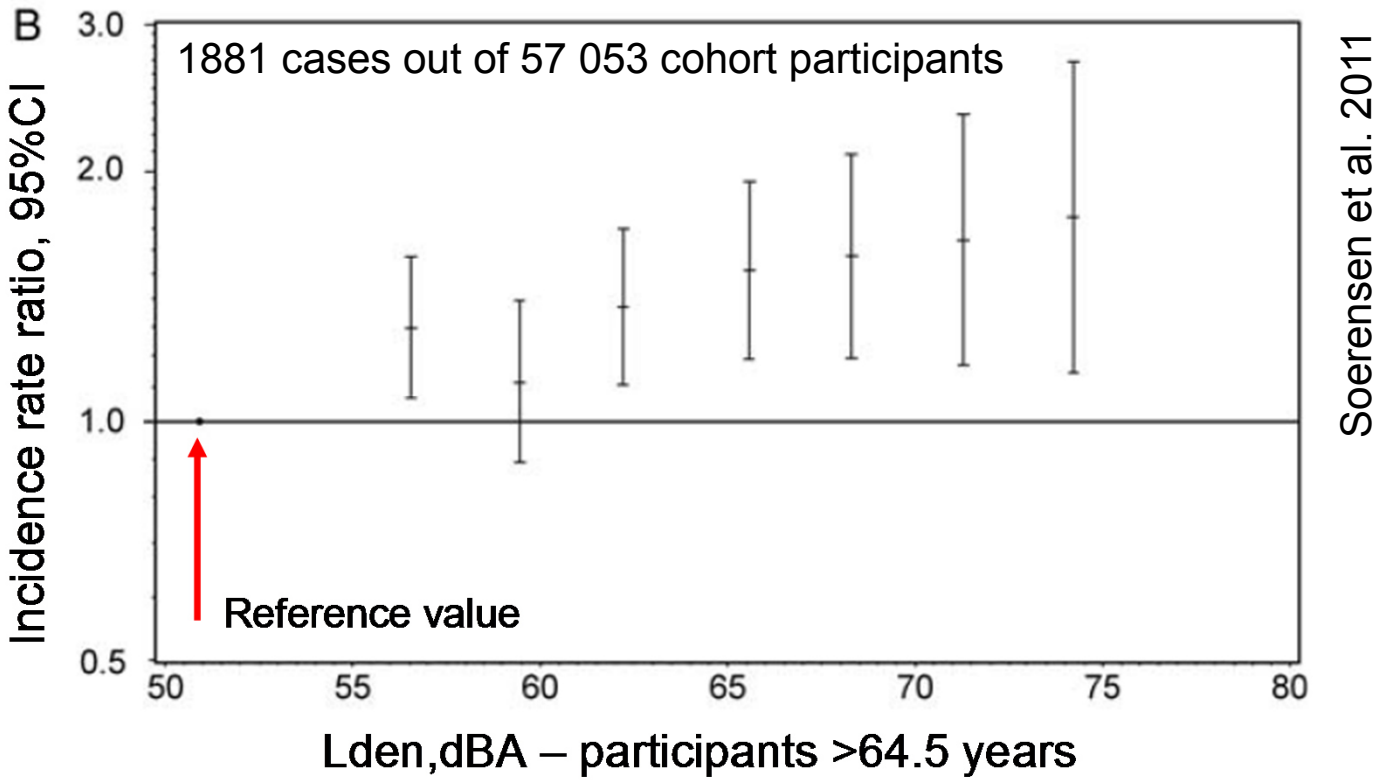
Susceptible groups: family histories



P Lercher, ALPNAP subset analysis for WHO evidence review

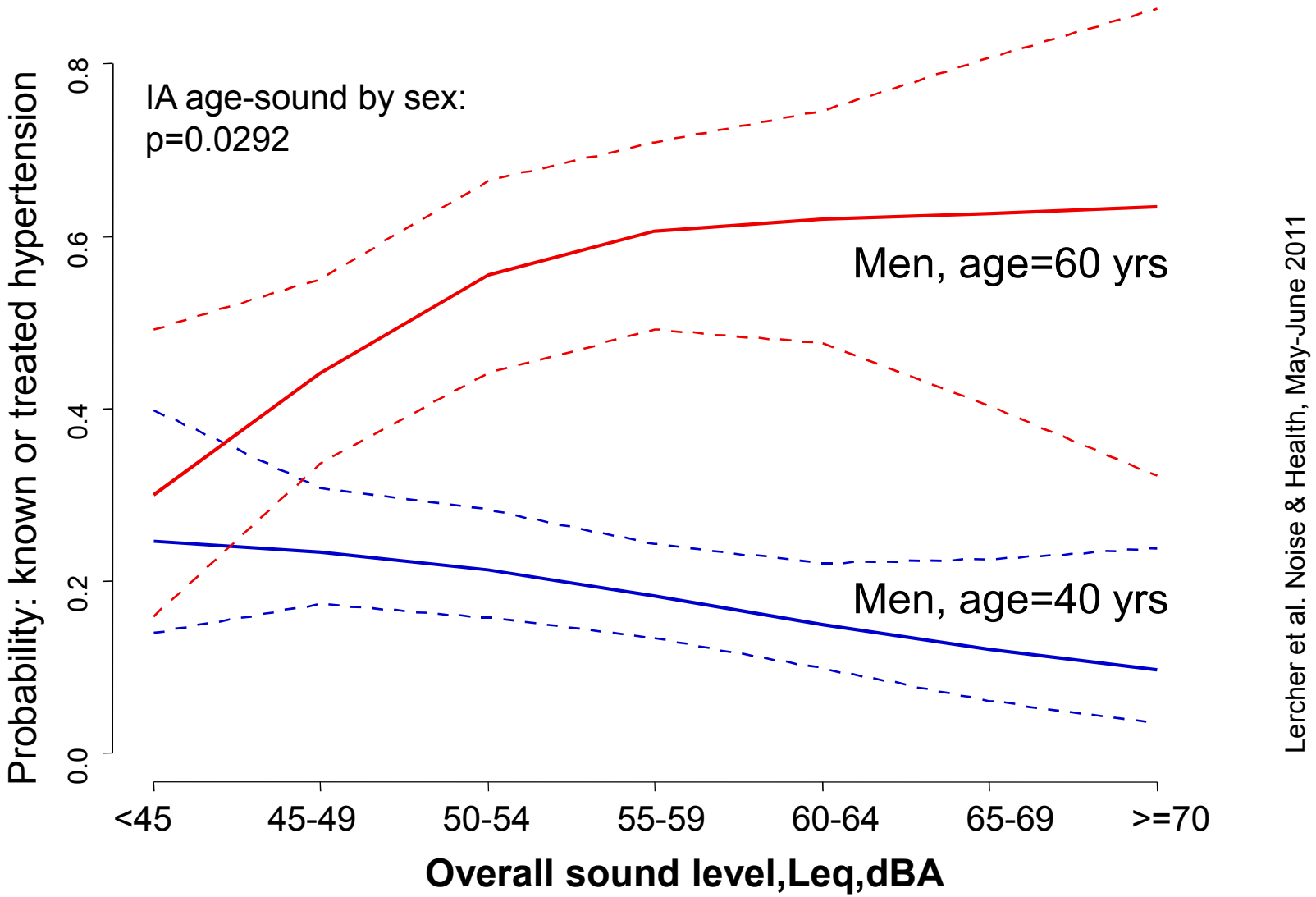
Stroke: longitudinal study

Susceptible groups: the elderly



Adjusted relation between road traffic noise (Lden) and incidence rate ratio (IRR) with 95% confidence intervals for stroke in **participants above 64.5 years of age**.

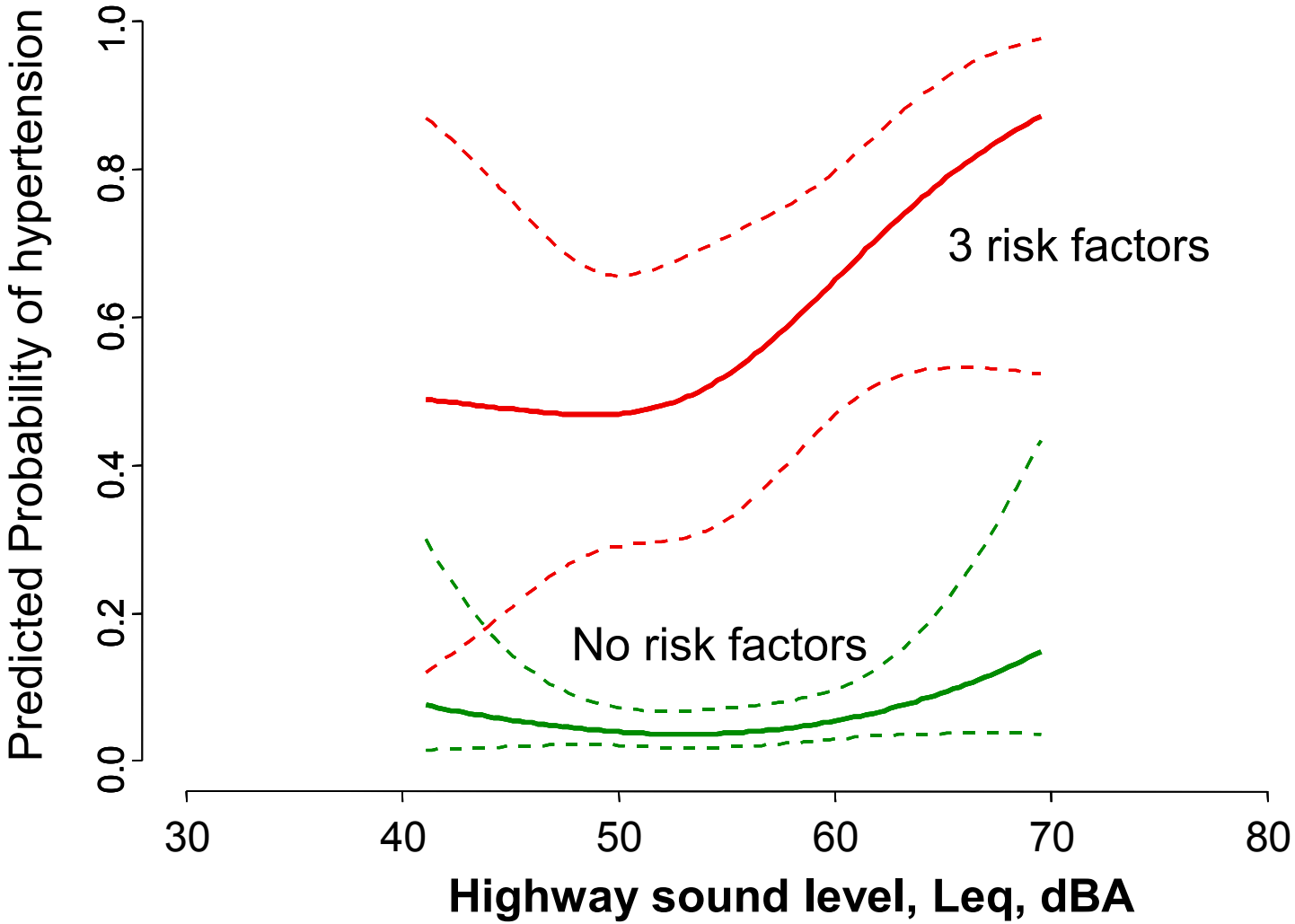
Interaction age and sound



Lercher et al. Noise & Health, May-June 2011

Figure 7: **Hypertension:** Exposure-response for overall sound exposure (road and rail traffic) by age in men. Adjusted for BMI, family history, cholesterol, education, noise sensitivity, IA sound level*age, sound level*sensitivity

Combined risk susceptibility



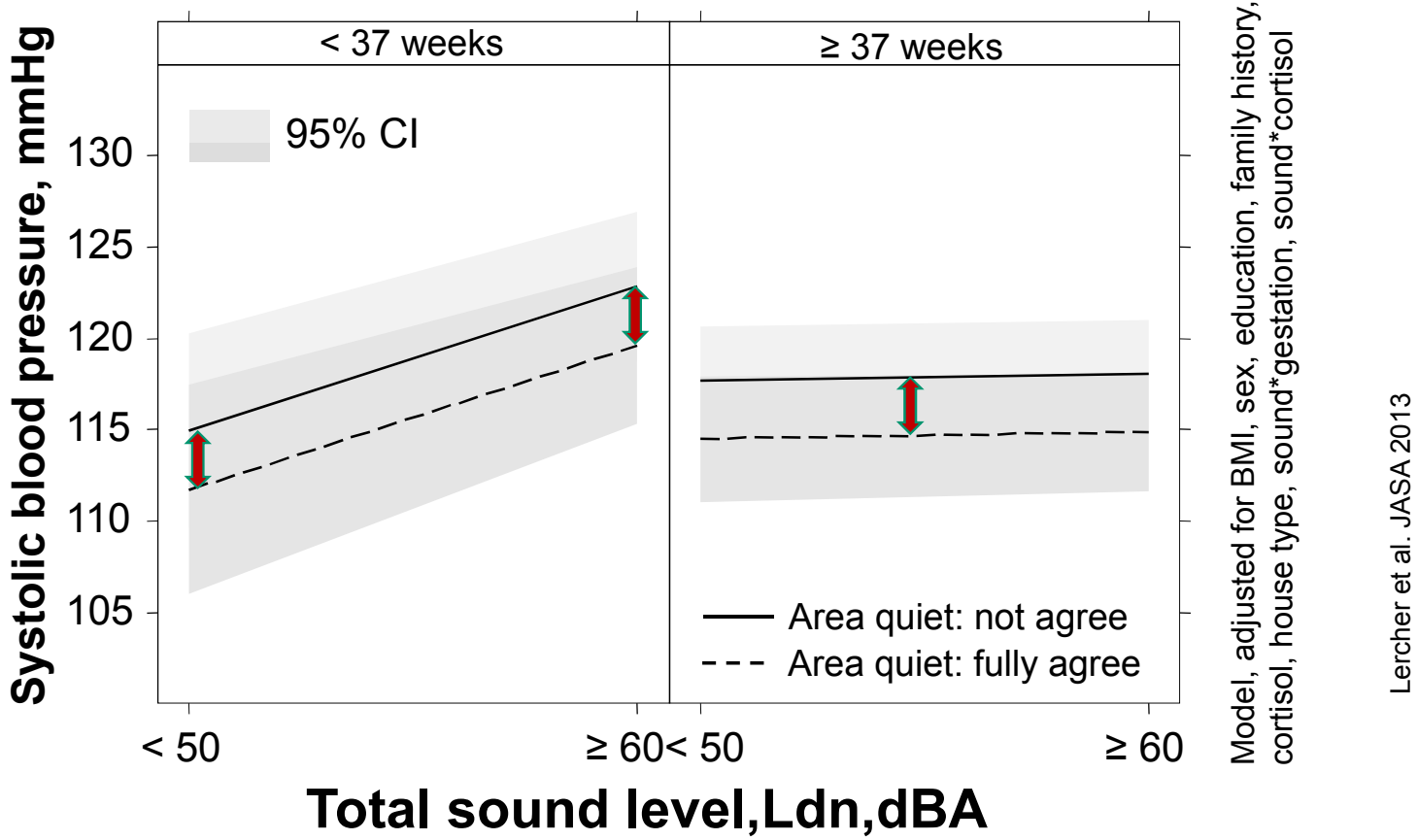
Exposure-response for highway sound exposure at age 60 years in poor health with a strong family history – against age 40 years, good health, no family history
Adjusted for sex, BMI, education, house type, annoyance, occupational noise, area

Lercher et al. Noise & Health, May-June 2011

Examples from children' studies

The effect of perceived quietness on systolic blood pressure in children

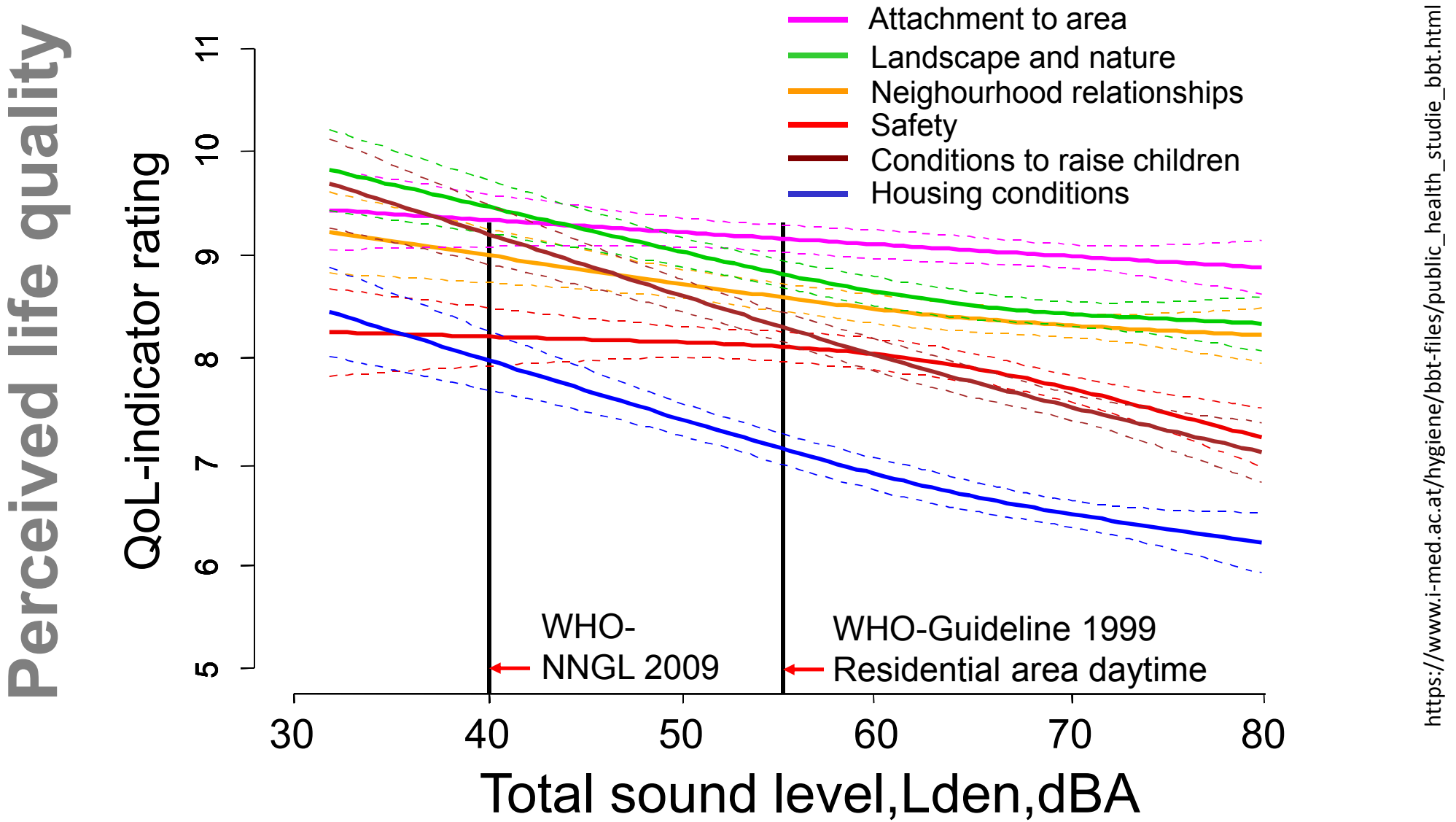
Paired with an interaction between sound level and short gestation (<37 weeks)



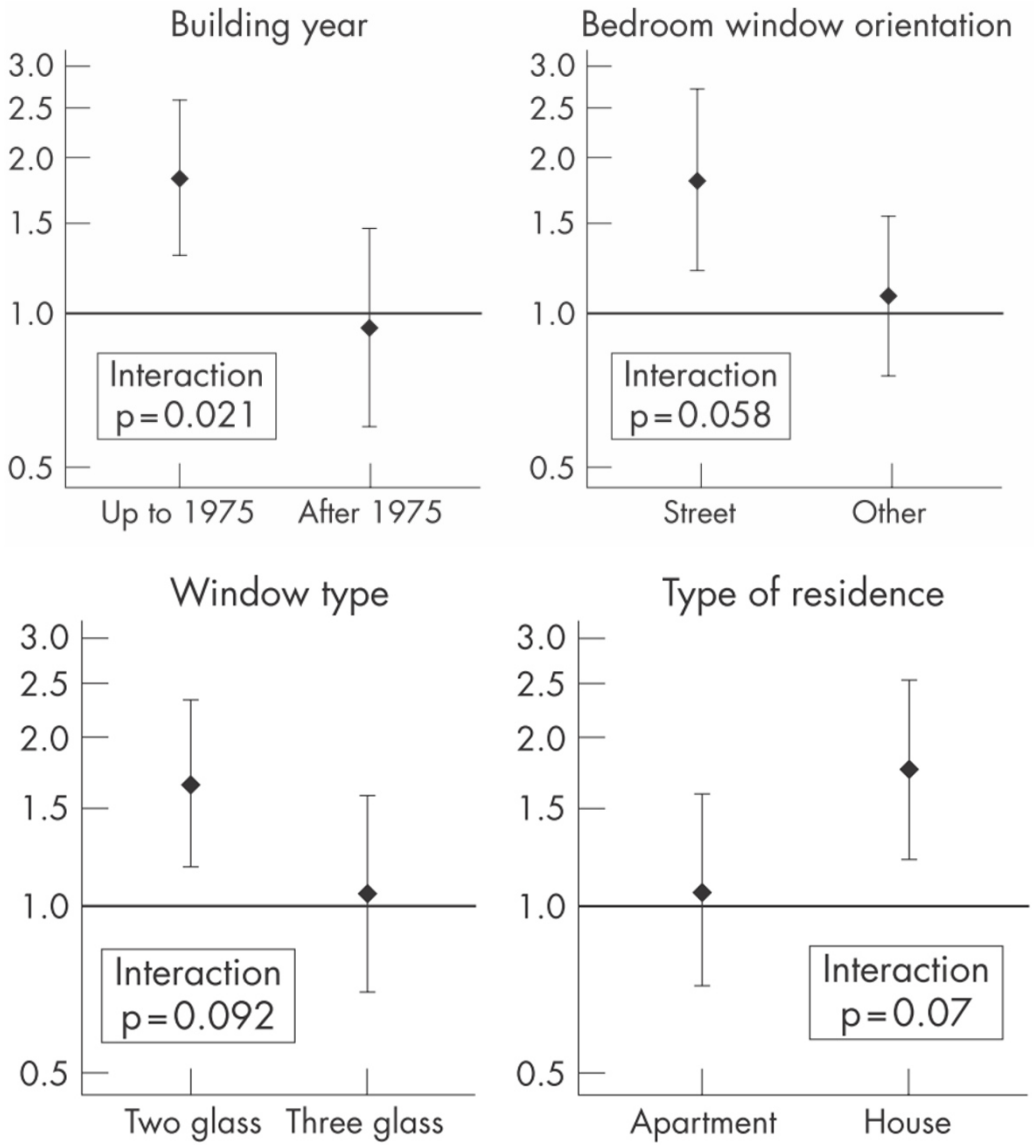
Sensitivity analysis: The coefficient of the "soundscape" indicator did not change in the presence of both annoyance indicators (road, rail) in the adjusted regression model

Moderation: The ecological level ("enviroscape")

Area-housing-safety-neighbourhood differences



https://www.i-med.ac.at/hygiene/bbt-files/public_health_studie_bbt.html



Moderation by Residential context

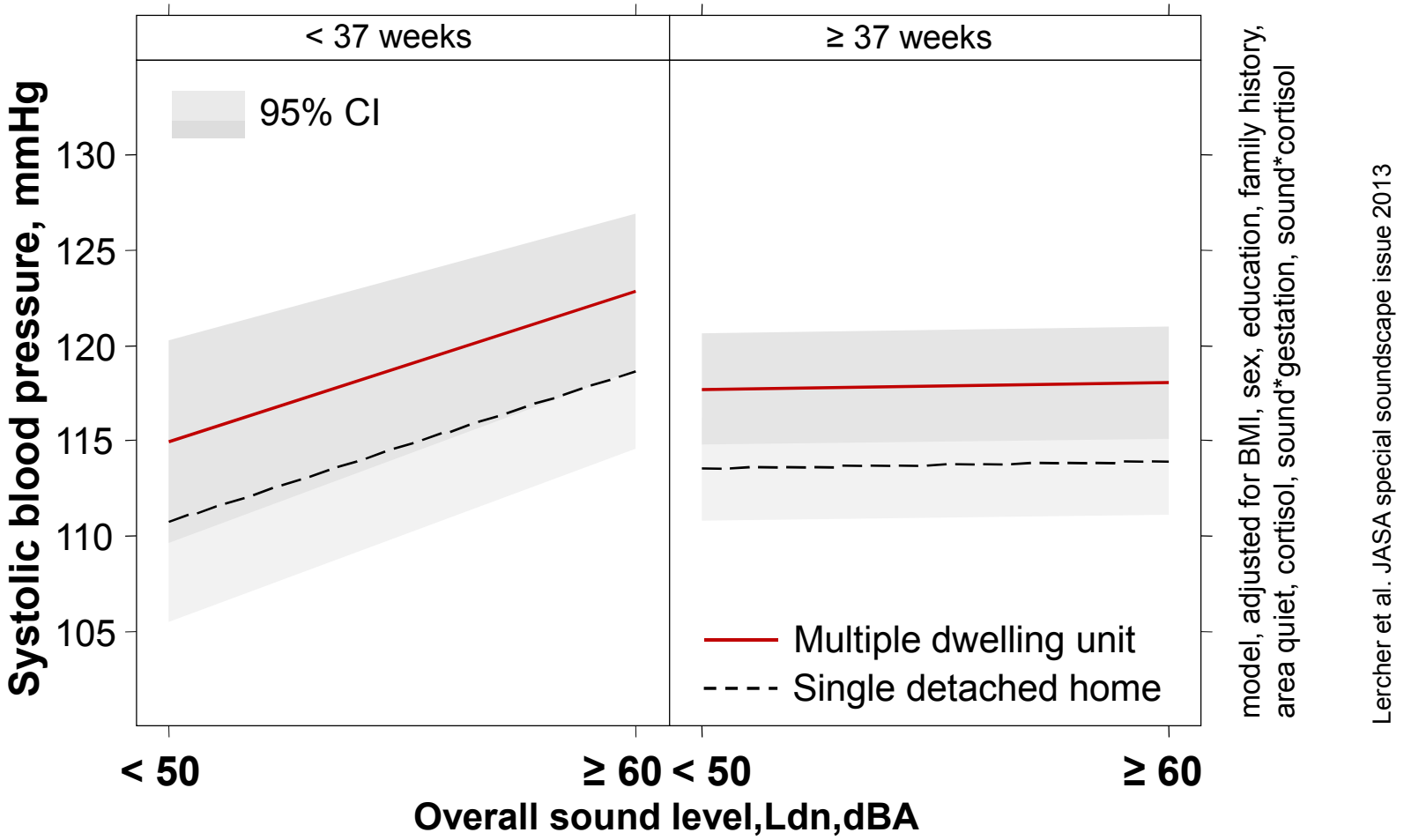
Odds ratio and 95% confidence intervals (CI) for hypertension associated with a 5 dBA increase in road traffic noise exposure by four moderators

Source: Bluhm et al., 2007

Examples from children' studies

The effect of multiple dwelling living on systolic blood pressure in children

Paired with an interaction between sound level and short gestation (<37 weeks)

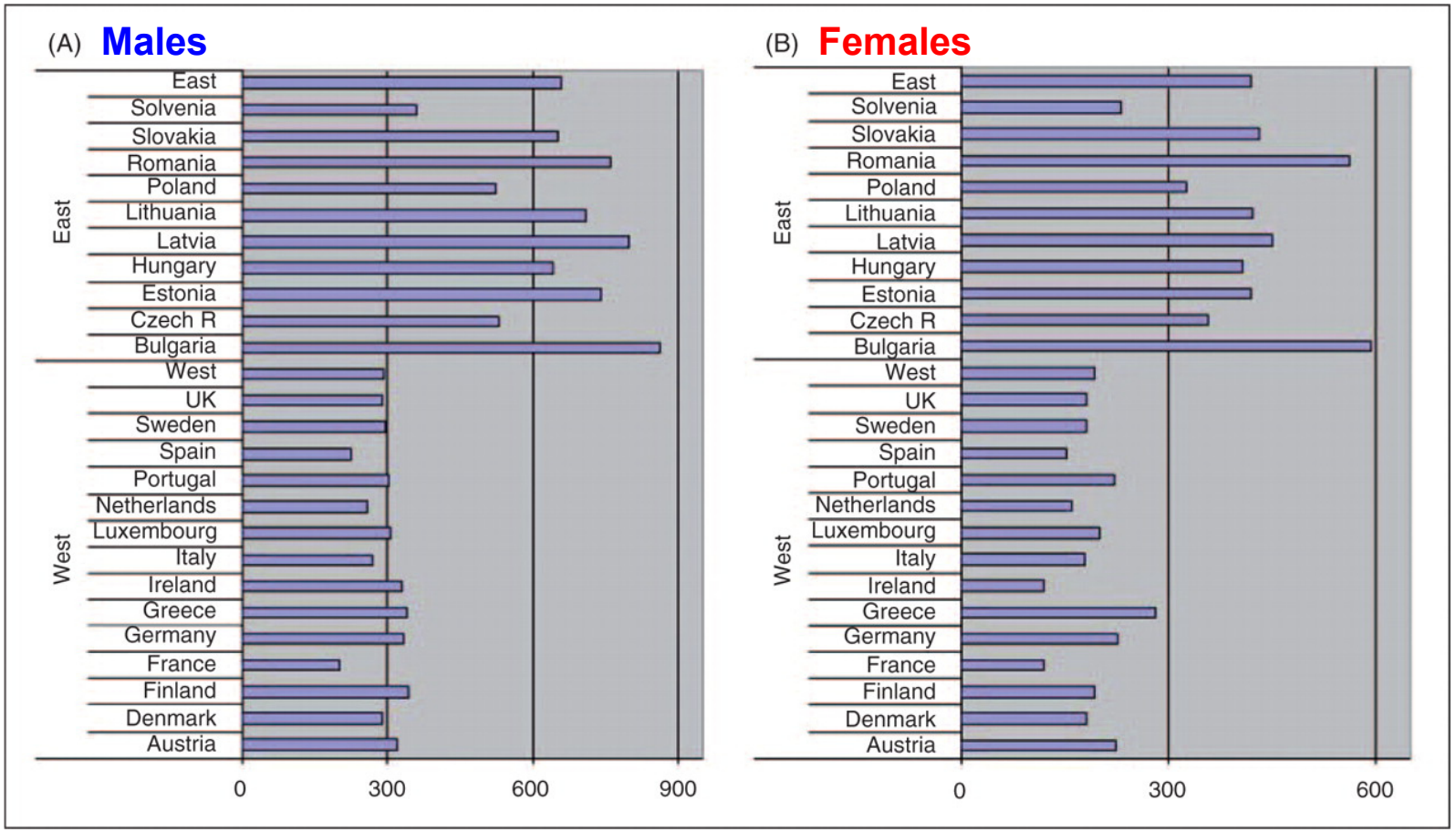


Check: “I like to live here,” etc. may be related to the more favorable blood pressure outcome of children living in single detached homes (Lercher et al., 2000)

Moderation: The ecological level ("enviroscape")

Heterogeity of background prevalence of health and disease in study populations

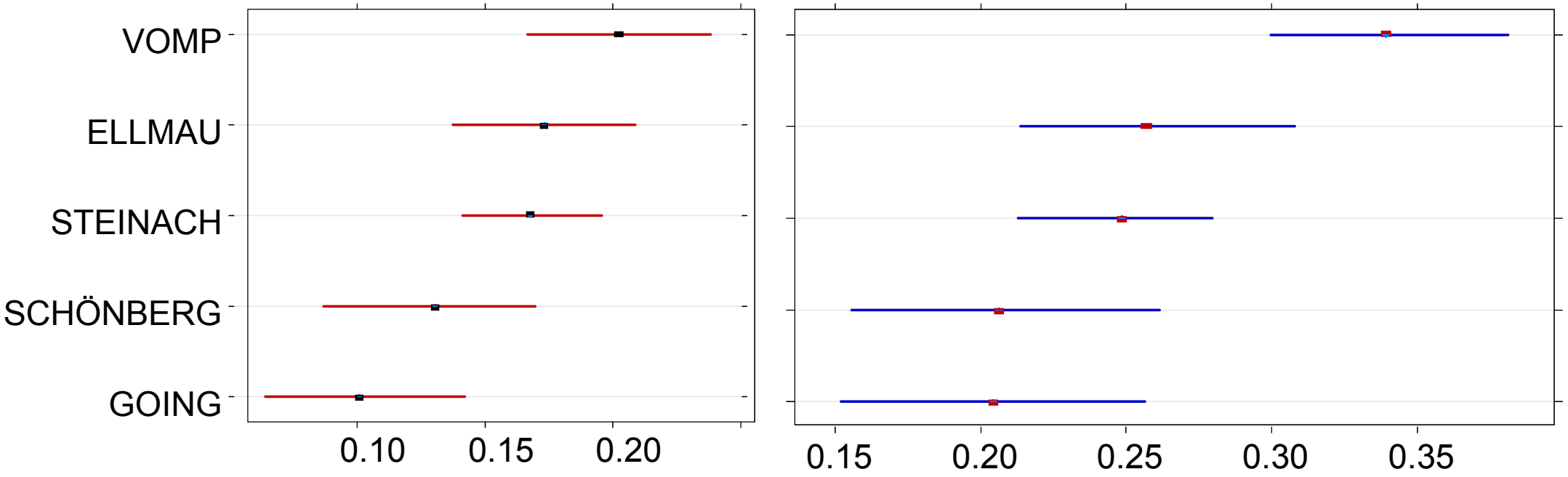
At the European level



Age-standardized CVD mortality rates (all ages, per 100,000) in East and West Europe for the period 2000–2007

Helis E et al. European Journal of Cardiovascular Prevention & Rehabilitation 2011;18:347-359

At the Community level



Prevalence of **hypertension**

Prevalence of **hypotension**

Unpublished: Lercher P, Transit study Tirol 1989

http://homepage.i-med.ac.at/q002pl/

Research Gate
https://www.researchgate.net/profile/Peter_Lercher3

Thank you
for your attention !