



National Institute for Public
Health and the Environment
Ministry of Health, Welfare and

Environmental noise guidelines for the European region

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NL Institute for Public Health and the Environment

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AJUNTAMENT DE
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#EUGREENWEEK

Why new guidelines ?

- It is a while ago that the guidelines for health protection against environmental noise were published (Berglund, Lindvall, Schwela 1999)
 - Among WHO,s most downloaded documents
- In the meanwhile: many new studies
- New guidelines also relevant for European Environmental Noise directives (END)
- Guidelines now focused on transport noise
- Ministerial Conference Parma 2010 emphasised the need for guidelines for other sources such as devices, toys and windturbines.



New Guidelines : proces and approach

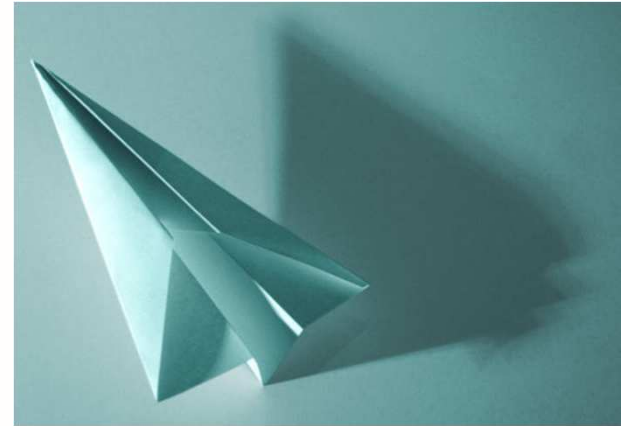
- Development according to a strict protocol
- The process guided by the Guideline Development Group (GDG) (GDG)
- Role Monitor the proces and responsible for the guidelines based on the systematic reviews per outcome.
- New guidelines need to be based on the latest state of art in science
- For several outcomes evidence reviews were prepared and published (Note evidence up to 2014 so already somewhat outdated)



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Evidence reviews

- Annoyance
- Sleep
- Cognitive effects and mental health
- Effects on cardiovascular and metabolic system
- Adverse Birth Outcomes
- Hearingloss and Tinnitus
- Effects of interventions



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References

- **Guski R, Schreckenber D, Schuemer R.** WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Annoyance. *International journal of environmental research and public health*. 2017 Dec 8;14(12):1539.
- **Mathias Basner and Sarah McGuire** WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep *Int. J. Environ. Res. Public Health* 2018, 15(3), 519; doi:10.3390/ijerph15030519
- **Clark C, Paunovic K.** WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cognition. *International journal of environmental research and public health*. 2018 Feb 7;15(2):285.
- **Kempen EV, Casas M, Pershagen G, Foraster M.** WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cardiovascular and Metabolic Effects: A Summary. *International journal of environmental research and public health*. 2018 Feb 22;15(2):379.
- **Nieuwenhuijsen MJ, Ristovska G and Dadvand P.** WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Adverse Birth Outcomes. *Int. J. Environ. Res. Public Health* 2017, 14(10), 1252; doi:10.3390/ijerph14101252
- **Śliwińska-Kowalska, M and Zaborowski K.** WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Permanent Hearing Loss and Tinnitus. *Int. J. Environ. Res. Public Health* 2017, 14(10), 1139; doi:10.3390/ijerph14101139
- **Brown AL, van Kamp I.** WHO environmental noise guidelines for the European region: A systematic review of transport noise interventions and their impacts on health. *International journal of environmental research and public health*. 2017 14(8): 873.

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Annoyance (inputs from Guski et al)

- In the recent WHO review on the impact of environmental noise on annoyance (Guski et al., 2017) including studies published between 2000 and 2014,
- the evidence for an exposure-response relationship for annoyance was (a.o) reviewed for the noise sources aircraft, railway, road traffic,
- Adding studies after 2014 : all provide consistent evidence of an exposure-response relationship (Erfs) between environmental noise and annoyance,
- Erfs (per source) show considerable variance over time and between studies,
- Supporting the preference for region specific curves



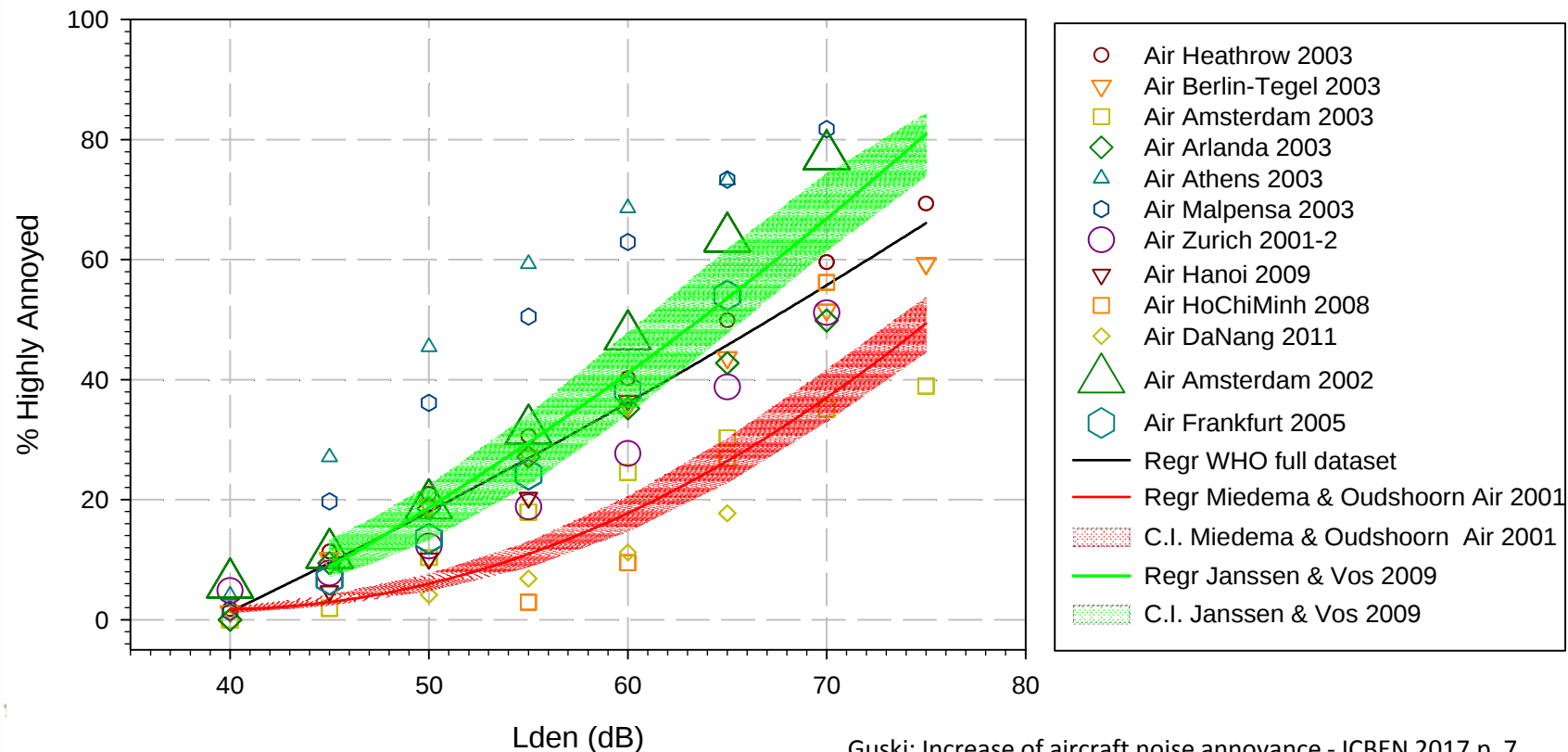
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Erfs differ from earlier studies 1

➤ **WHO Evidence Review 2017** (Guski, Schreckenberg & Schuemer, 2017.

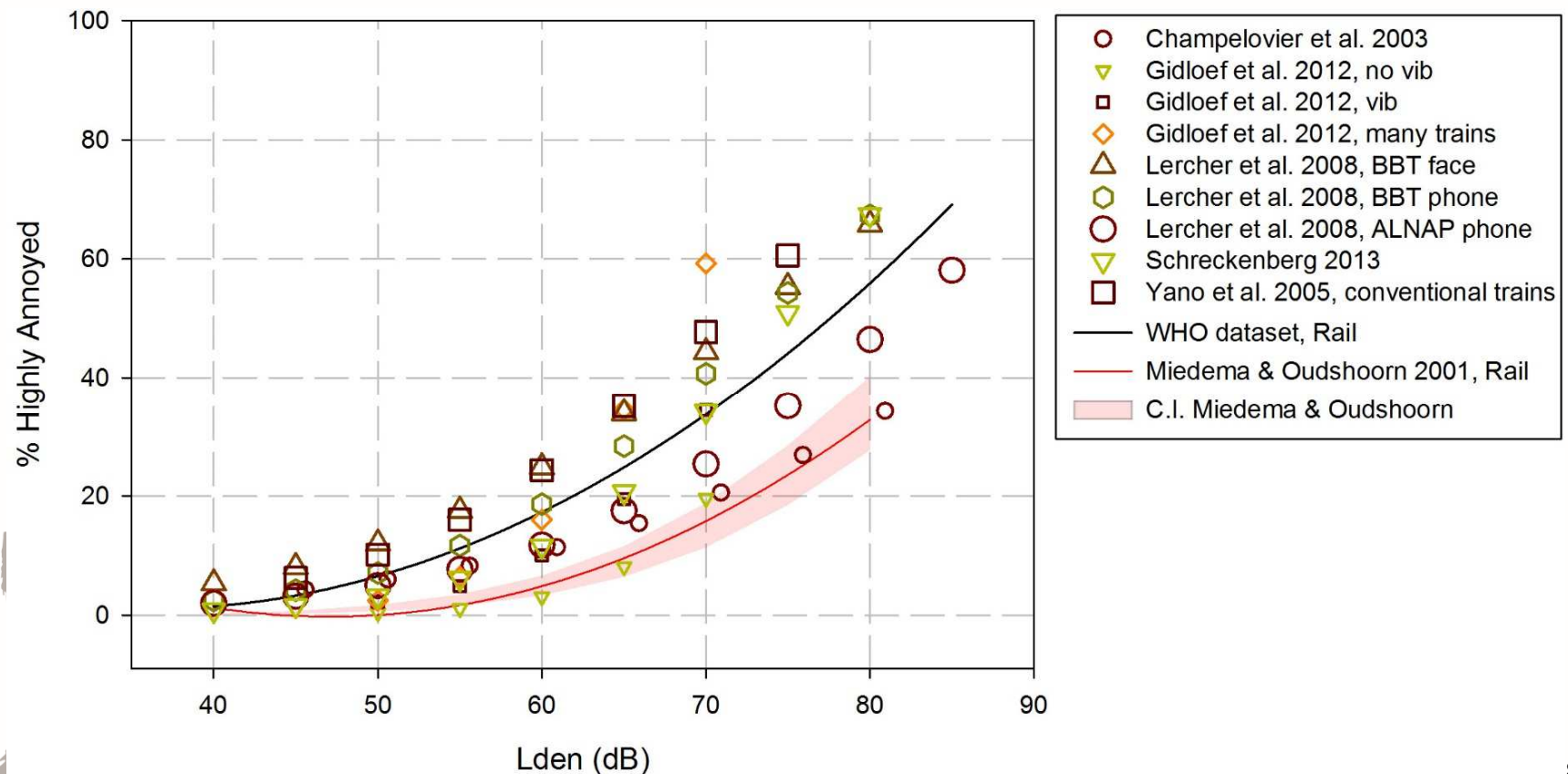
Covers publications 2000-2014):

- 12 aircraft noise surveys provided ERFs, $\Sigma N=17,094$
- Modelled data from ERFs were weighted by study size, and aggregated: % HA higher than EU standard curve at comparable Lden



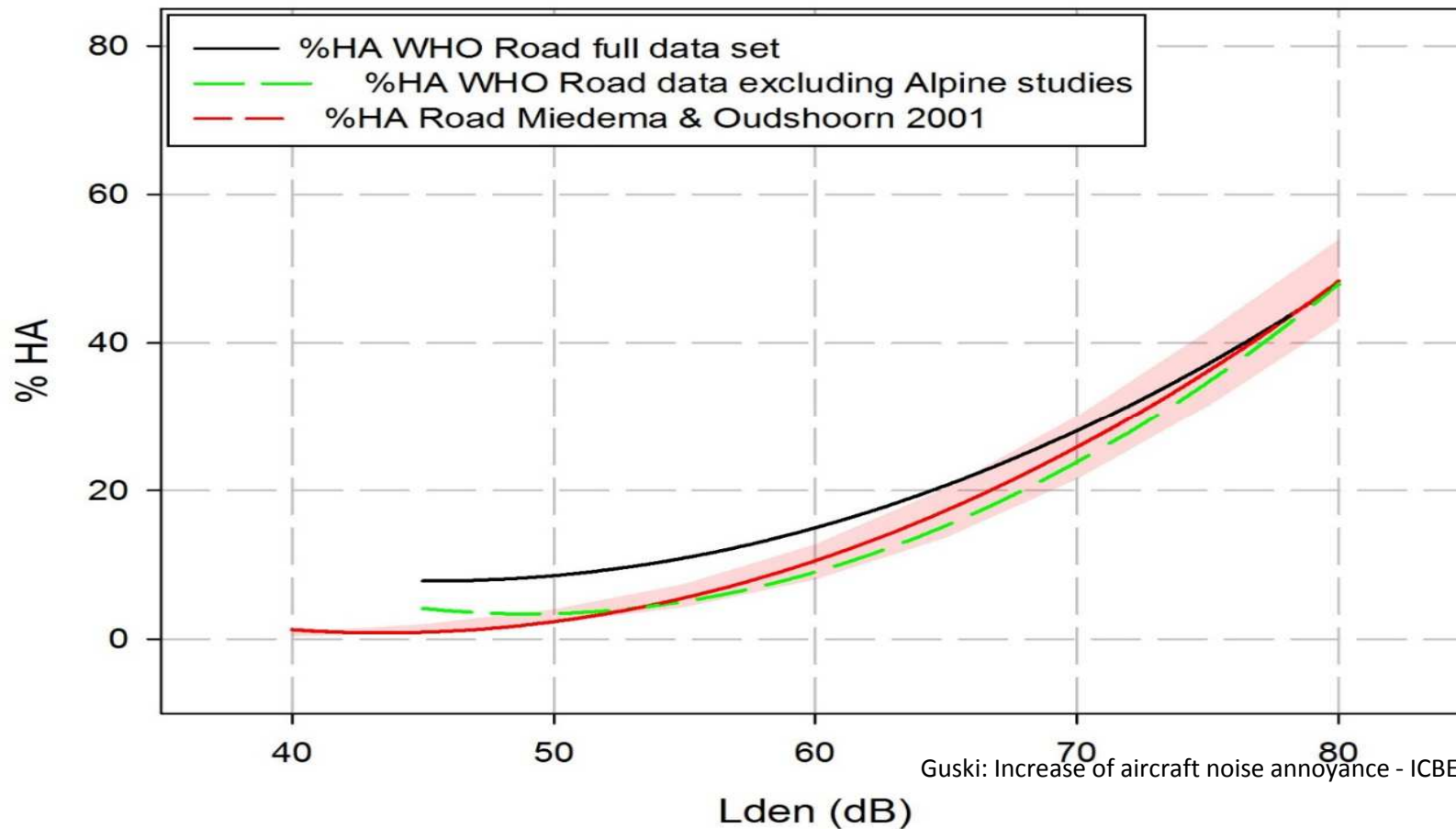
Increase of % HA is not unique to aircraft noise 1

- WHO Evidence Review 2017, Railway noise annoyance:
 - %HA higher than EU standard curve at comparable Lden
 - Esp. at higher Lden levels



Increase of % HA is not unique to aircraft noise 2

- WHO Evidence Review 2017, Road traffic noise annoyance:
 - %HA higher than EU standard curve at lower Lden levels
 - Esp. if Alpine studies are included



Sleep (inputs from Basner and McGuire)

- - Published in the year 2000 or later (to update previous guidelines) except for hospital noise (all studies included regardless of year)
 - Studies that either measured or predicted noise levels (e.g. studies that used distance only were excluded)

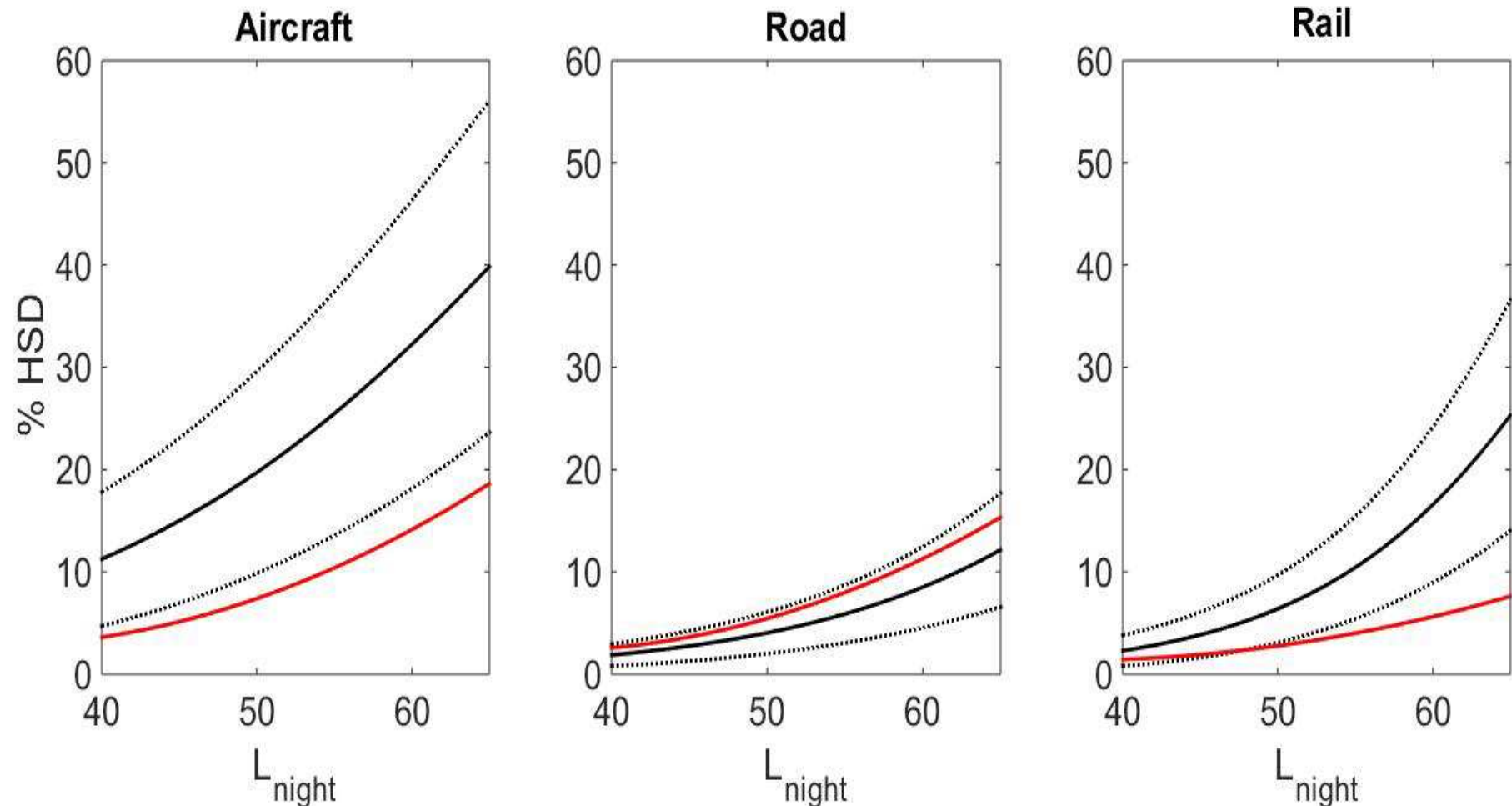
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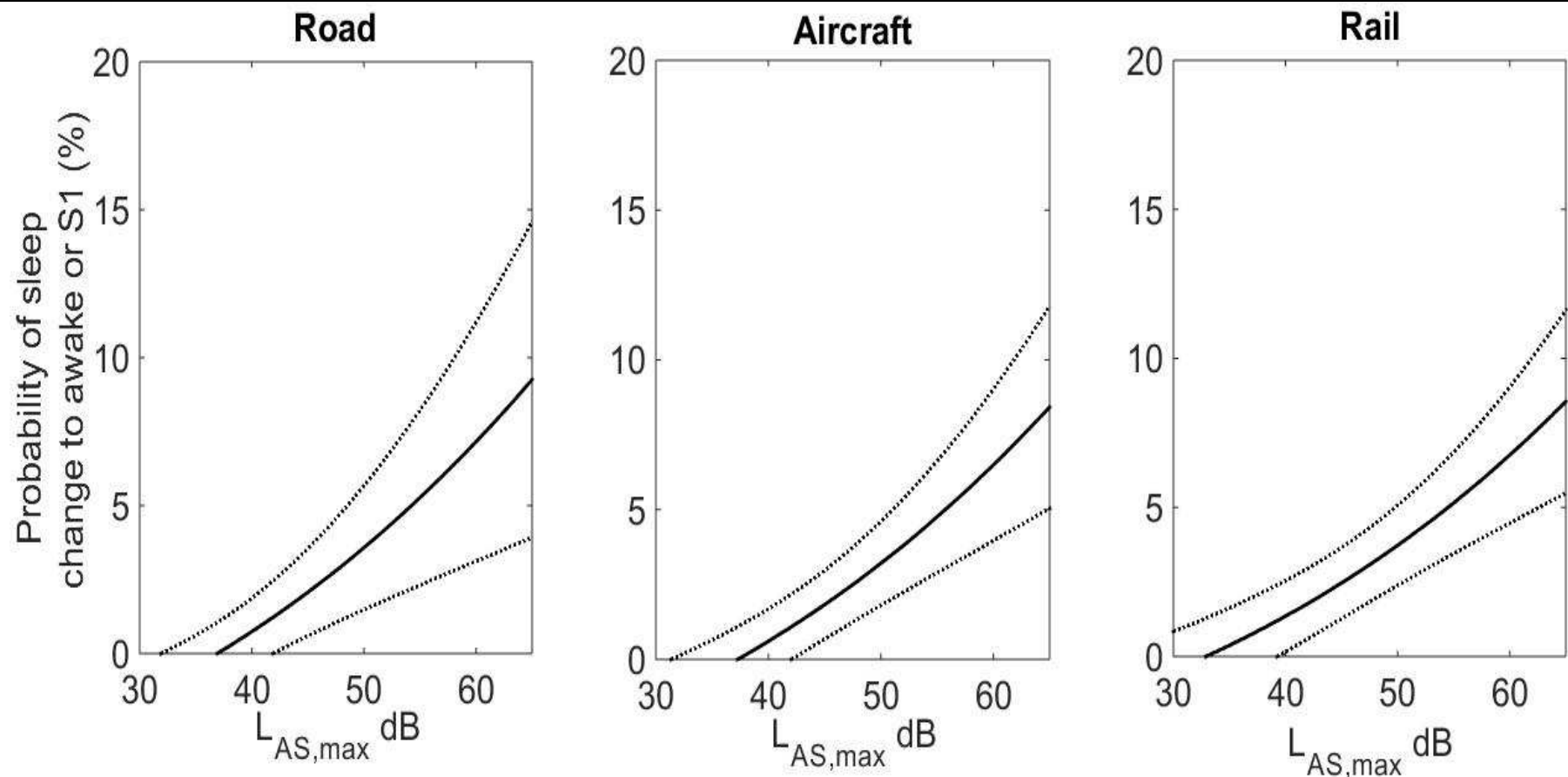
Percent Highly Sleep Disturbed (HSD)

Red Lines are Miedema and Vos (2007) HSD Exposure-Response Curves



Probability of additional sleep stage changes to wake or S1

- Calculated random subject effect logistic regression models with $L_{AS,max}$ as the only predictor
- Calculated spontaneous awakening probability (probability of awakening during noise-free periods), separately for each transportation mode



Cognitive effects (inputs Clark, Paunovic and Klatte)

Four main recent studies which meet basic methodological quality criteria and comparable measures:

- NORAH (Frankfurt Airport) study (Klatte et al. 2016) To be published soon in broad lines like RANCH.
- RANCH study (Stansfeld et al, 2005), as follow up of West London School study) Air- and Road-traffic: Impaired reading comprehension and recognition memory, after taking a range of socioeconomic and confounding factors into account) – Airtraffic.
- Munich Airport study (Evans, Hygge & Bullinger, 1995; Evans, Bullinger & Hygge, 1998; Hygge, Evans & Bullinger, 2002) Memory deficits and reading comprehension.
- Tyrol Study (Lercher, 2006) predominantly road and rail sources Effect on intentional and incidental memory (effects smaller than those found around airports).

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Exposure-Effect relationships

RANCH Study

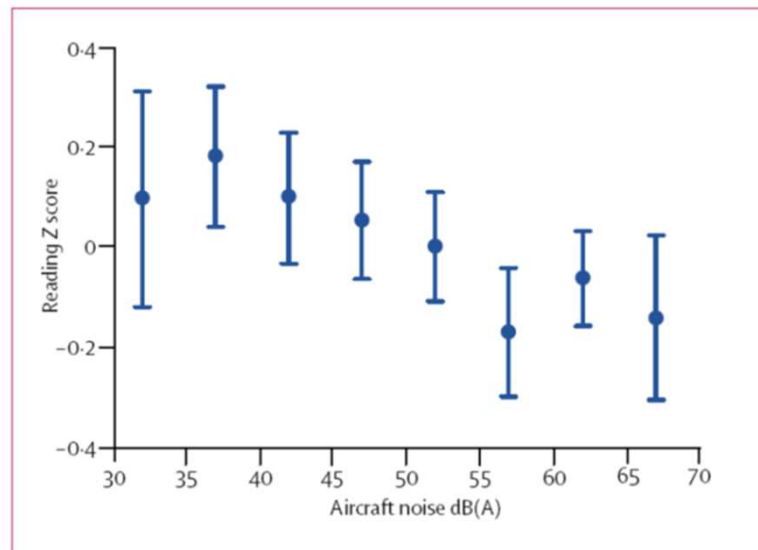
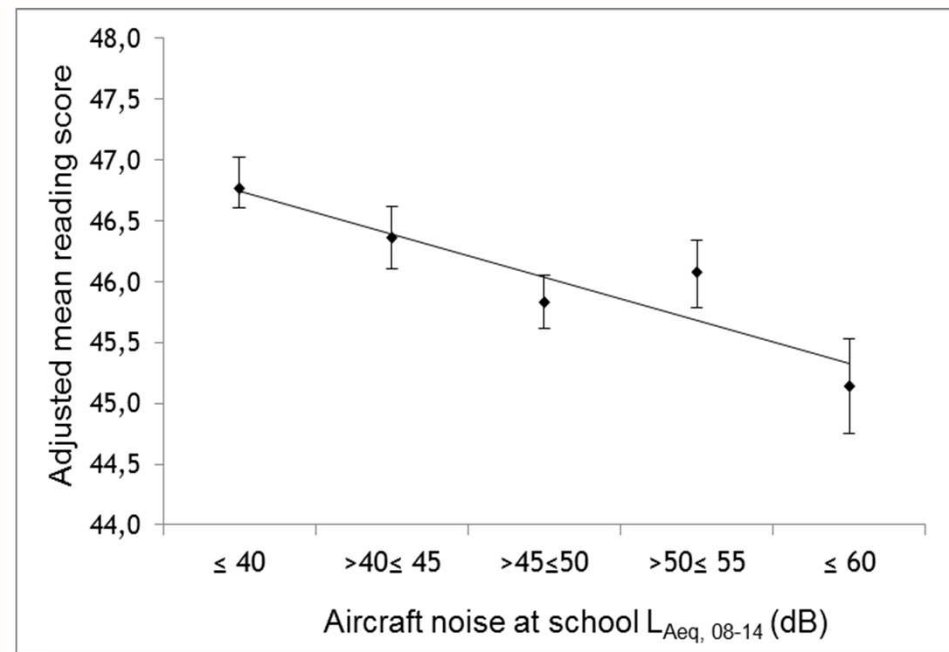


Figure 1: Adjusted mean reading Z score (95% CI) for 5 dB bands of aircraft noise (adjusted for age, sex, and country)

Stansfeld et al., 2005, *The Lancet*; 365: 1942-1949.

NORAH Study

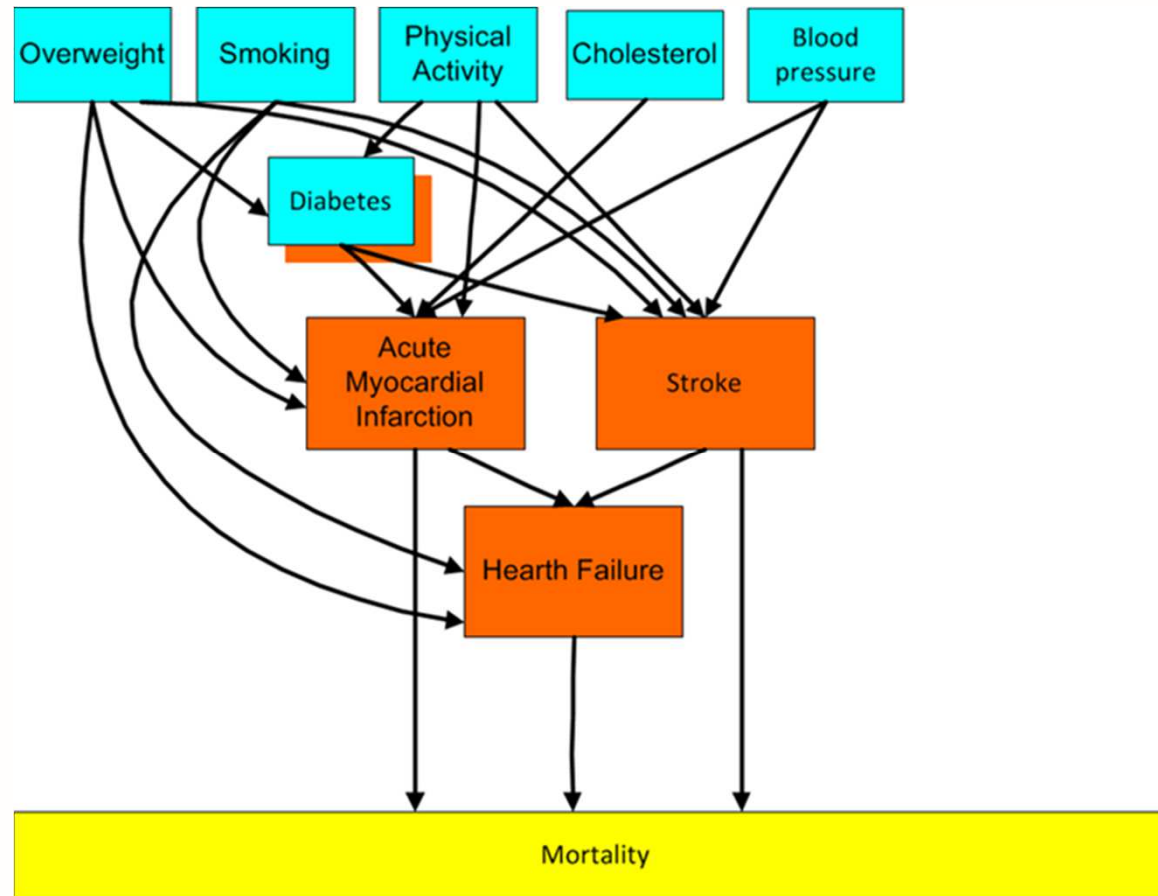


Klatte et al., 2016, *Environment & Behavior*

- In both studies, linear exposure-effect relationships were found after full adjustment for potential confounders.
- A 20 dB increase in aircraft noise at school was associated with a decrease in reading performance of 1/5th of a SD.
- **How bad is that? Mechanisms? → Implications for abatement**

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Cardiovascular Effects: New Endpoints



Selection of studies (inputs van Kempen, Foraster et al)

Identification

504 of records identified through database searching

104 of additional records identified through other sources

Screening

480 of records after duplicates removed

Eligibility

480 of records screened

313 records excluded (see table 3.2 for reasons)

167 full-text articles assessed for eligibility

54 full-text articles excluded, with reasons (see table 3.3)

Included

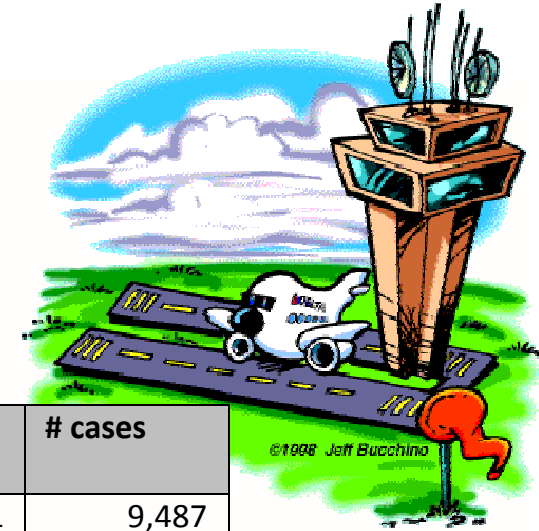
61 studies (113 records) included in qualitative synthesis

57 of studies included in quantitative synthesis (meta-analysis)

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Airtraffic



Outcome		# studies, designs †	RR per 10 dB (L_{den}) (95%Bthi)	# participants	# cases
Hypertension	Prevalence	9 CS	1.05 (0.95 – 1.17)	60,121	9,487
	Incidence	1 CO	1.00 (0.77 – 1.30)	4,712	1,346
IHD	Prevalence	2 CS	1.07 (0.94 – 1.23)	14,098	340
	Incidence	2 ECO	1.09 (1.04 – 1.15)*	9,619,082	158,977
	Mortality	2 ECO	1.04 (0.97 – 1.12)	3,897,645	26,066
		1 CO	1.04 (0.98 – 1.11)	4,580,311	15,532
Stroke	Prevalence	2 CS	1.02 (0.80 – 1.28)	14,098	151
	Incidence	2 ECO	1.05 (0.96 – 1.15)	9,619,082	97,949
	Mortality	2 ECO	1.07 (0.98 – 1.17)	3,897,645	12,086
		1 CO	0.99 (0.94 – 1.04)	4,580,311	25,231

† ECO = Ecological study CS = Cross sectional , CO = Cohort study; RR = Relative Risk
 dB = decibel, 95%Bthi = 95% confidence interval

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Road Traffic



Endpoint		# studies, design [†]	RR per 10 dB (L _{den}) (95%Bthi)	# participants	# cases
Hypertension	Prevalence	26 CS	1.05 (1.02 – 1.08)*	154,398	18,957
	Incidence	1 CO	0.97 (0.90 – 1.05)	43,635	3,145
IHD	Prevalence	8 CS	1.24 (1.08 – 1.42)*	25,682	1,614
	Incidence	1 ECO	1.08 (1.02 – 1.15)*	262,830	418
	Incidence	3 CO, 4 CC	1.08 (1.01 – 1.15)*	67,224	7,033
	Mortality	1 CO, 2 CC	1.05 (0.97 – 1.13)	532,268	6,884
Stroke	Prevalence	2 CS	1.00 (0.91 – 1.10)	14,098	151
	Incidence	1 CO	1.14 (1.03 – 1.25)*	51,485	1,881
	Mortality	3 CO	0.87 (0.71 – 1.06)	581,517	2,634

[†] ECO = Ecological study, CS = Cross sectional

CC = Case Control study, CO = Cohort study;

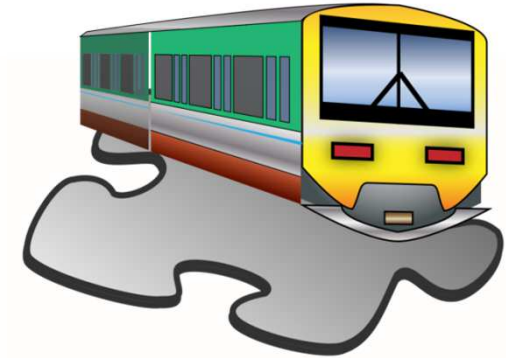
: RR = Relative Risk

dB = decibel, 95%Bthi = 95% Confidence interval

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Railtraffic



Endpoint		# studies, designs†	RR per 10 dB (L_{den}) (95%Bthi)	# participants	# cases
Hypertension	Prevalence	5 CS	1.05 (0.88 – 1.26)	15,850	2,059
	Incidence	1 CO	0.96 (0.88 – 1.04)	7,249	3,145
IHD	Prevalence	4 CS	1.18 (0.82 – 1.68)	132,41	283
Stroke	Prevalence	4 CS	1.07 (0.92 – 1.25)	9,365	89

† CS = Cross sectional study , CO = Cohort study
Confidence interval

RR = Relative Risk,

dB = decibel, 95%Bthi = 95%

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Other effects: hearing, mental health and adverse birth defects

- The WHO review on noise related to hearing loss and tinnitus showed that the evidence, limited as it is, of adverse permanent hearing outcomes from exposure to environmental noise is only for noise exposure from personal listening devices.
- Evidence on the effect on mental health in adults and children is inconclusive. Earlier evidence confirms an effect of noise on wellbeing rather than psychopathology.
- There is insufficient evidence for the association between environmental noise and adverse birth outcomes.

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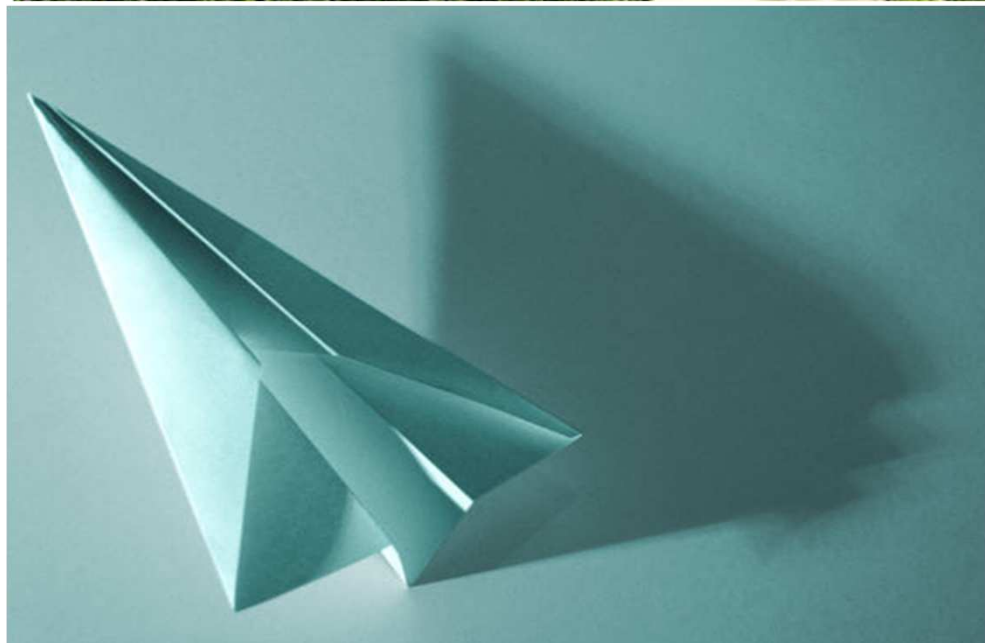
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A systematic review of evidence of the effect of transport noise interventions on human health

Irene van Kamp &
Lex Brown

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CONTEXT

The WHO Protocol for this systematic review defined an environmental noise intervention as:

- a measure that aims to change noise exposure and associated health effects, or
- a measure that aims to change noise exposure, with no particular evaluation of the impact on health or ,
- a measure designed to reduce health effects, but that may not include a reduction in noise exposure.



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Environmental noise sources of interest

- Road traffic noise →
- Aircraft noise →
- Railway noise →
- Noise from wind farms →
- Noise in hospitals
- Noise from personal listening devices & music venues

Points of Departure

1. Exposure to high levels of environmental noise have adverse effects on human health:
 1. Sleep disturbance
 2. Cognitive development in children
 3. Cardiovascular disease
 4. Annoyance etc
2. Changing exposure to environmental noise (*Noise Interventions, Noise Management, Noise Control*) should change magnitude of health effect.
3. Task: review the literature for evidence of interventions leading to a change in human health outcomes.

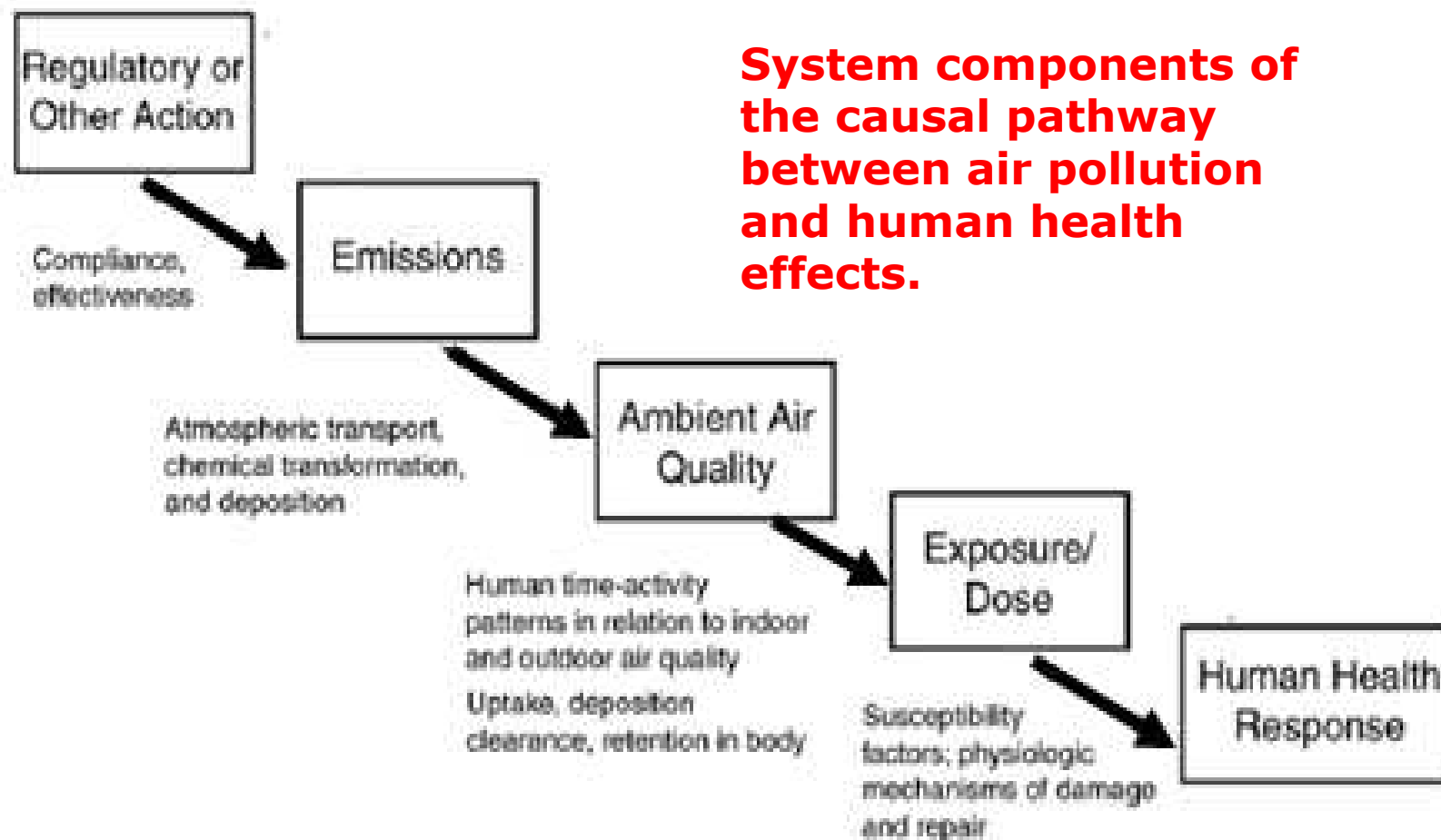
Where to start?

Need a model.....

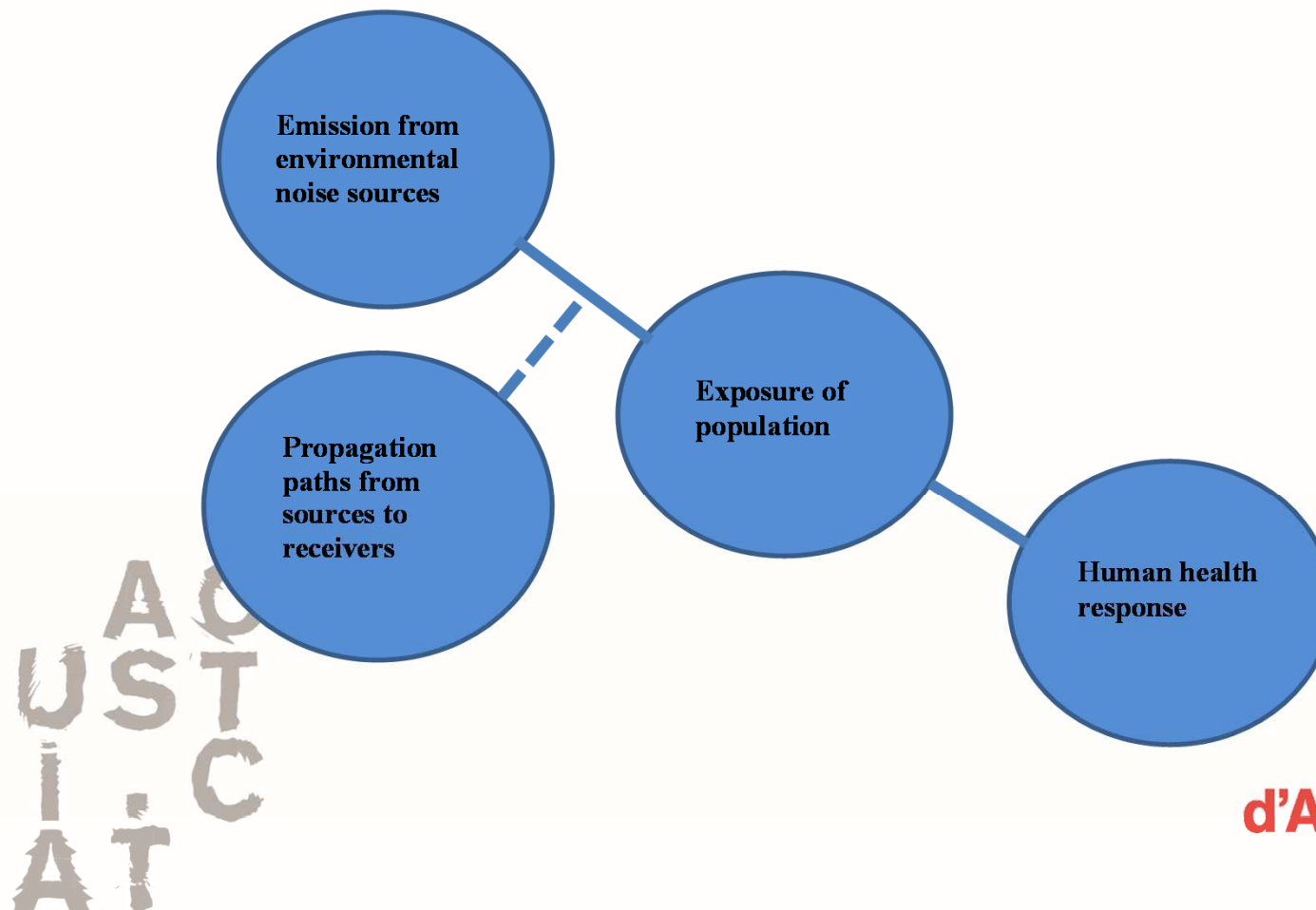
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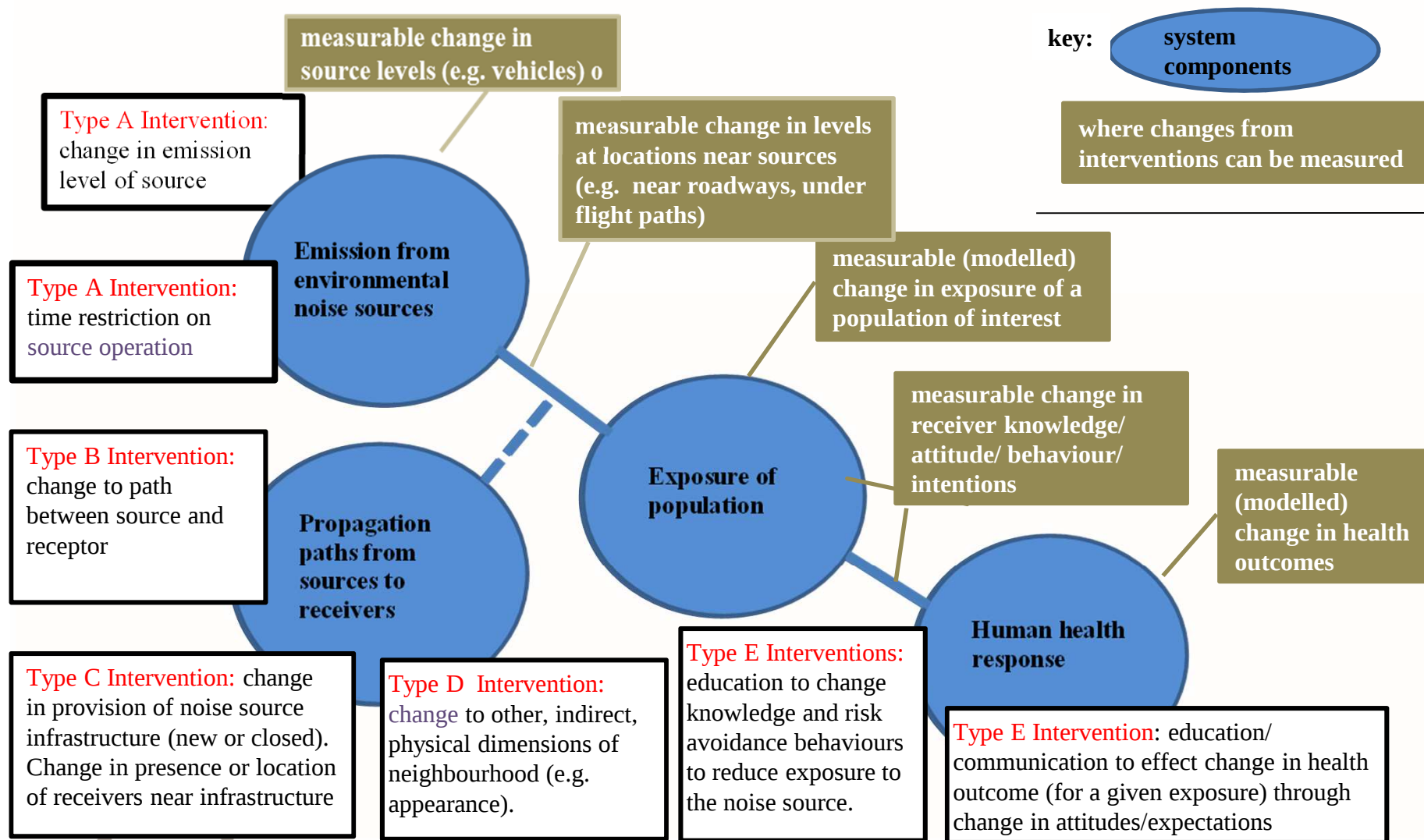
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Air pollution “accountability research” model after: HEI (2003) & Burns et al. (2014)



System components of the causal pathway between environmental noise and human health effects.



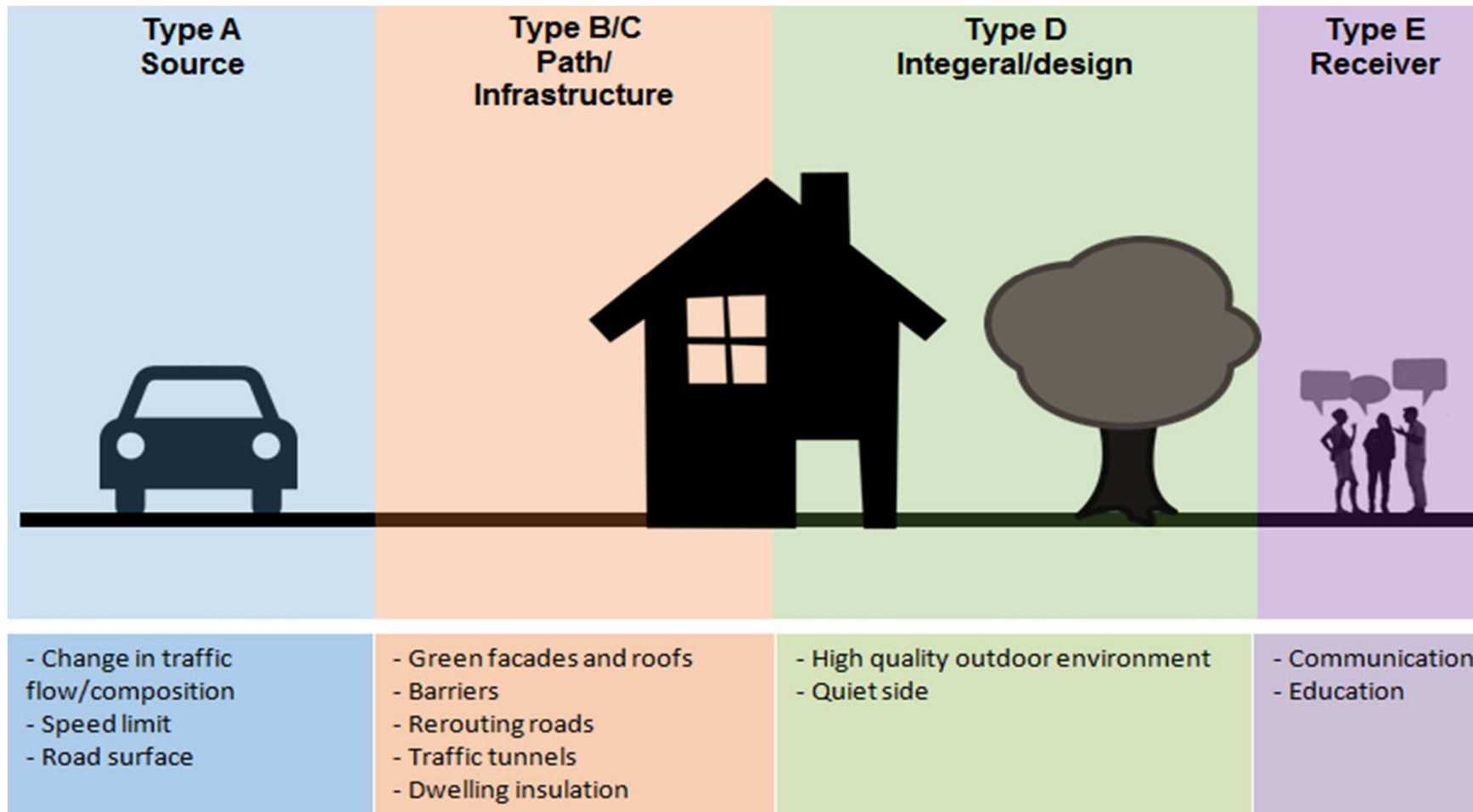


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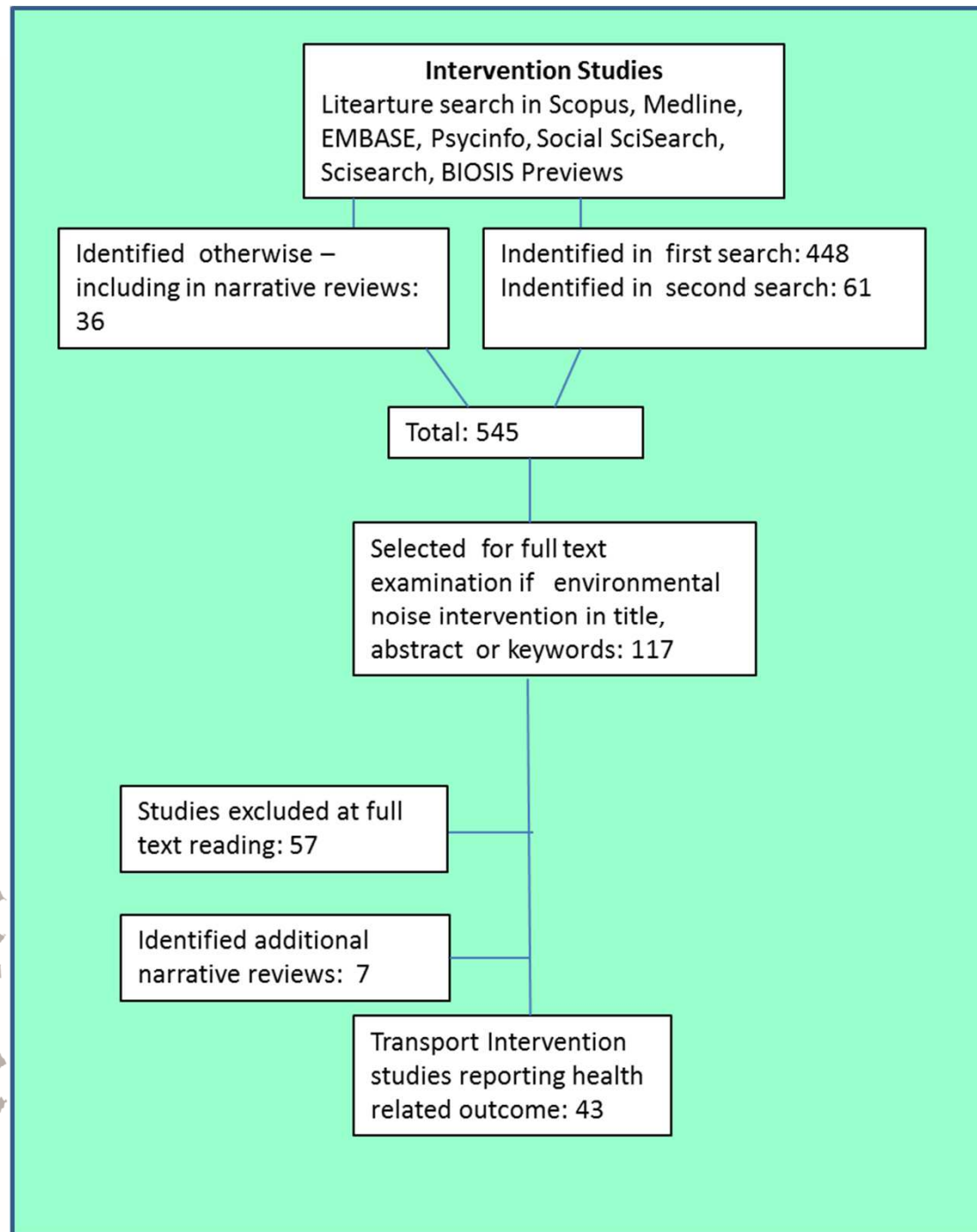
Type	Intervention Category	Intervention Sub-category	Examples
A	Source interventions	change in emission levels of sources	motor vehicle emission regulation; playback levels personal listening devices; rail grinding; road surface change;
		time restrictions on source operations	airport curfew, heavy vehicle curfew
B	Path interventions	change in the path between source and receiver	noise barrier; creation of dwelling quiet side
		path control through insulation of receiver/receiver's dwelling	insulation of building envelope; wearing of ear protectors
C¹	New/closed infrastructure	opening of a new infrastructure noise source, or closure of an existing one	new flight path; new railway line; new town road bypass; new windfarm; or closure of any of these
		distance controls between (new) receivers and sources	urban planning control; 'buffer' requirements
D	Indirect Intervention	change in other dimensions of dwelling/neighbourhood	appearance of the neighbourhood
E	Change in behaviour interventions	change in individual behaviour to reduce exposures; avoidance or duration of exposure	education regarding playback levels on personal listening devices, or potential hearing damage through loud music
		community education, communication	changing opinions regarding sources, or explaining reason for noise changes

Types of Interventions



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ROAD TRAFFIC NOISE SOURCES			
Outcome: Annoyance			
A Source Intervention	7	3	10
B Path Intervention	4	2	6
C New/Closed Infrastructure	1	1	2
E Other Physical	6	1	7
Outcome: Sleep Disturbance			
A Source Intervention	1	-	1
B Path Intervention	1	1	2
C New/Closed Infrastructure	2	-	2
E Other Physical	1	-	1
Outcome: Cardiovascular Effects			
C New/Closed Infrastructure	1	-	1
E Other Physical	3	-	3
Outcome: Modelled Change in Exposure/Effect ¹			
A Source Intervention	1	1	2
AIRCRAFT NOISE SOURCES			
Outcome: Annoyance			
B Path Intervention	1	-	1
C New/Closed Infrastructure	2	1	3
Outcome: Sleep Disturbance			
C New/Closed Infrastructure	1	1	2
Outcome: Cognitive Development in Children			
C New/Closed Infrastructure	1	-	1
Outcome: Modelled Change in Exposure/Effect ¹			
A Source Intervention	1	-	1

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RAIL NOISE SOURCES				
Outcome: Annoyance				
A Source Intervention	-	1	1	1
C New/Closed Infrastructure	1	-	1	1
E Education/Communication	-	1	1	1
NOTE: studies that reported on more than one outcome are included under each outcome.				
¹ The modelled change studies are reported separately in Annex 2				

Synthesis across studies? Examine association between Δ_{level} and Δ_{outcome} ?

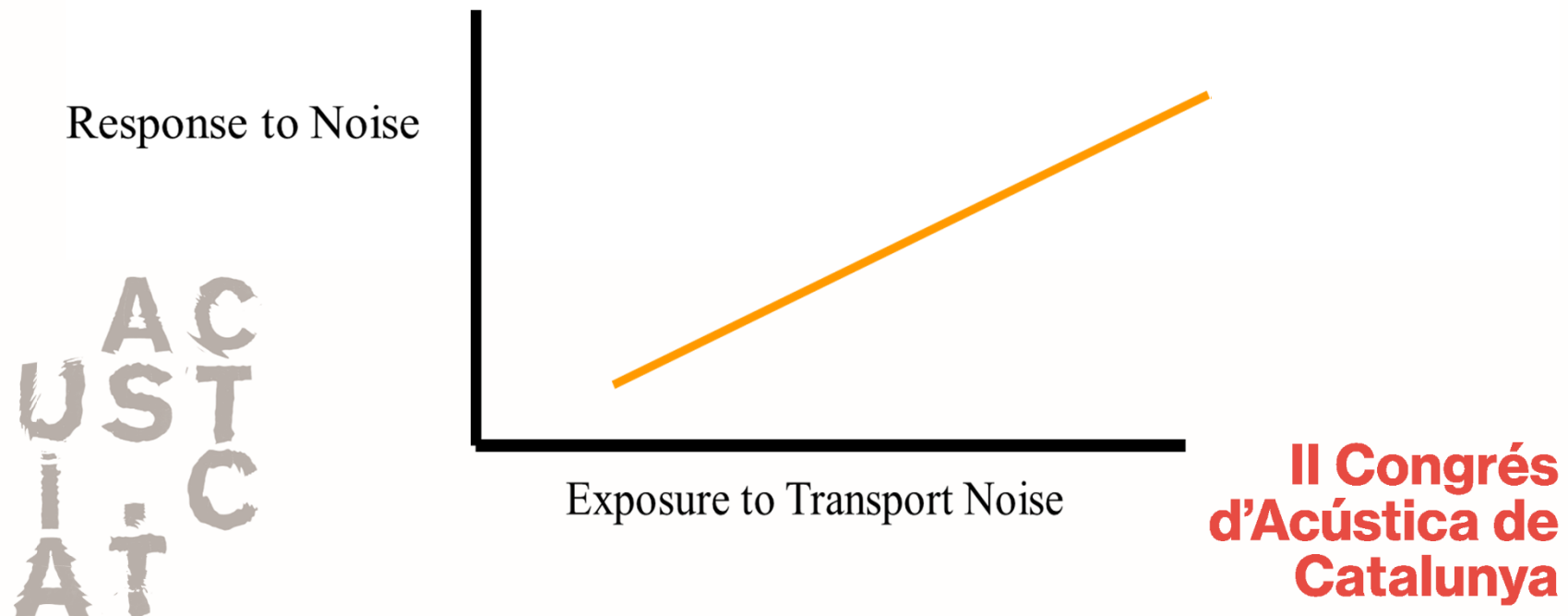
- Too much diversity **between studies** in:
 - study designs
 - methods of analyses
 - exposure levels
- Changes in exposure experienced **within studies** complex and not always adequately linked to individual,s outcomes.
- ERGO: Not possible....



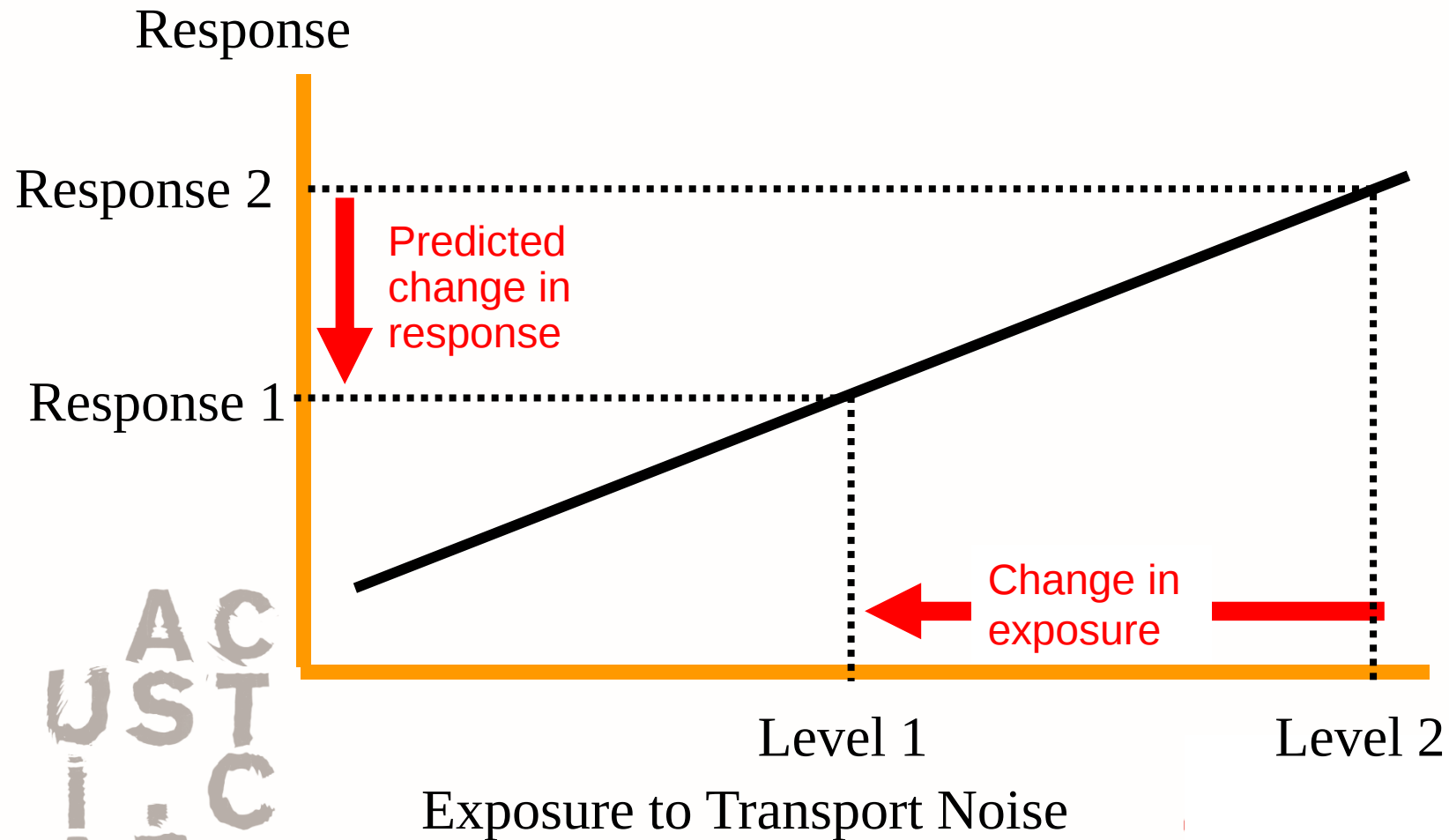
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Instead...two questions.....

- 1) Did interventions result in a change in health outcome?
- 2) What was the relationship between the intervention outcome and the Exposure-Response Function (ERF) for that outcome?

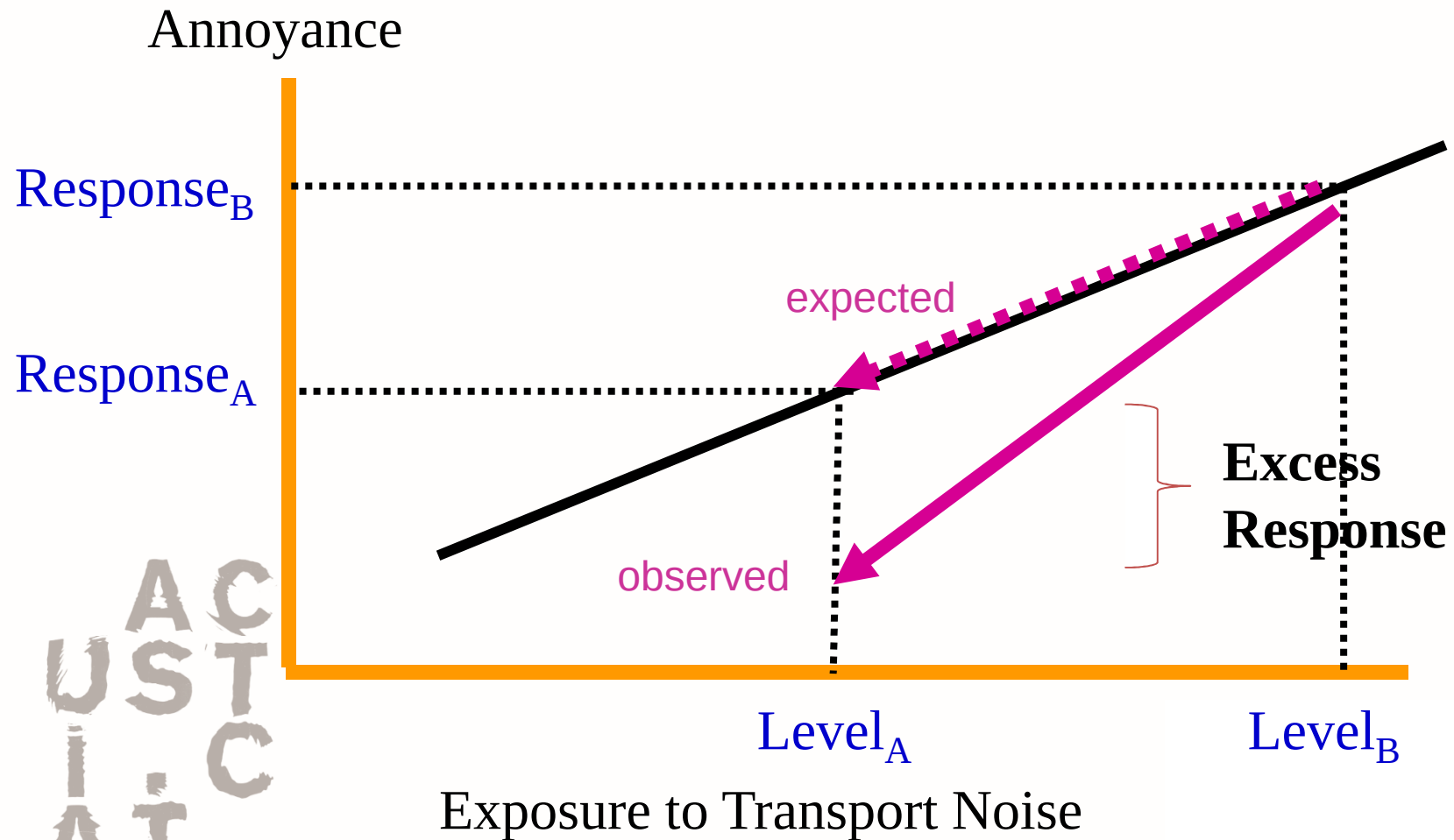


Predicted change in response to a change in exposure (INTERVENTION)



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Change Effect – (Excess Response)



	Number of Papers	Evidence ¹ that health outcome changed?			Observed magnitude of change in health outcome		
		YES	NO	n.a.	Magnitude at least as predicted by ERF ¹	Excess ² Response	n.a. ³
ROAD TRAFFIC NOISE SOURCES (33)							
Outcome: Annoyance (23)							
A Source Intervention	9	***** **		**	***** *	***** **	**
B Path Intervention	6	***** *			*****	**?	**
C New/Closed Infrastructure	2	**			**	**	
D Other physical	6	***** *					
Outcome: Sleep Disturbance (6)							
A Source Intervention	1			*			*
B Path Intervention	2	**					**
C New/Closed Infrastructure	2	**					**
D Other physical	1	*					
Outcome: Cardiovascular Effects (4)							
D Other physical	4	***	*				

- * Statistical significance reported
- * Finding interpreted by original, or current, authors based on data/tables/plots in original study

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AIRCRAFT NOISE SOURCES (7)						
Outcome: Annoyance (4)						
B Path Intervention	1	*				*
C New/Closed Infrastructure	3	***			***	***
Outcome: Sleep Disturbance (2)						
C New/Closed Infrastructure	2	**			*	*
Outcome: Cognitive Development in Children (1)						
C New/Closed Infrastructure	1	*				*
RAIL NOISE SOURCES (3)						
Outcome: Annoyance (3)						
A Source Intervention	1	*				*
C New/Closed Infrastructure	1			*		*
E Education/Communication	1	*				

Conclusions I

- There is limited evidence base of the health effects of environmental noise interventions.
- More intervention studies needed!
- These should report:
 - observed changes in health outcomes.
 - observed changes in exposures.
 - quantitative details on change effects per change in noise level.
-not just changes in emissions or changes in noise levels.



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Conclusions II

From the evidence that is available:

- Environmental noise interventions invariably result in a change in health outcome (for all sources, outcomes, interventions).
- The **minimum** change in outcome can be predicted from the ERF (at least for the “annoyance” outcome, and for “road” and “airtraffic” sources)
- The observed changes in outcome exceed those from ERFs - they exhibit *excess response*.

(see also Brown and van Kamp 2009)



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Conclusions III

- The review does not confirm clear evidence with respect to **thresholds** regarding changes in health outcomes as a result of interventions.
- Little evidence on **longitudinal effects**, but evidence that the initial change in response is sustained over at least several years.
- The studies of ,other physical interventions, (such as the provision of a quiet side to the dwelling, or the provision of green space in the neighbourhood) were not intervention studies per se as they did not provide direct evidence of an intervention.
- >> But indirect....

Implications for noise management and Policy

- The noise management strategies currently utilized have, at least, the potential of a beneficial effect on human health confirms current management approaches.
- **Caveat** : evidence not extensive nor well distributed over all transport noise sources, intervention types, or health outcomes.
- Magnitude of the interventions in improving health outcomes still unknown.
- The evidence on sleep disturbance is restricted to one aircraft noise study only.

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