

THE HANDBOOK OF THE EFFECTS OF ENVIRONMENTAL NOISE ON HEALTH

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The handbook of the effects of environmental noise on health

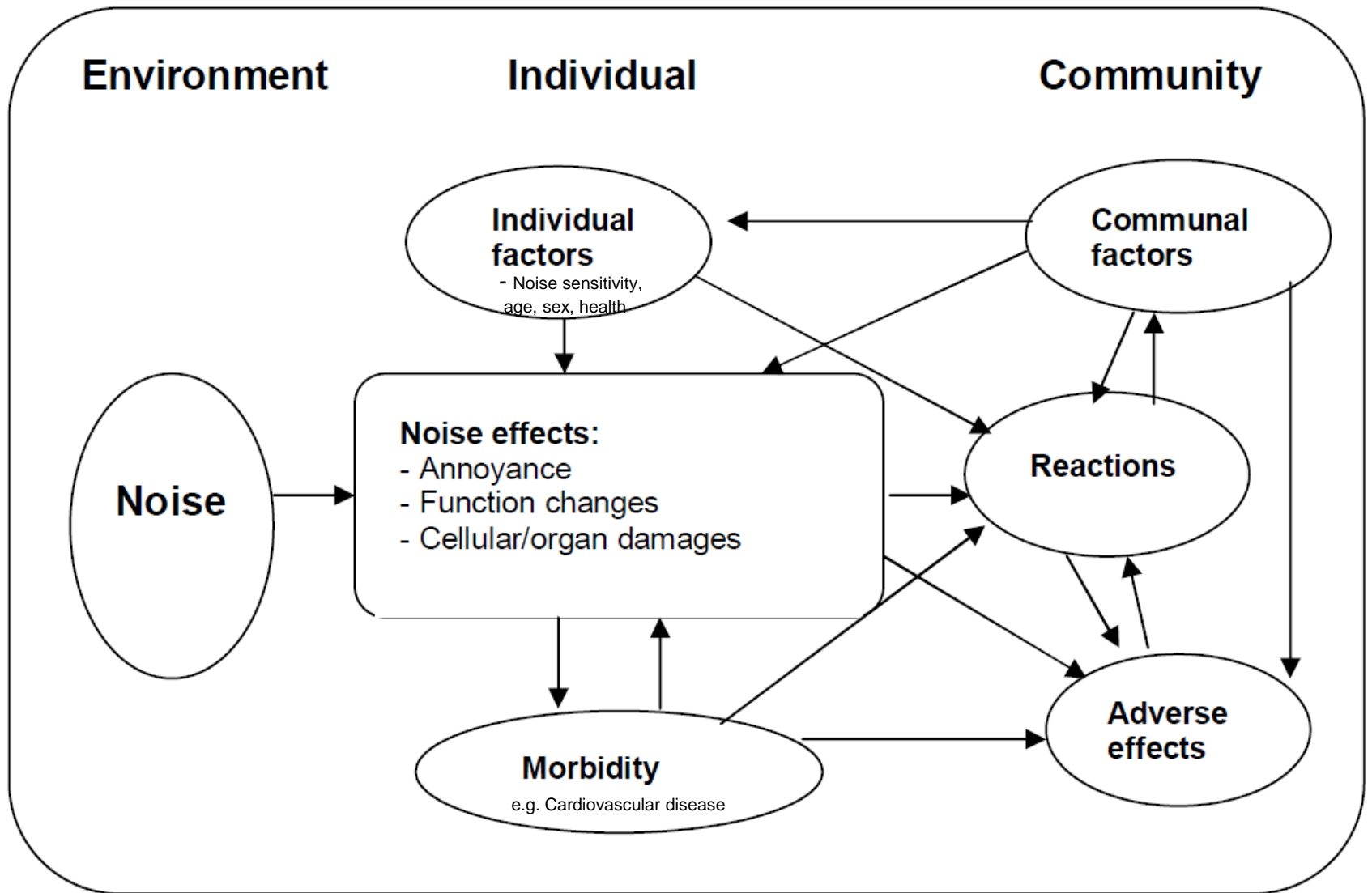
- A publication of the **Finnish Ministry of the Environment**
- **Based on "Guidelines for Community Noise". World Health Organization**
Geneva, 1999, 1–159. Berglund B, Lindvall T, Schwela DH (eds.)
<http://www.who.int/docstore/peh/noise/guidelines2.html>
- Deals with noise in accordance with **the WHO recommendation of the classification of diseases, impairments and disabilities due to various external and internal causes**
- **Stresses the various noise effects**
- **Helps the environmental authorities in their work**

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Noise

- **unwanted sound** that human beings consider **unpleasant or disturbing**
or
- in some other way is **harmful to the human health or well-being**



Factors relating to effects of noise

Health effects of environmental noise according to the terminology of ICIDH* (WHO)

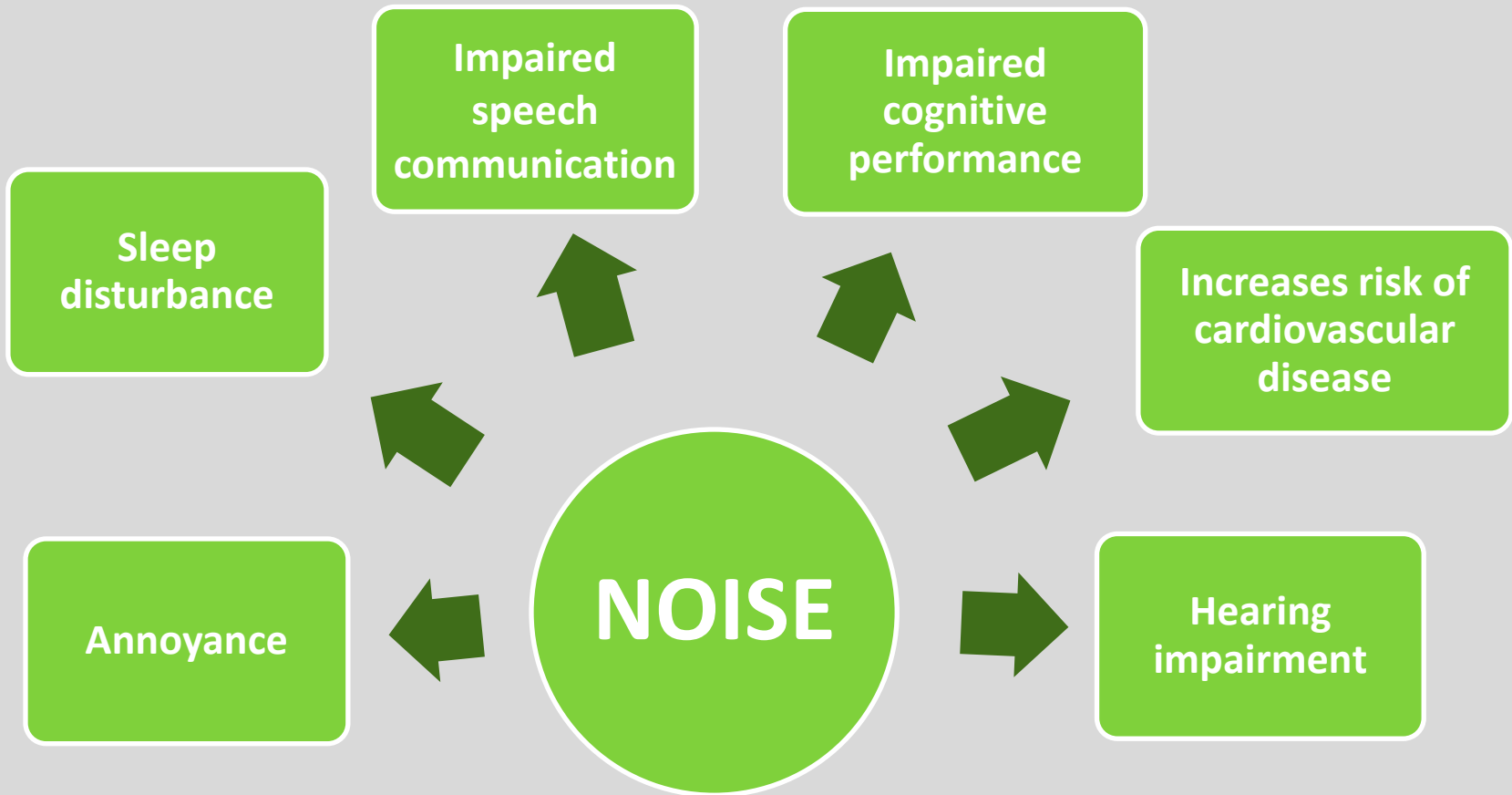
External exposure or/and internal cause

Examples (noise effects)

Disease	- organ or cellular lesion	- inner ear lesions
Impairment	- measurable change of function	- blood pressure
Disability	- experienced functional effect	- annoyance
Handicap	- handicap for an individual - handicap for the society	- morbidity, working ability - need of health services

* ICIDH = International Classification of Functioning, Disability and Health

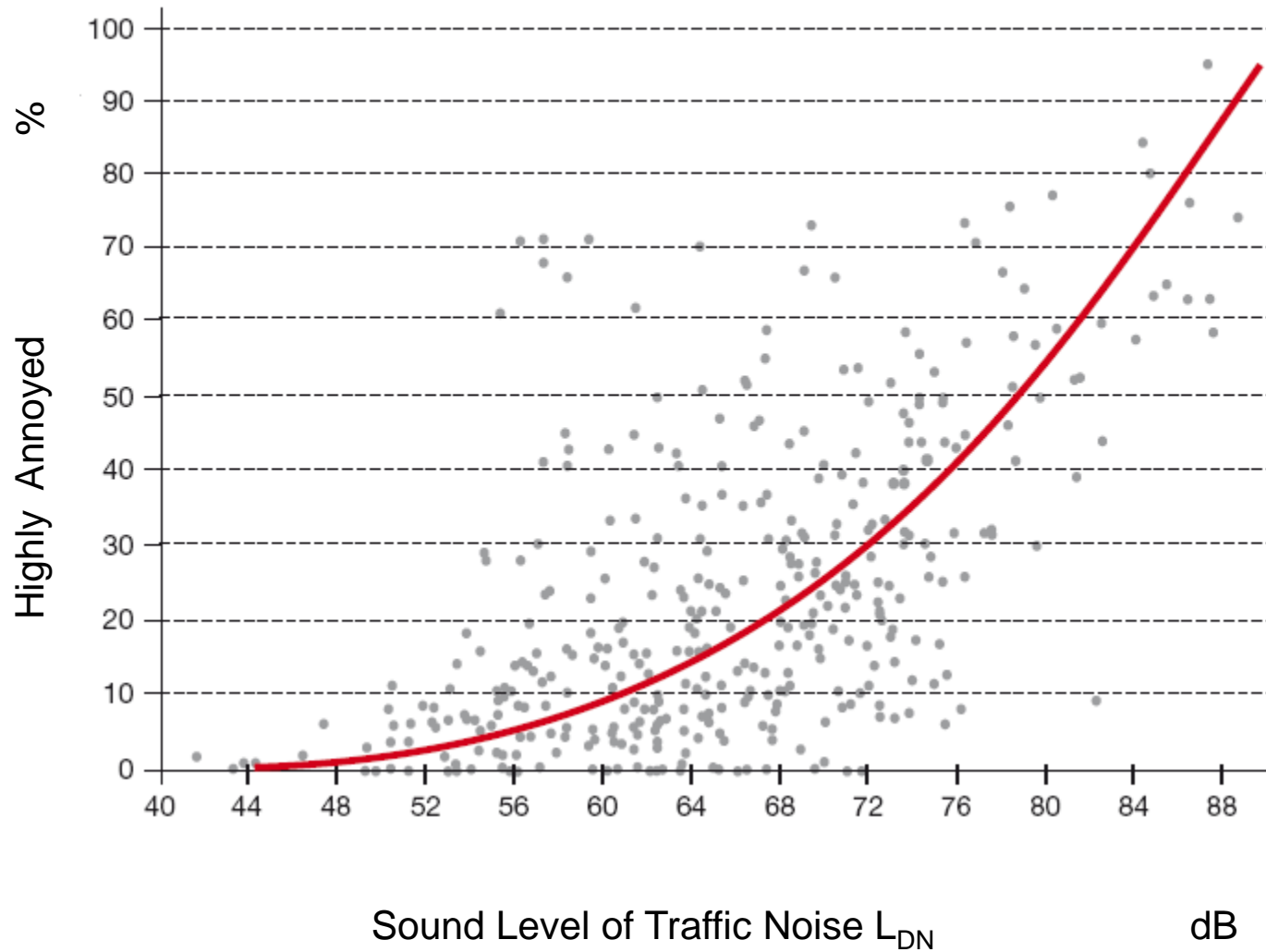
Noise effects



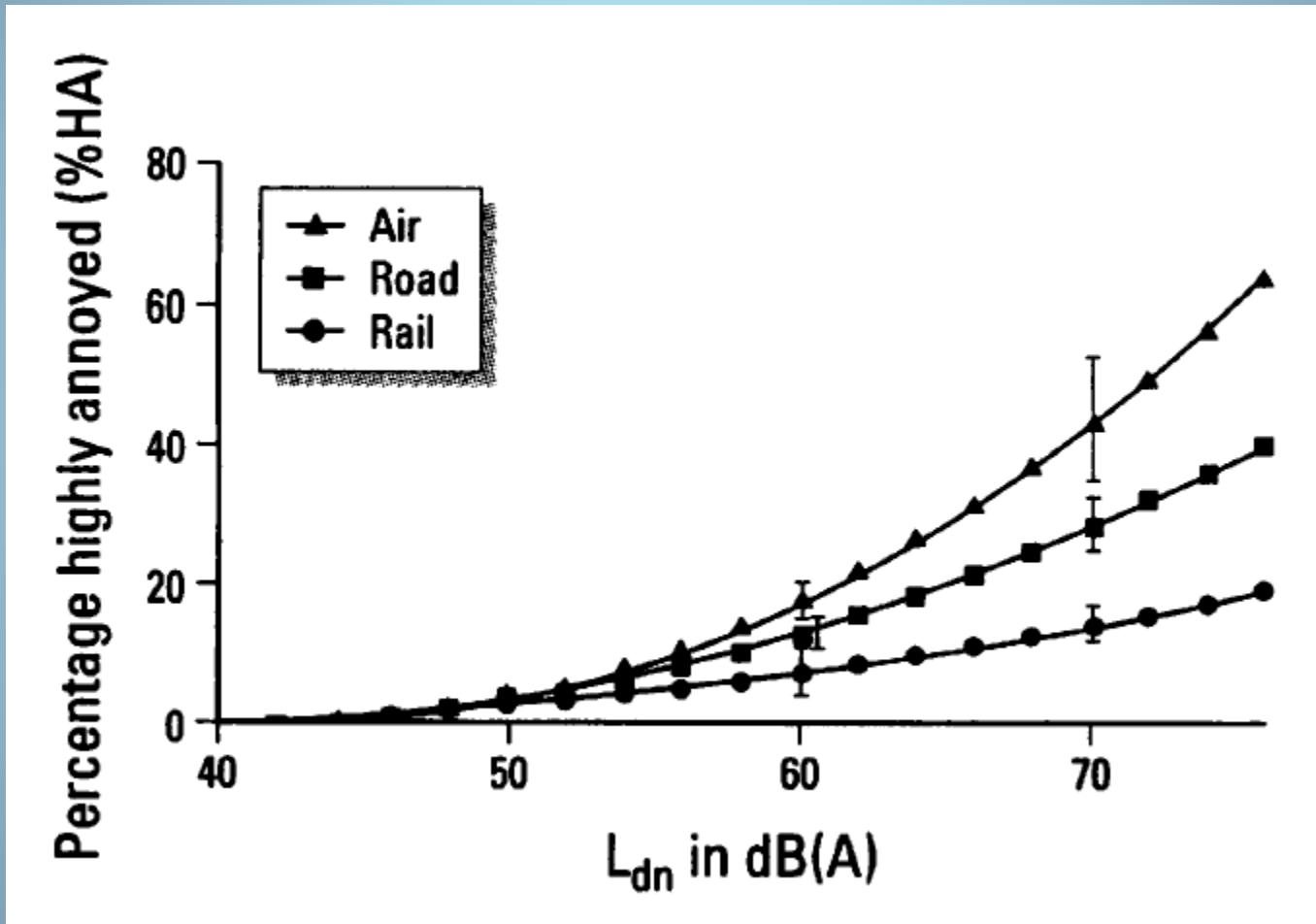
Annoyance

- immediate **behavioural** noise effects aspects, like disturbance and interfering with intended activities
and
- **evaluative** aspects like “nuisance”, “disturbance”, “unpleasantness”, and “getting on one's nerves”

Relationship between the percentage of highly annoyed and the sound level of traffic noise (L_{DN}) (Fidell et al. 1991)



Annoyance caused by aircraft, road traffic and railway noise



Relationship between the percentage of highly annoyed persons and L_{dn} for air, road and railway traffic noise (Passchier-Vermeer W, Passchier W 2000)

Noise effects on sleep and relaxation

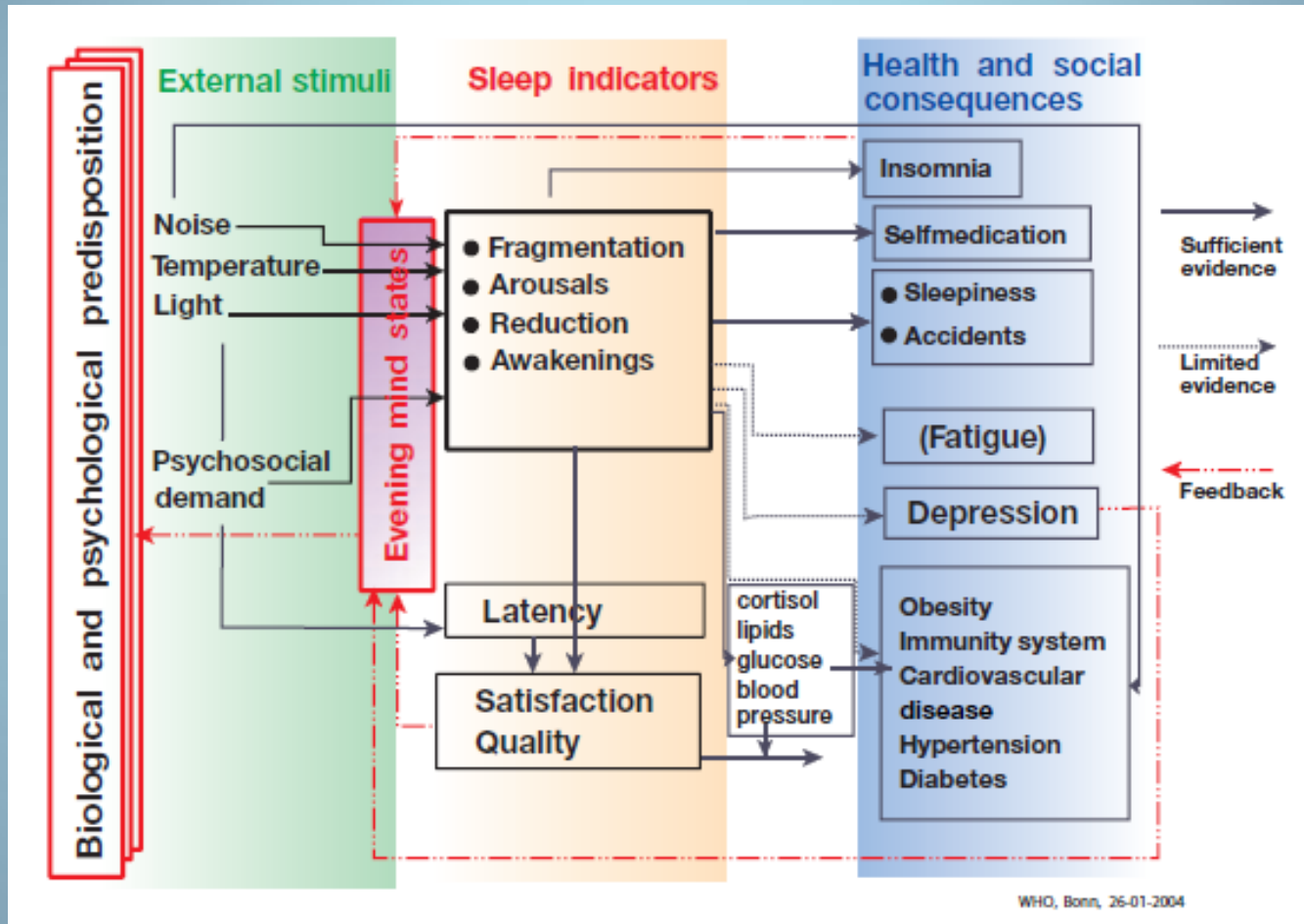
Primary effects

- difficulties to fall asleep
- alterations of sleep stages or depth
- awakenings
- increase in body movements, heart rate and blood pressure

Secondary/after effects

- reduced perceived sleep quality
- increased fatigue
- depressed mood or well-being
- decreased performance

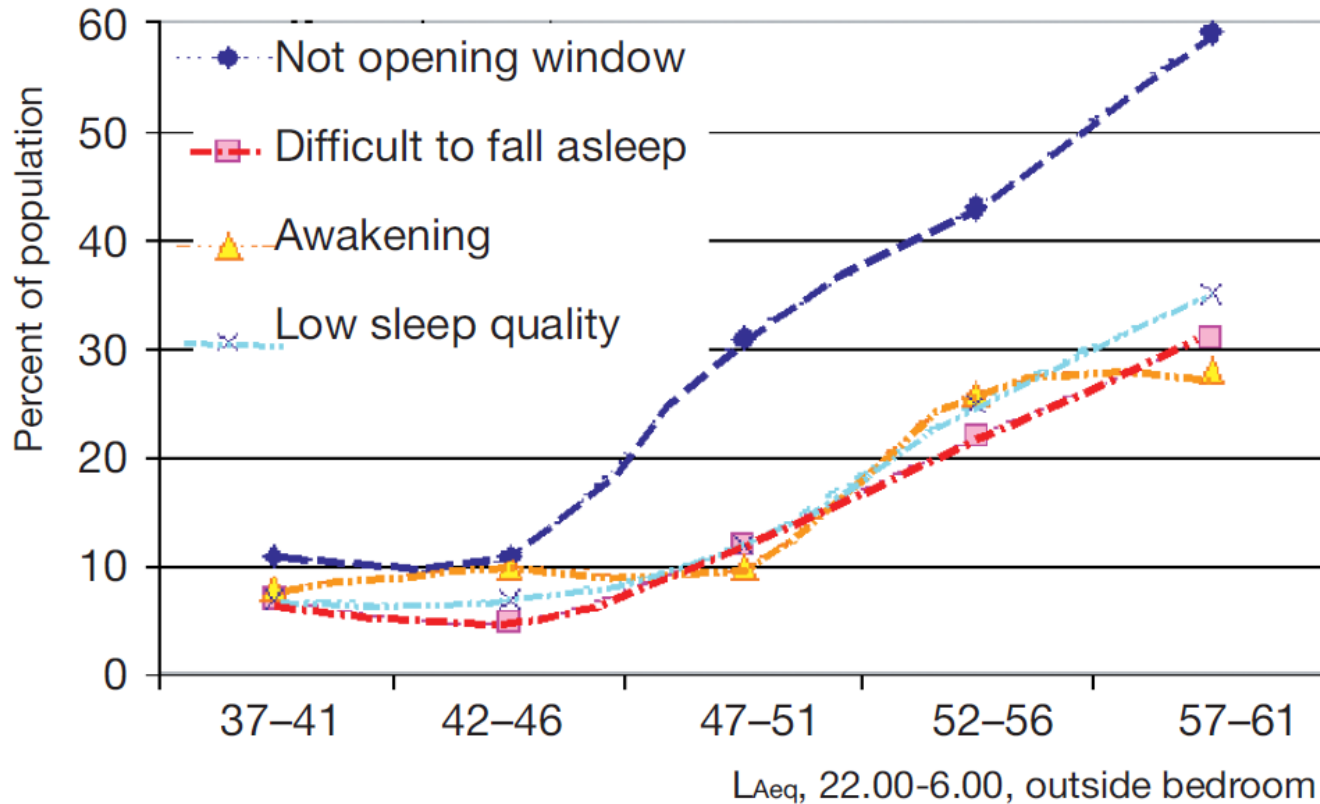
The relation between sleep and health



In the figure the relations with sufficient evidence are indicated with solid lines, while relations for which limited evidence exists are indicated with interrupted lines. Feedback connections are in red and double-dotted.

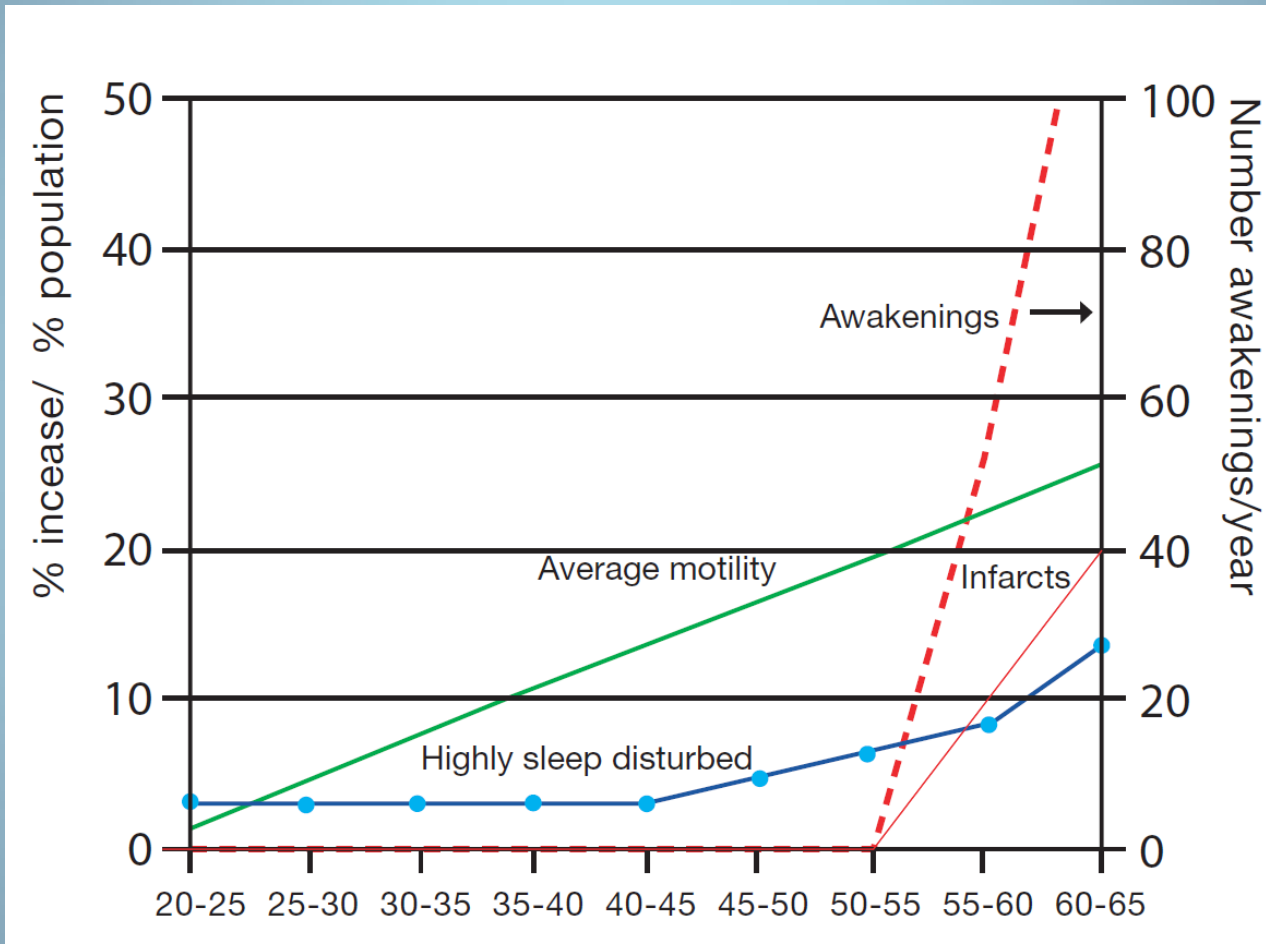
Source: *Night noise guidelines for Europe, WHO*

Effects of night-time road traffic noise



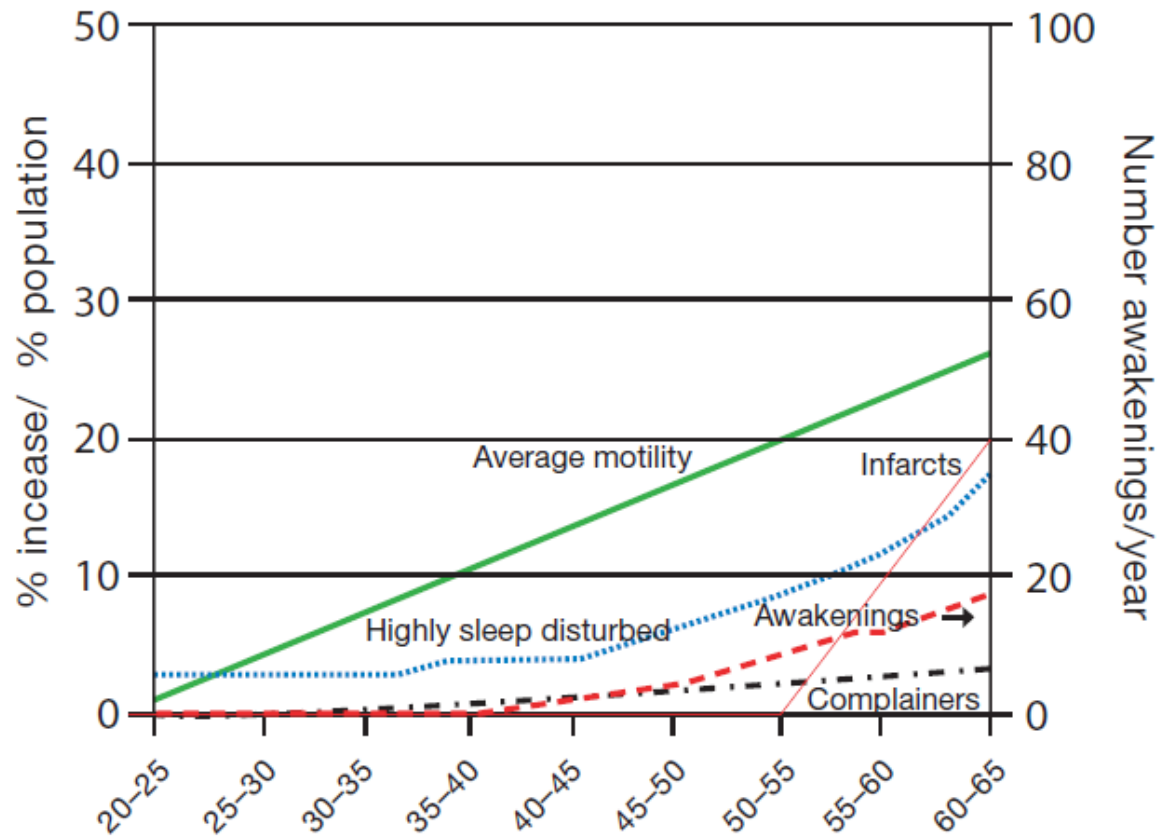
Source: Öhrström, in European Commission, 2002a.

Effects of road traffic noise at night



*Average motility and infarcts are expressed in percent increase (compared to baseline number); the number of highly sleep disturbed people is expressed as a percent of the population; awakenings are expressed in number of additional awakenings per year.

Effects of aircraft noise at night



*Average motility and infarcts are expressed in percent increase (compared to baseline number); the number of highly sleep disturbed people is expressed as a percent of the population; complainers are expressed as a % of the neighbourhood population; awakenings are expressed in number of additional awakenings per year.

Thresholds for effects of night noise with sufficient evidence

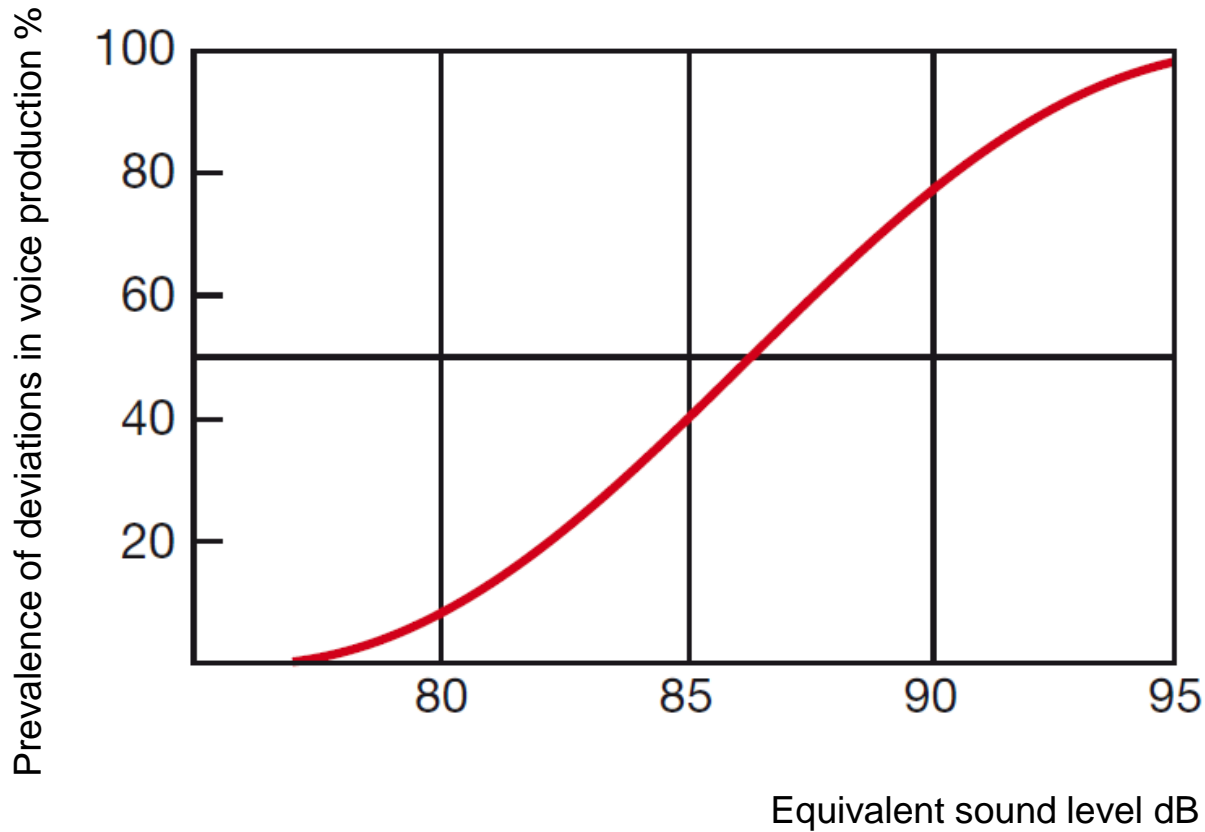
	Effect	Indicator	Threshold
Biological effects	Change in cardiovascular activity>	*	*
	EEG awakening	L _{Amax,inside}	35 dB
	Motility, onset of motility	L _{Amax,inside}	32 dB
Sleep quality	Fragmentation of sleep structur>	L _{Amax,inside}	35 dB
	Waking up in the night	L _{Amax,inside}	42 dB
	Prolongation sleep latency	*	*
	Sleep fragmentation, reduced sleeping time >	*	*
Well-being	Increased average motility	L _{night,outside} >	42 dB
	Self-reported sleep disturbance>	L _{night,outside} >	42 dB
	Use of somnifacient drugs and sedatives >	L _{night,outside} >	40 dB
Medical conditions	Environmental insomnia	L _{night,outside} >	42 dB

* Although the effect has been shown to occur or a plausible biological pathway could be constructed, indicators or threshold levels could not be determined.

Impaired speech communication

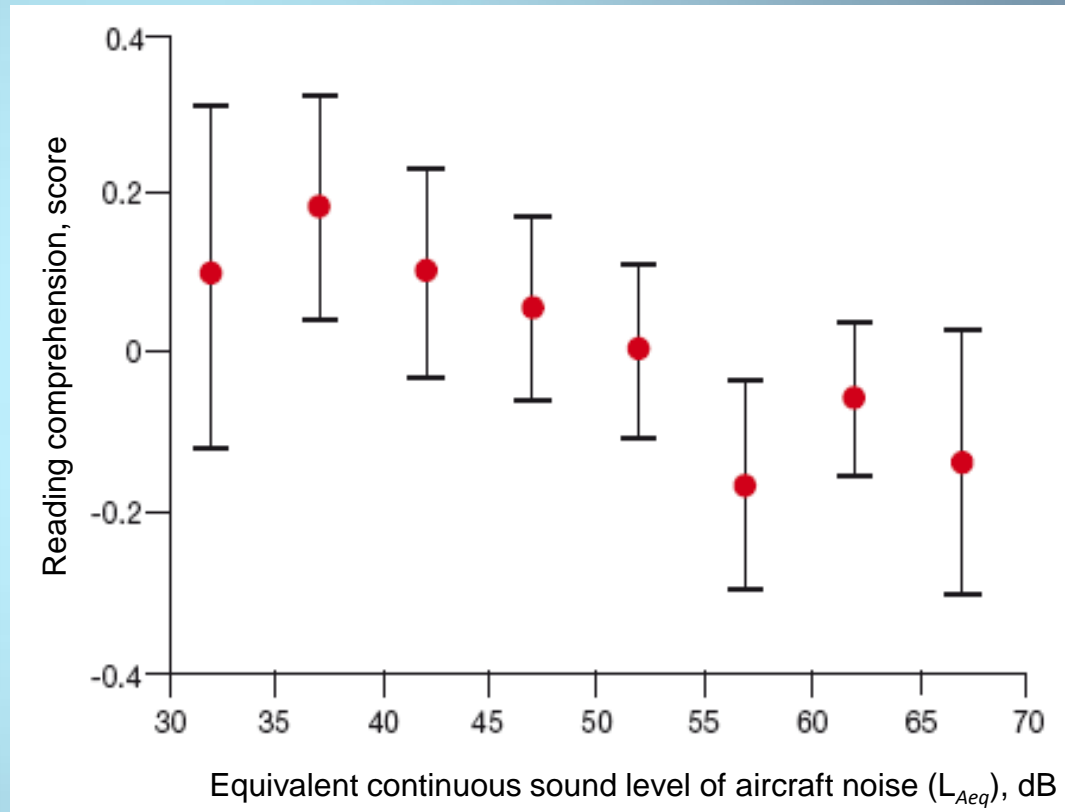
- Communication disturbances (**auditory**)
 - noise masking
 - problems in speech discrimination
- Communication disturbances (**voice**)
 - lesions of the vocal cords (secondary)->
 - hoarseness, voice fatigue

Prevalence of deviations in voice production on different noise levels *(Klingholz et al. 1978)*



Disorders of cognitive performance

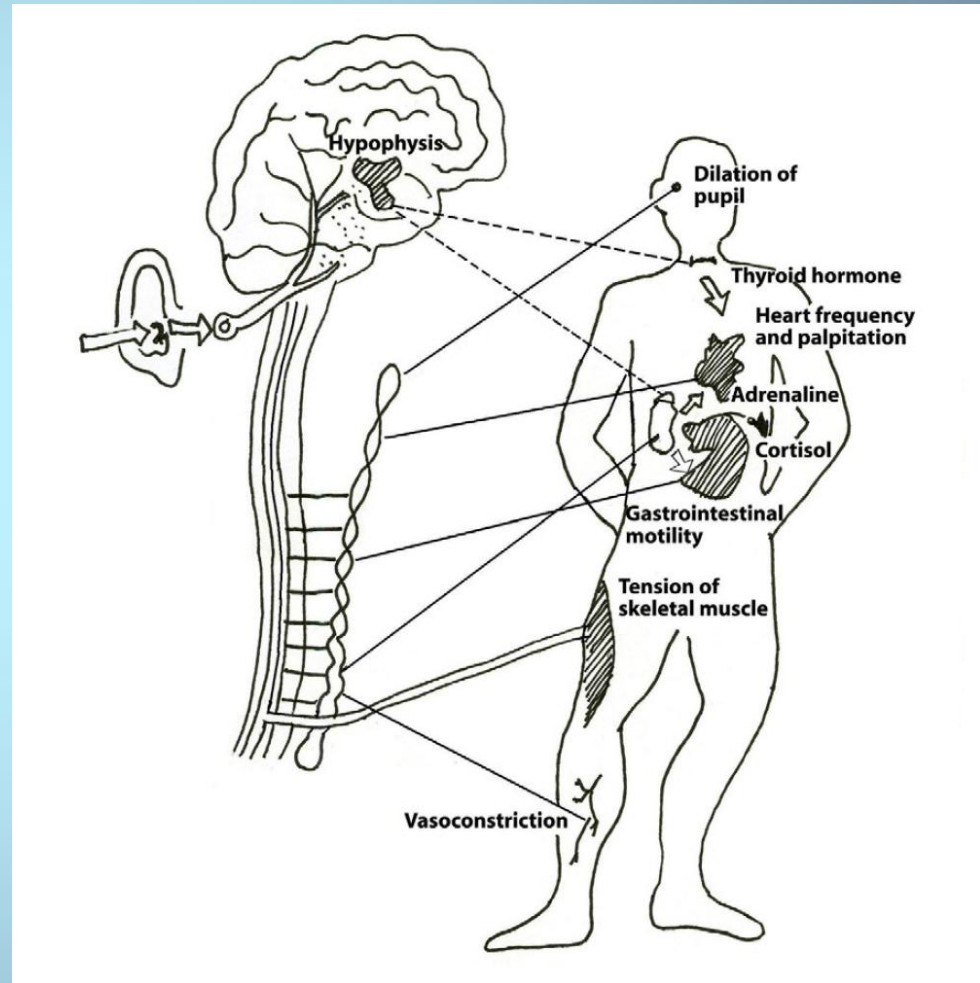
- In children chronic aircraft noise exposure has been associated with **poorer reading comprehension, limitations in learning-ability and sustained attention**



Weakening of reading comprehension by increasing equivalent continuous sound level of aircraft noise
(Stansfeld et al. 2005)

Physiological effects of noise

- Direct reactions to noise are mediated by nervous and/or endocrine transduction to different organs without cortical intermediation
- Acute noise exposure activates the **autonomic nervous system** and **endocrine system**, which leads to temporary changes such as increased heart rate, vasoconstriction and increased blood pressure



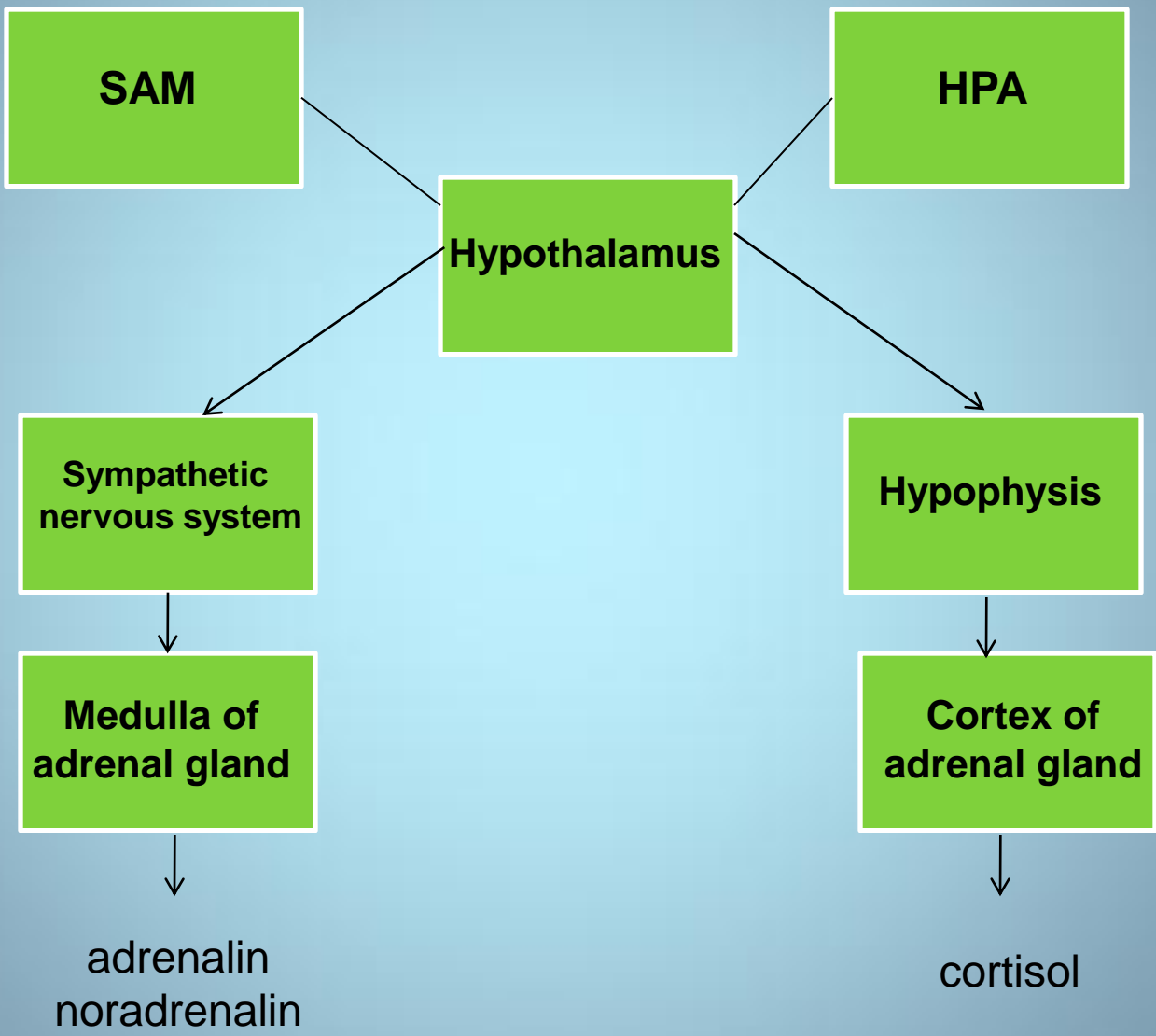
Transmission paths of direct noise effects (*adapted from Ising and Rebentisch 1993*)

Noise as stress

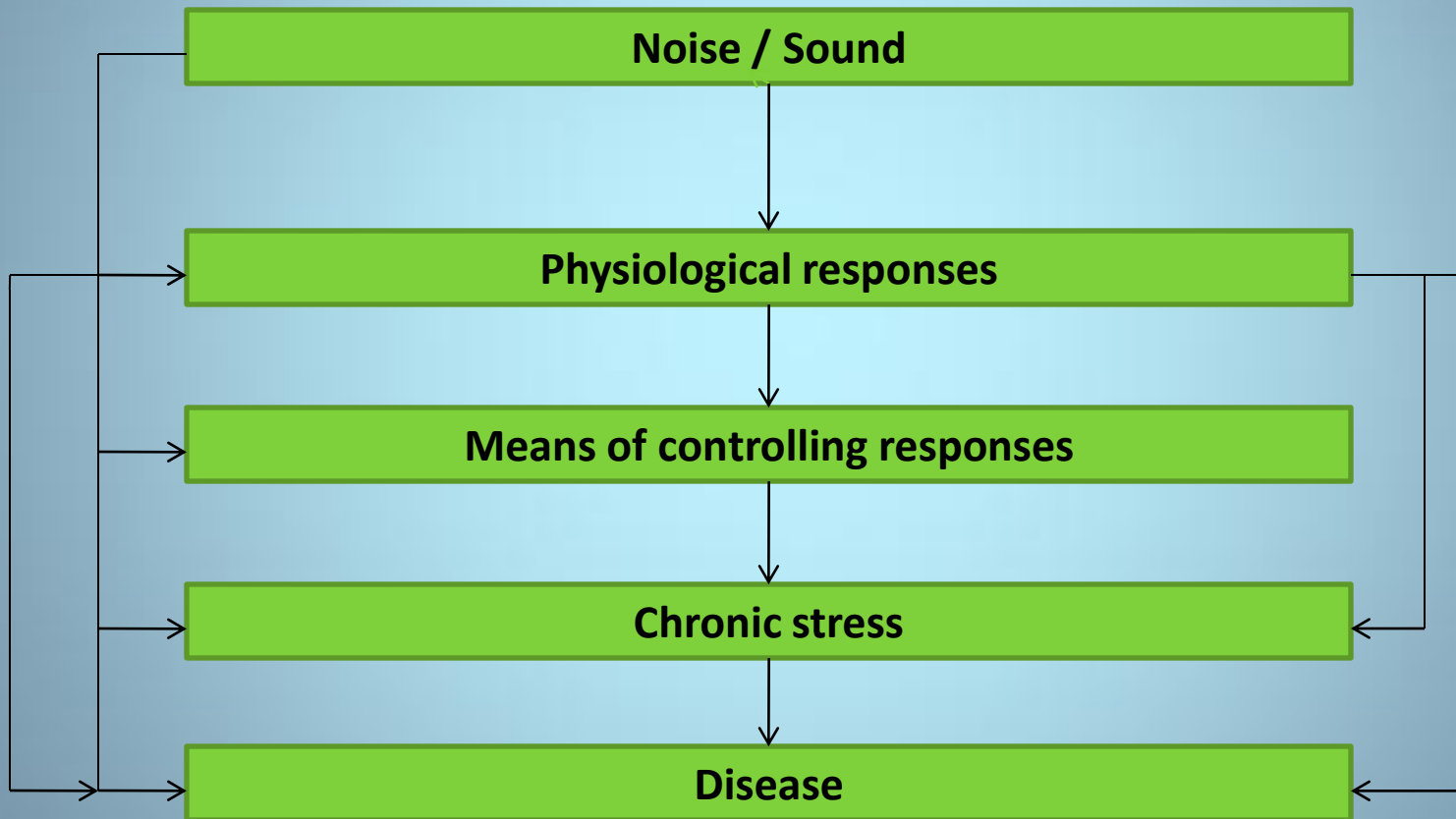
Noise activates the **sympathetic-adrenal-medullary (SAM)** axis and the **hypothalamic-pituitary-adrenal (HPA)** axis



increased heart rate, vasoconstriction and increased blood pressure,
increases in levels of stress hormones
adrenaline, noradrenaline and/or cortisol

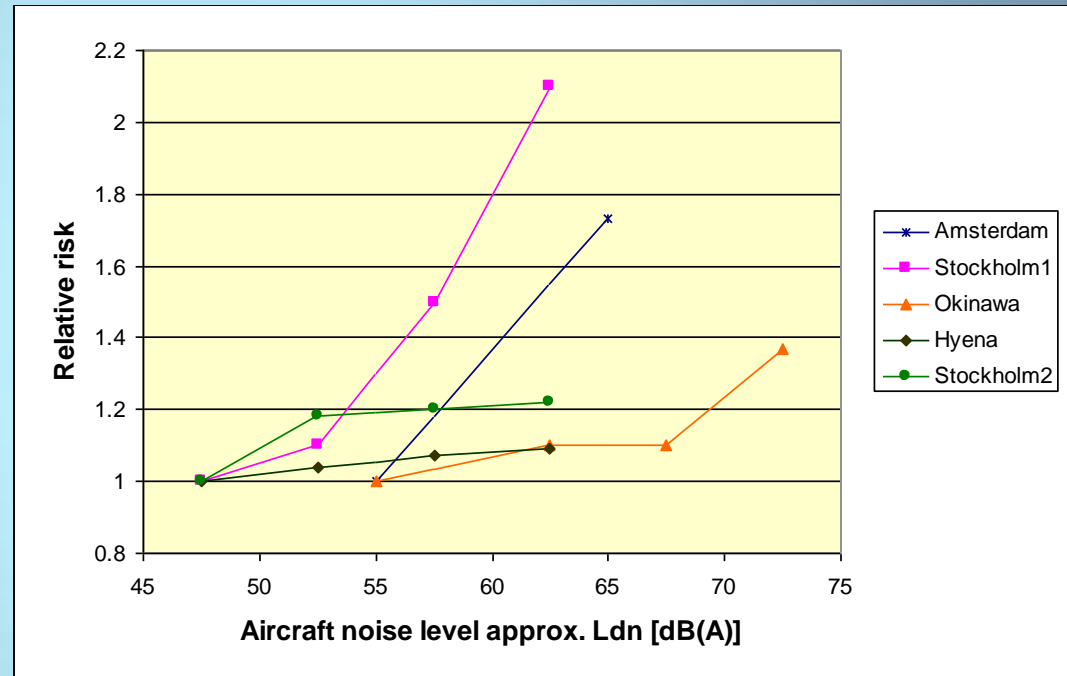


The possible relationship between noise, stress and development of diseases



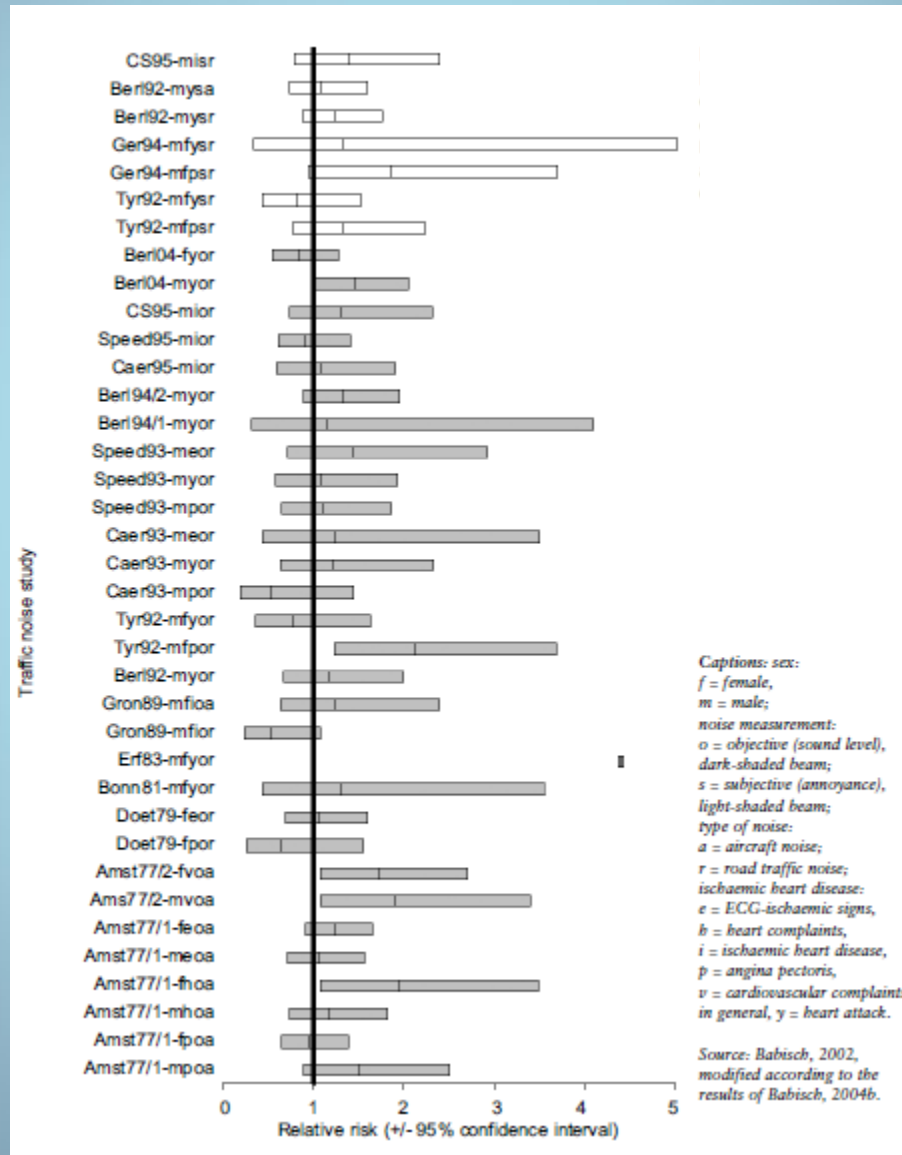
Hypertension

- Epidemiological studies have suggested a **higher risk of hypertension, in subjects who were chronically exposed to high levels of aircraft noise**
- Hypertension is a **multifactorial disease and the relative contribution by noise is probably quite small compared to other factors**



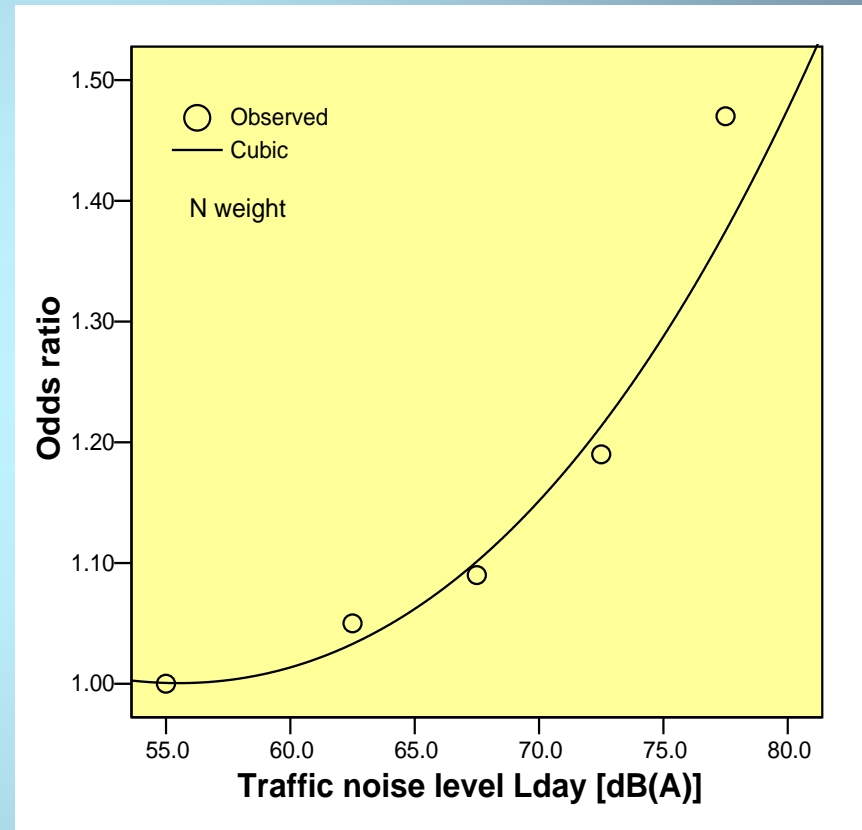
Association between aircraft noise level and the prevalence or incidence of hypertension (*Babisch 2008*)

Results of epidemiological studies on the association between traffic noise and coronary (ischaemic) heart disease *(Babisch 2002, 2004)*



Myocardial infarction

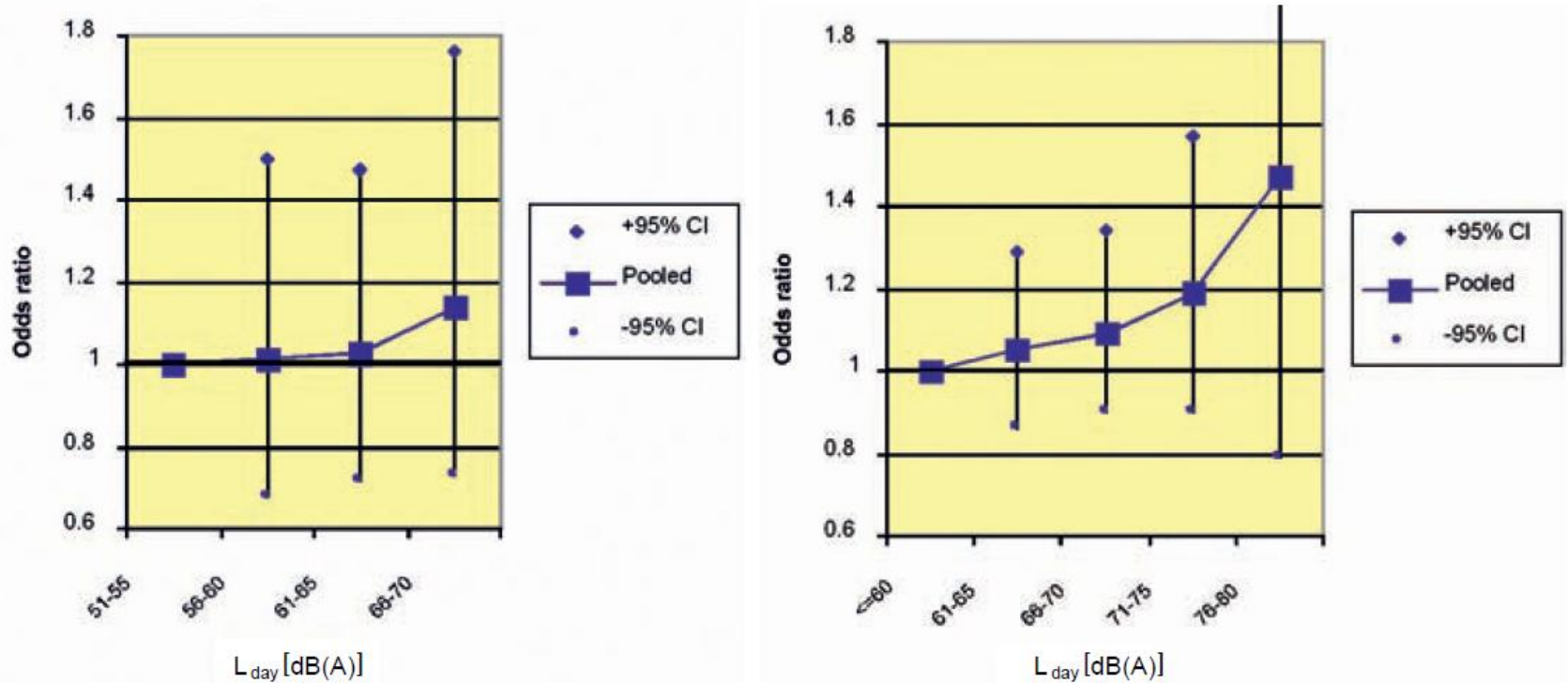
- Epidemiological studies have also suggested a **higher risk of coronary heart disease and myocardial infarction**, in subjects who were chronically exposed to high levels of road traffic noise



Exposure-response curve for road traffic noise level ($L_{\text{day},16\text{h}}$) and incidence of myocardial infarction (*Babisch 2008*)

Road traffic noise and myocardial infarctions

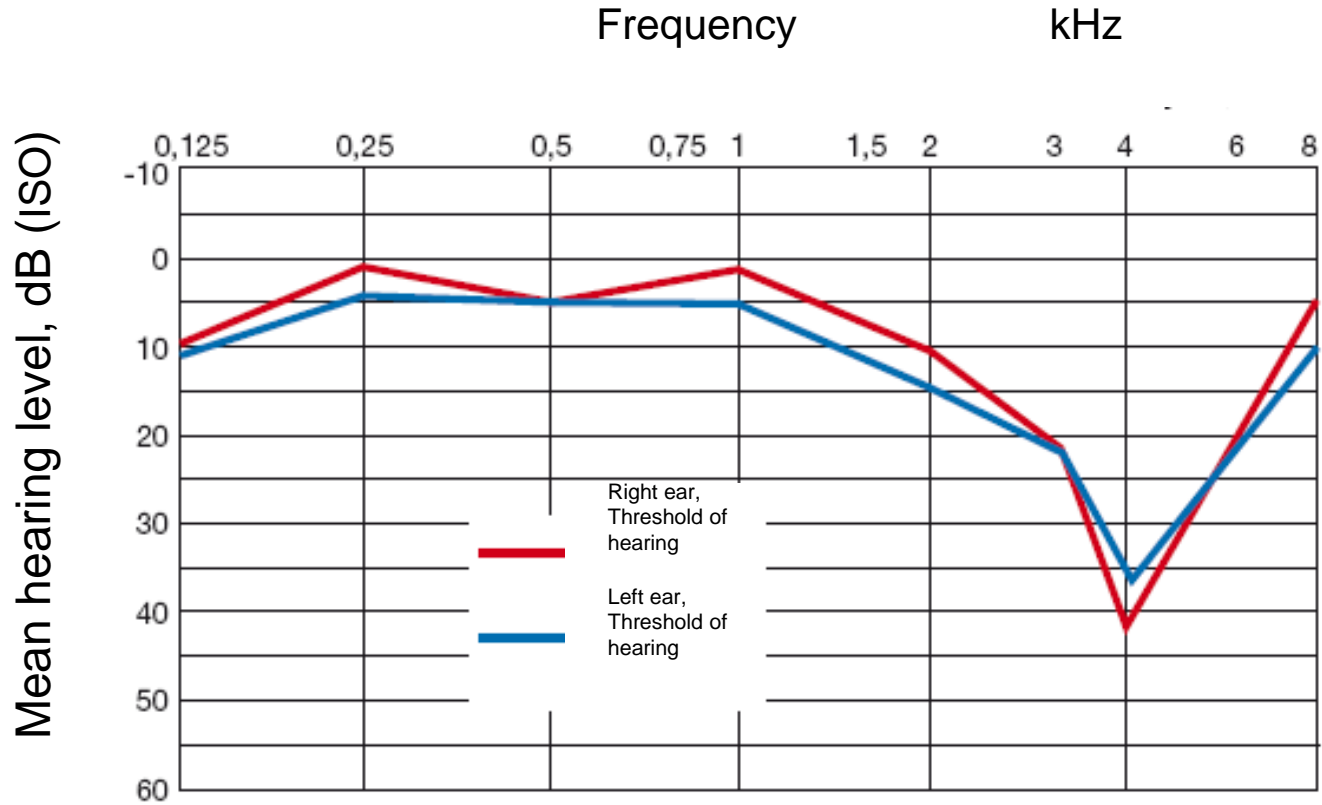
Pooled effect estimates (meta analysis) of descriptive and analytic noise studies of the association between road traffic noise level and the prevalence (left graph) and incidence (right graph), respectively, of myocardial infarction (odds ratio \pm 95% confidence interval).



Hearing impairment

- **Inner ear lesions** caused by noise
- Not so common effect of environmental noise, mainly caused by **occupational noise**

An example of hearing impairment caused by noise as an alteration of mean hearing level



Noise effects in different population groups

- Noise and children
- Noise sensitive individuals

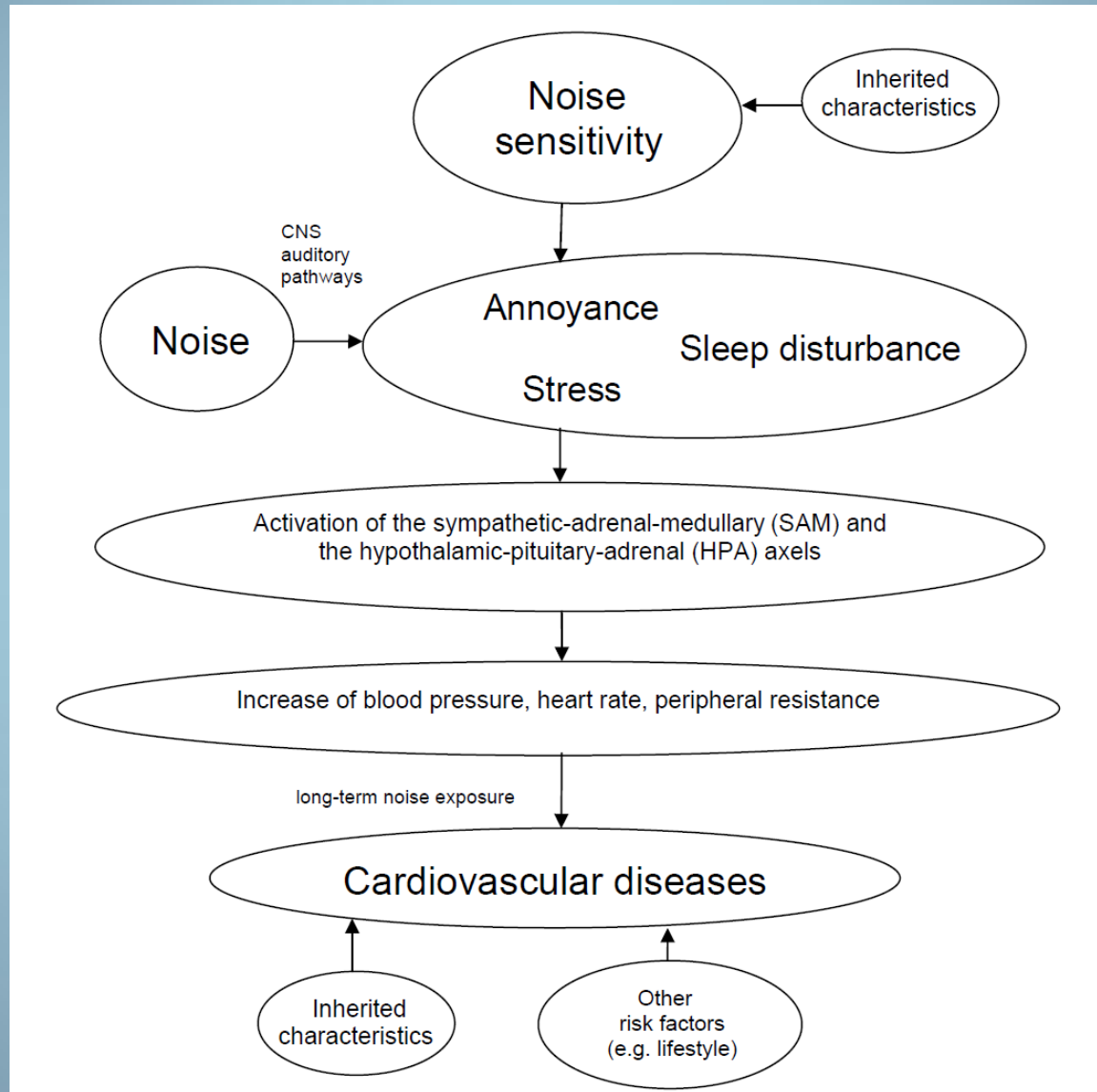
Environmental noise and children

- Sound environments:
 - home, day care center (kindergarten), school, leisure time
- Children at risk:
 - other developmental problems and delays
 - bi - multilingualism
 - social deprivation
 - chaotic environment
 - other health problems
 - noise sensitivity

Noise sensitivity

- A measure of attitudes to noise in general
- A predictor of noise annoyance
- Noise sensitive individuals are more affected by noise than less sensitive individuals
They pay more readily attention to noise, perceive more threat from noise and may react more to noise than less sensitive individuals.
- The risk of health effects caused by noise may be higher for noise sensitive individuals

Model of the schematic pathways of the possible relationship of noise sensitivity with development of cardiovascular disease



Noise sensitivity questionnaires

- Short questions like **“People experience noise in different ways. Do you experience noise generally as very disturbing, quite disturbing, not especially disturbing, not at all disturbing or can’t say?”**

Subjects answering “very disturbing” and “quite disturbing” are classified as noise sensitive (high and quite high noise sensitivity)

Subjects answering “not especially disturbing” and “not at all disturbing” are classified as non-noise sensitive (quite low and low noise sensitivity)

- The **Weinstein’s Noise Sensitivity Scale**

Occurrence and stability of noise sensitivity

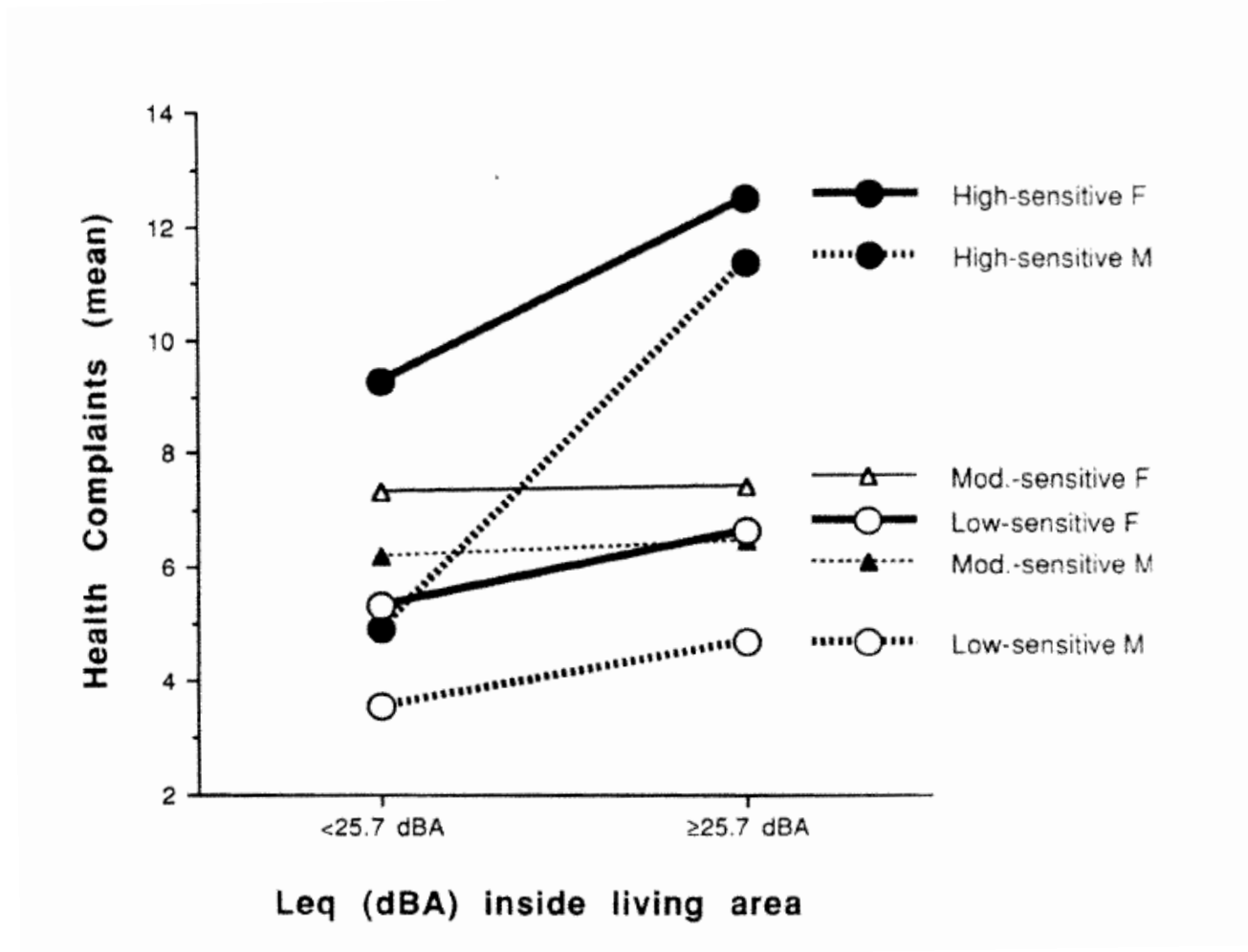
- The percentage of noise sensitive subjects has varied between 20 % and 43 % in different studies
- In a Finnish study 38 % were noise sensitive
- Noise sensitivity is a quite stable trait

(Heinonen-Guzejev et al. 2004)

Association of noise sensitivity with somatic and psychological factors

- Noise sensitivity is associated with
 - hypertension**
 - use of psychotropic drugs** (sleeping pills, tranquilizers and pain relievers)
 - stress**
 - hostility**
 - smoking**
 - emphysema**

Mean number of total health complaints in relation to noise (inside the living room), gender and degree of noise sensitivity (Nivison 1992)



Association of noise sensitivity with cardiovascular mortality

- **Cardiovascular mortality has been significantly increased among noise sensitive women**
- **In women the interaction of noise sensitivity and lifetime noise exposure has been statistically significant for coronary heart mortality; Among men no statistically significant effects**

(Heinonen-Guzejev et al. 2007)

Genetic component of noise sensitivity

- **Aggregates in families** and probably has a genetic component
- The best fitting genetic model provided an estimate of heritability of 36 %

(Heinonen-Guzejev et al. 2005)

WHO guideline values for community noise in specific environments

Specific environment	Critical health effect(s)	L _{Aeq} [dB]	Time base [hours]	L _{Amax, fast} [dB]
Outdoor living area	Serious annoyance, daytime and evening Moderate annoyance, daytime and evening	55 50	16 16	- -
Dwelling, indoors	Speech intelligibility and moderate annoyance, daytime and evening	35	16	
Inside bedrooms	Sleep disturbance, night-time	30	8	45
Outside bedrooms	Sleep disturbance, window open (outdoor values)	45	8	60
School class rooms and pre-schools, indoors	Speech intelligibility, disturbance of information extraction, message communication	35	during class	-
Pre-school Bedrooms, indoors	Sleep disturbance	30	sleeping -time	45
School, playground outdoor	Annoyance (external source)	55	during play	-
Hospital, ward rooms, indoors	Sleep disturbance, night-time Sleep disturbance, daytime and evenings	30 30	8 16	40 -
Hospitals, treatment rooms, indoors	Interference with rest and recovery	#1		
Industrial, commercial, shopping and traffic areas, indoors and Outdoors	Hearing impairment	70	24	110
Ceremonies, festivals and entertainment events	Hearing impairment (patrons:<5 times/year)	100	4	110
Public addresses, indoors and outdoors	Hearing impairment	85	1	110
Music through headphones/ Earphones	Hearing impairment (free-field value)	85 #4	1	110
Impulse sounds from toys, fireworks and firearms	Hearing impairment (adults) Hearing impairment (children)	- -	- -	140 #2 120 #2
Outdoors in parkland and conservation areas	Disruption of tranquillity	#3		

#1: as low as possible; #2: peak sound pressure, measured 100 mm from the ear; #3: existing quiet outdoor areas should be preserved and the ratio of intruding noise to natural background sound should be kept low; #4: under headphones, adapted to free-field values

**Thank you for
your attention!**