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Environmental noise and health

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Le Bruit urbain et ses impacts sur la santé des habitants

7es Assises nationales de la qualité de l'environnement sonore

Cité Centre de Congrès de Lyon
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Overview

- Evidence on environmental noise and health:
- Annoyance, Hypertension, CVD, Diabetes, Mental Health, Cognitive Performance
- Noise and air pollution and health
- Noise and the burden of disease
- Conclusion

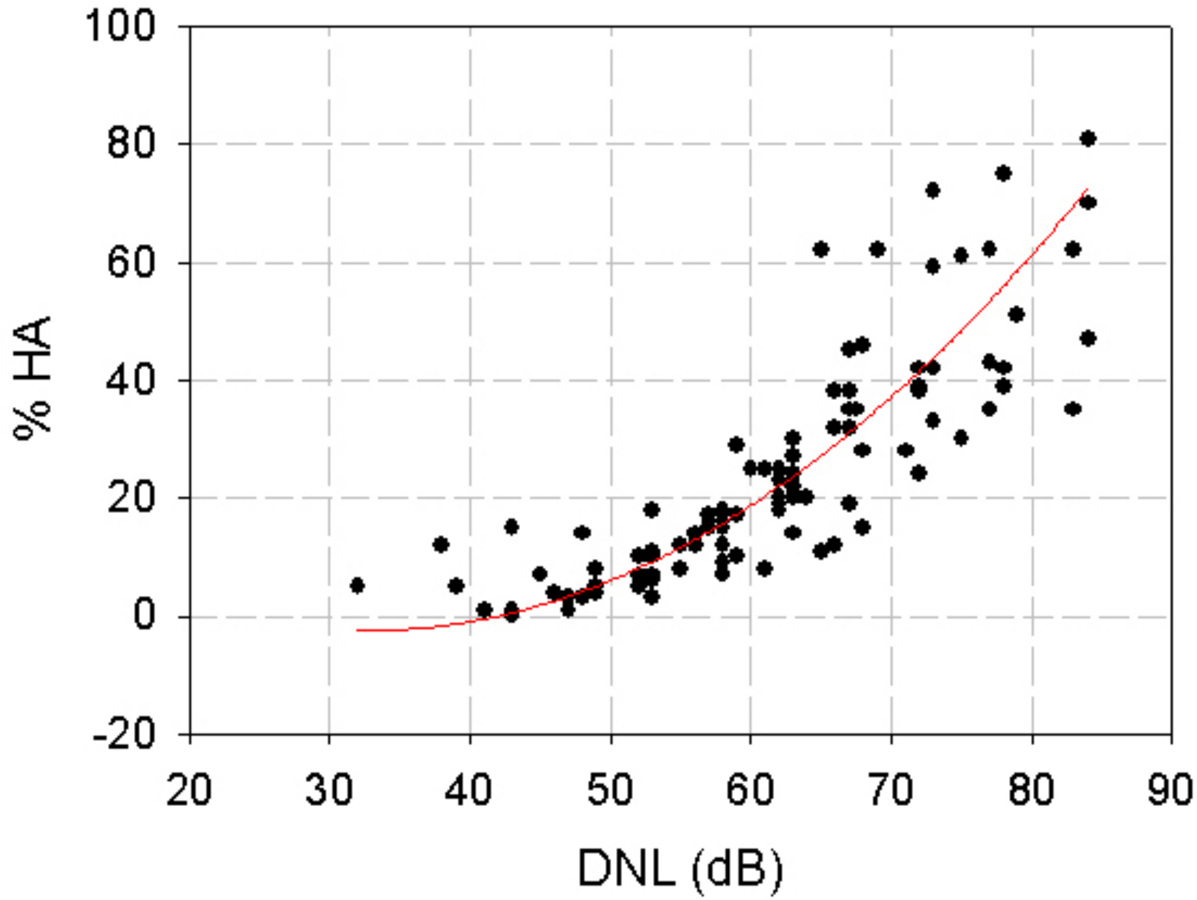
The Policy Background in Europe

- It is estimated that roughly 20 % of the Union's population [approx 80 million people] suffer from noise levels which scientists and health experts consider unacceptable (European Commission Green paper, Future noise policy, Brussels, 1996).

- The Environmental Noise Directive" [END] [Directive 2002/49/EC] defines a common approach across the European Union for avoiding, preventing or reducing the harmful effects of environmental noise exposure.

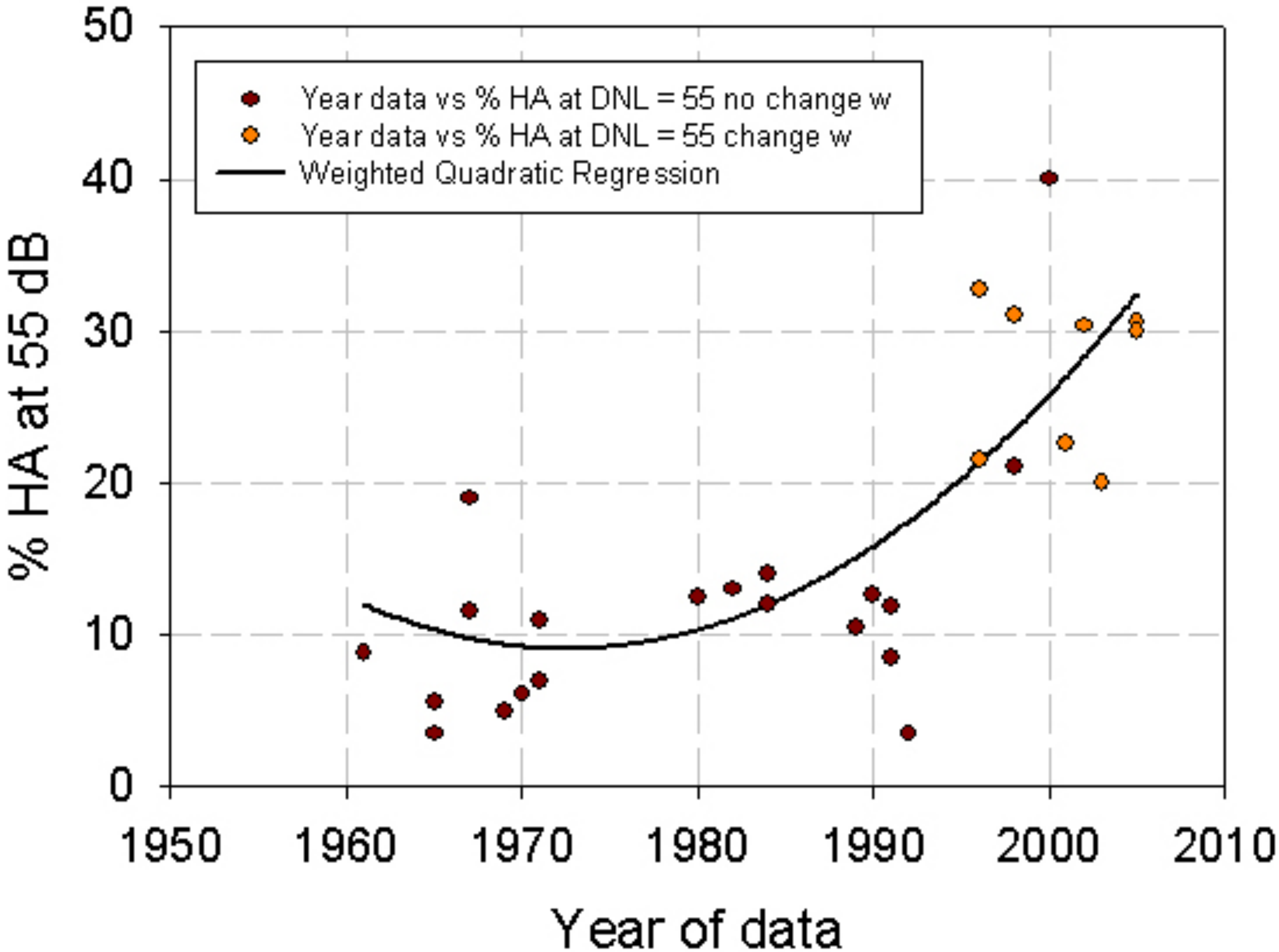
- Develop **noise maps** to describe the exposure of the population to noise from sources including aircraft, road, railway, industry: and develop **action plans** to enable the preservation of quality areas and to reduce noise pollution where necessary.

Aircraft noise annoyance
According to Miedema & Vos 1998



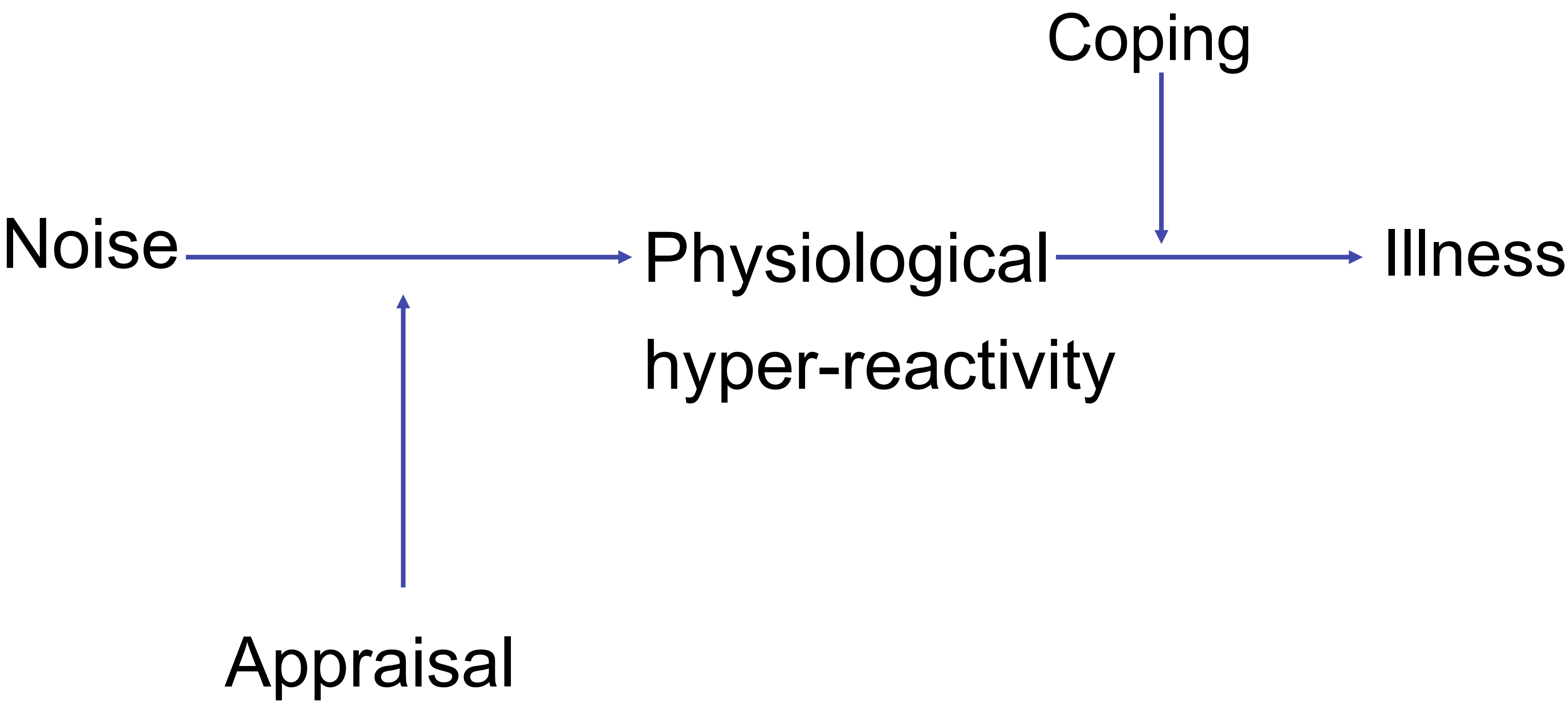
Scattergram of exposure-response relations and the weighted synthesis curve for aircraft noise annoyance according to Miedema & Vos (1998).
Note the definition of “highly annoyed”: 70 - 75 % of the length of the response scale.

Trend of aircraft noise annoyance



The statistical trend for aircraft noise annoyance at DNL = 55 dB over time (1961 -2005).
Note: HA = 70 – 75 % of the response scale). Red Points show data from high-rate change studies.
The quadratic regression curve covers all data points, weighted according to sample size (Sqrt N).

Noise and the Arousal Hypothesis



Hypertension, Cardiovascular Disease

HYENA Study: support for noise effects on blood pressure

- 4,861 persons, 45-70yrs around 6 major European airports
- Aircraft noise contours modelled using Integrated Noise model
- ACN $L_{night,}$ 10 dBA increase OR=1.14 (95% 1.01-1.29)
- ACN L_{eq}, 24h dBA increase OR=1.10 (95% CI 1.00-1.20)
- RTN > 65dB OR=1.54 (95% CI 0.99-2.40)
- Annoyance may modify ACN effect and closing windows RTN effects on hypertension

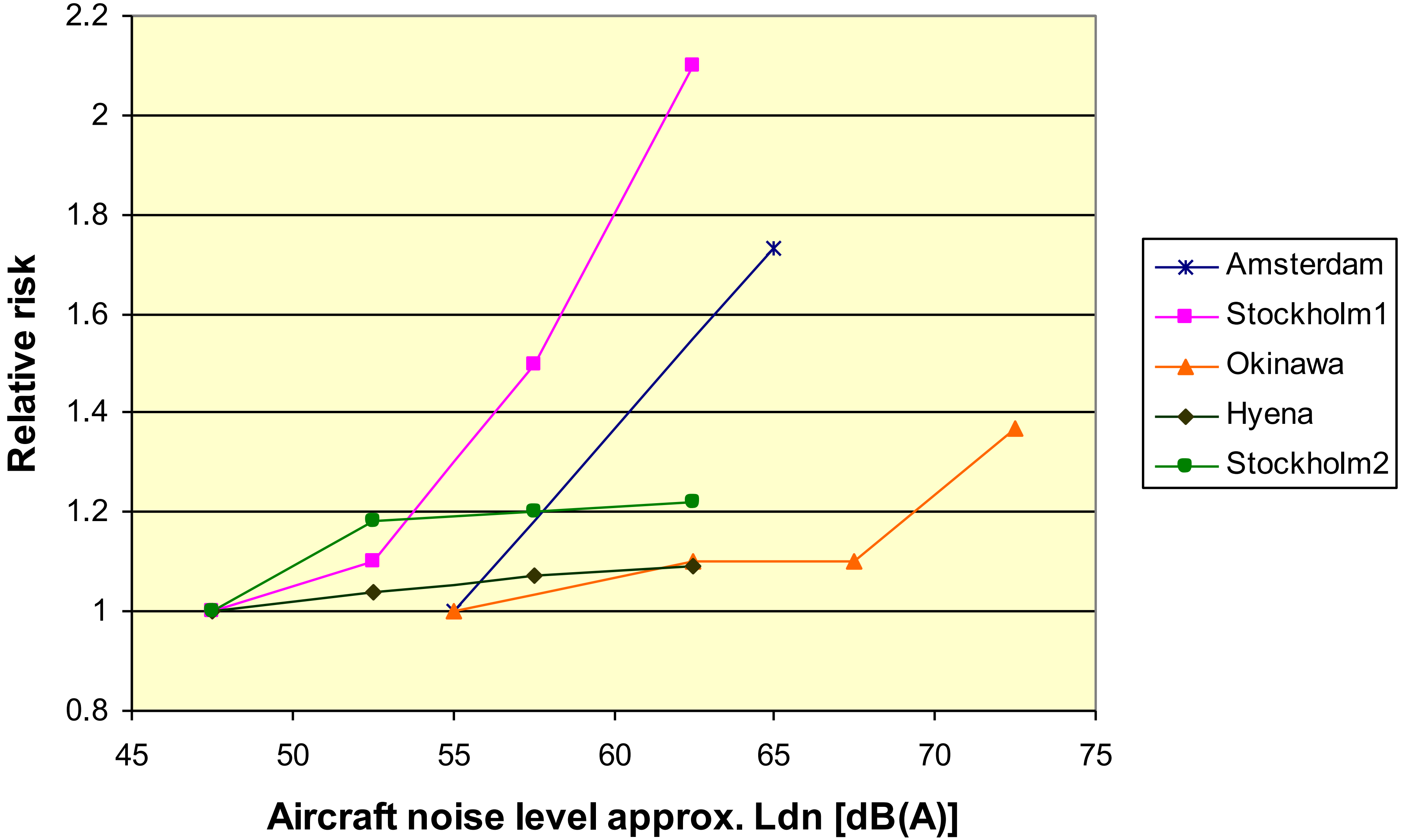
(Jarup et al, 2008)

Aircraft Noise and Cumulative Incidence of hypertension in 2027 men around Stockholm Arlanda airport

			Unadjusted	Adjusted[+]
	No	No with hypertension	RR 95% CI	RR 95% CI
Energy-averaged aircraft noise level based on GIS				
<50 dBA	1610	478	1.00	1.00
>50 dBA	410	148	1.22 1.05-1.41	1.19 1.03-1.37
Minimum Aircraft Noise level				
<65 dBA	1709	513	1.00	1.00
>65 dBA	311	113	1.21 1.03-1.43	1.20 1.03-1.40

[+] Adjusted for age and BMI. Hypertension measured BP> 140/90. (Subjects >57yrs RR= 1.36 95% CI 1.14-1.62; sample family history of diabetes: RR= 1.29 95% CI 1.10-1:52 in subjects with normal glucose tolerance

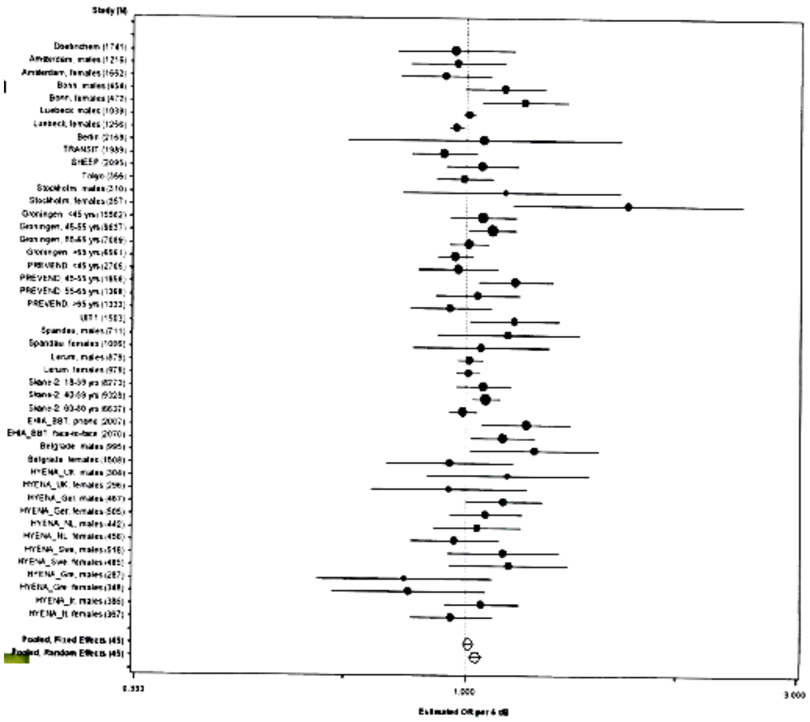
(Eriksson et al, 2007)



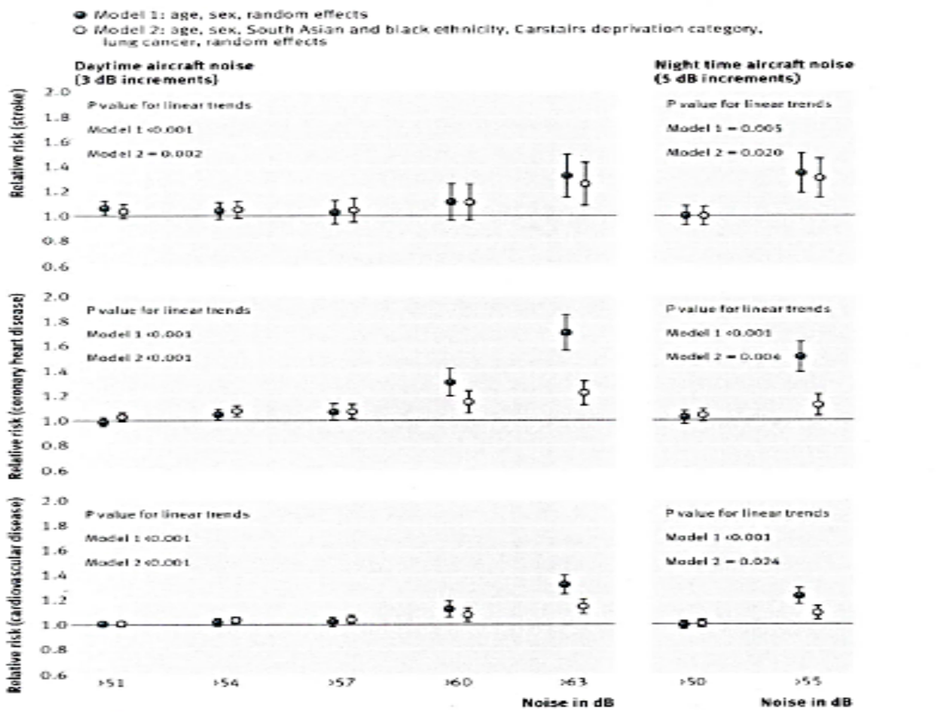
2.2
2
1.8
1.6
1.4
1.2
1
0.8
Relative risk
45
50
55
60
65
70
75
Aircraft noise level approx. Ldn [dB(A)]
Amsterdam
Stockholm1
Okinawa
Hyena
Stockholm2

Road traffic noise and hypertension: meta-analysis of 27 studies
OR=1.068 (95%CI 1.021-1.117) per 10 dB increase

(Van Kempen &Babisch, 2012)



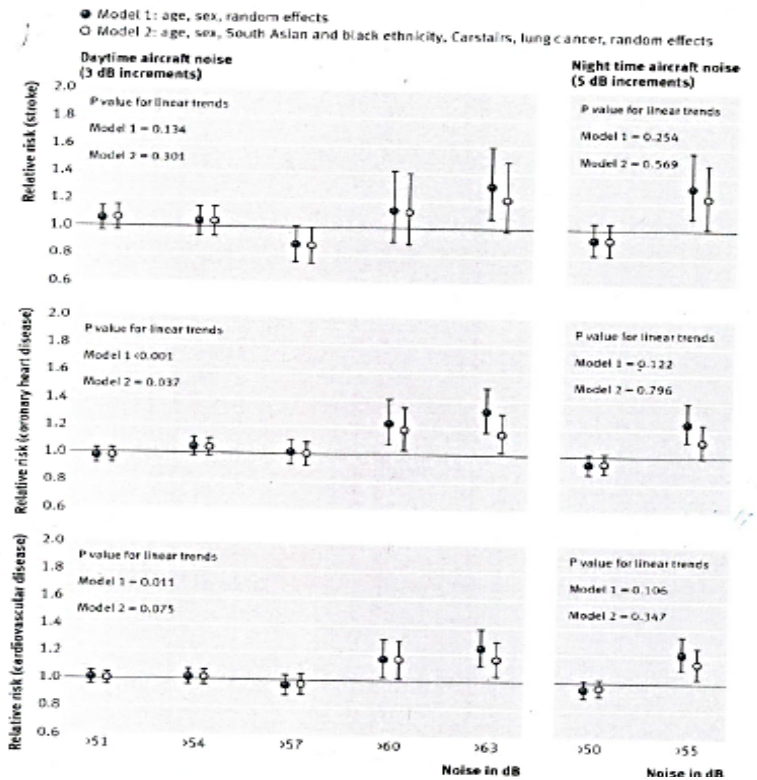
Aircraft noise and CVD hospital admissions: ecological analyses around Heathrow
(Hansell et al, 2013)



Relative risks (95% confidence intervals) for associations between hospital admissions for stroke, coronary heart disease and cardiovascular disease in 2001-05 and annual population weighted average daytime aircraft noise (relative to ≥51dB) and night time aircraft noise (relative to ≥50dB) in 2001, census output areas

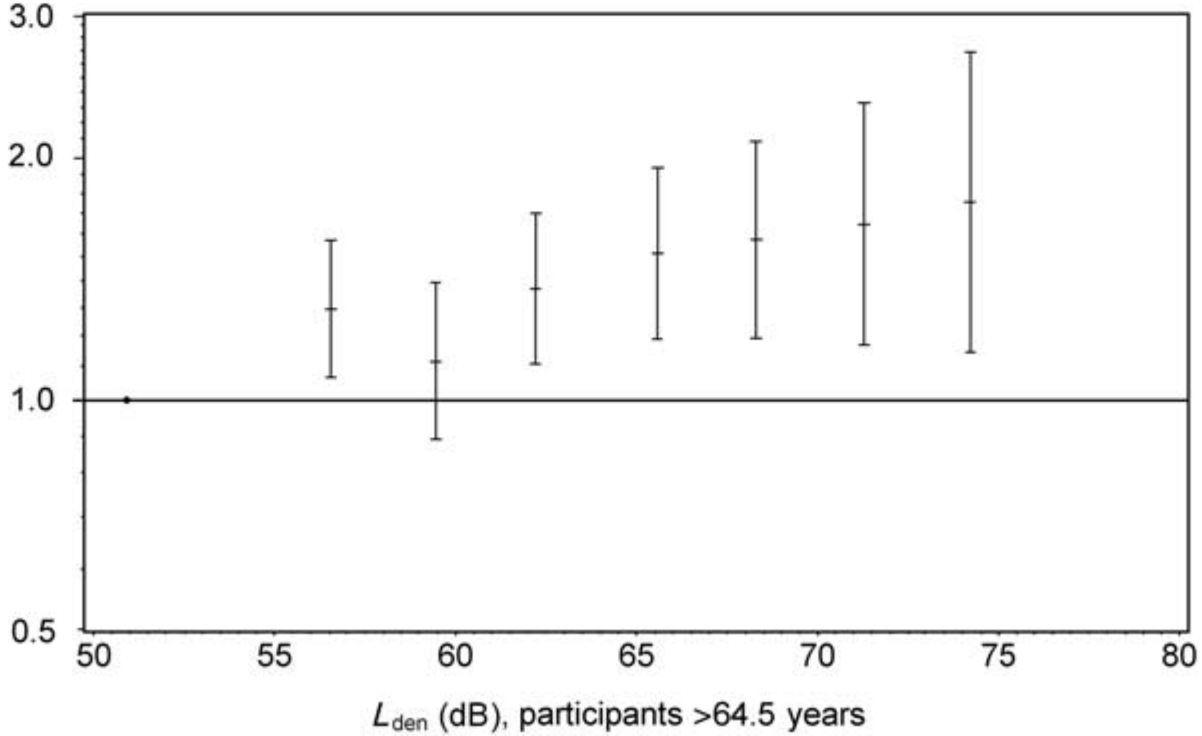
Aircraft noise and mortality: ecological analyses around Heathrow Airport

(Hansell et al, 2013)



Relative risks (95% confidence intervals) for associations between mortality from STROKE, CORONARY HEART DISEASE and CARDIOVASCULAR DISEASE in 2001-05 and annual population weighted average daytime aircraft noise (relative to ≥51dB) and night time aircraft noise (relative to ≥50dB) in 2001, super output areas

Road traffic noise and incidence rate ratio for stroke in Copenhagen and Aarhus



57053 participants: noise exposure calculated for 1990, 95, 200, 05, road lines, yearly average daily traffic, traffic composition, traffic speed, road type, building height

(Sörensen et al. 2011)

Noise, stroke incidence and mortality

	RR per 10 dB	(95% CI)
Huss et al 2010	0.99	(0.94-1.04)
Sorensen et al 2011	1.14	(1.03-1.26)
Correia et al 2013	1.02	(0.95-1.09)
Floud et al 2013	1.08	(0.87-1.33)
Hansell et al 2013	1.08	(1.03-1.13)
De Kluizenaar 2013	1.00	(0.91-1.10)

(Van Kempen, 2014)

Risk of death from selected causes by aircraft noise and air pollution exposure categories, Switzerland, 2000-2005

	Hazard Ratios (95% Confidence Intervals)			
	Model 1	**Model II**	**Model III**	**Model III Subpopulation[a]**
Exposure				
Acute myocardial infarction				
Aircraft noise (dB(A))				
<45	1.00	1.00	1.00	1.00
45-49	0.96 (0.87-1.04)	1.00 (0.91-1.10)	1.02 (0.93-1.12)	1.03 (0.90-1.17)
50-54	0.97 (0.88-1.07)	1.01 (0.91-1.11)	1.02 (0.92-1.13)	1.05 (0.91-1.21)
55-59	0.98 (0.86-1.11)	1.04 (0.91-1.18)	1.05 (0.92-1.19)	1.14 (0.96-1.37)
≥60	1.27 (0.94-1.71)	1.28 (0.95-1.73)	1.30 (0.96-1.76)	1.48 (1.01-2.18)

Model I, adjusted for sex
Model II, adjusted for sex, civil status (single, married, divorced, widowed), nationality (Swiss, other), educational level (primary, secondary, tertiary), setting (urban, rural), language region (German, French, Italian), type of building (older than 30 years without renovation versus other), and socioeconomic status of the municipality, age, gender, smoking status and area level indicators of socioeconomic status
Model III, adjust for the same variables as in model II and all 3 exposure variables (noise, distance, PM10) in the same model.
Major roads include motorways, slip roads and main roads between towns and main traffic connections within the larger cities.
[a]Model III, analysis restricted to persons who lived at least 15 years at the same place of residence.

(Huss et al, 2010)

Meta-analysis of transportation noise and myocardial infarction

- Road traffic and aircraft noise included
- Ischaemic Heart disease (410-414 in ICD 9)
- 37 studies included
- Myocardial infarction risk increases >60 dBA
- Effect estimate for a linear trend per 10 dB OR= 1.17 (95%CI, 0.87-1.57)
- Subsample living in dwelling 10 years+ OR = 1.44 (95%CI, 0.97-2.12)

(Babisch, 2008)

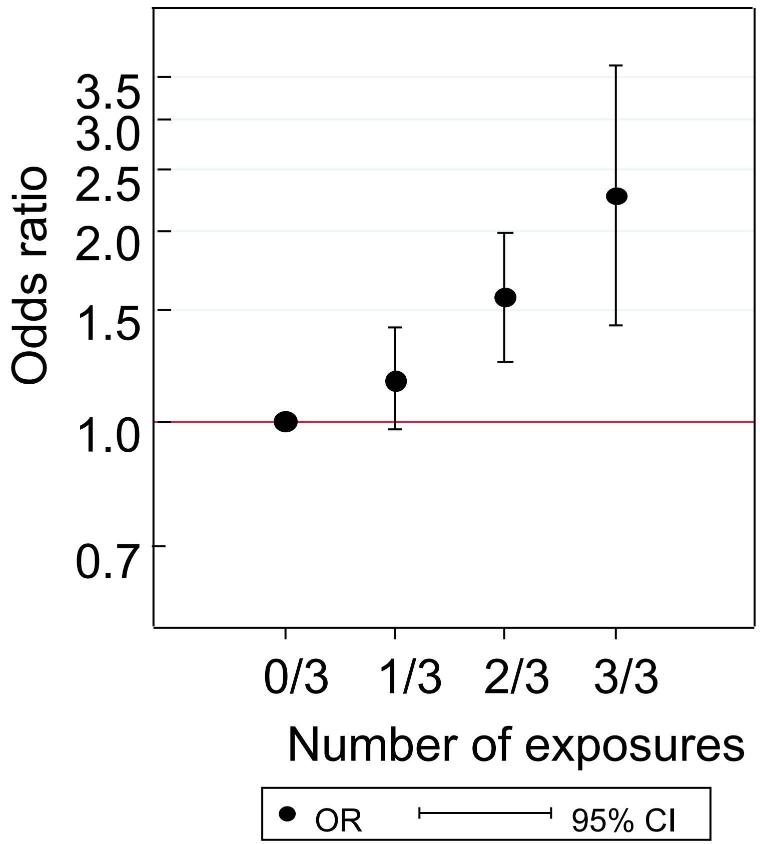
Road traffic noise, myocardial infarction and ischaemic heart disease (IHD)

- Road traffic noise, IHD (studies from 2000-2007)
  For MI RR = 1.12 (95% CI 1.02-1.23)
  per 10dB increase
  (Van Kempen & Houthuijs, 2008)

- 8 studies on road and aircraft noise and incident IHD
  IHD incidence RR = 1.08 (95% CI 1.03-1.14)
  MI mortality RR = 1.03 (95% CI 0.98-1.09)
  per 10dB increase
  (Vienneau et al, 2013)

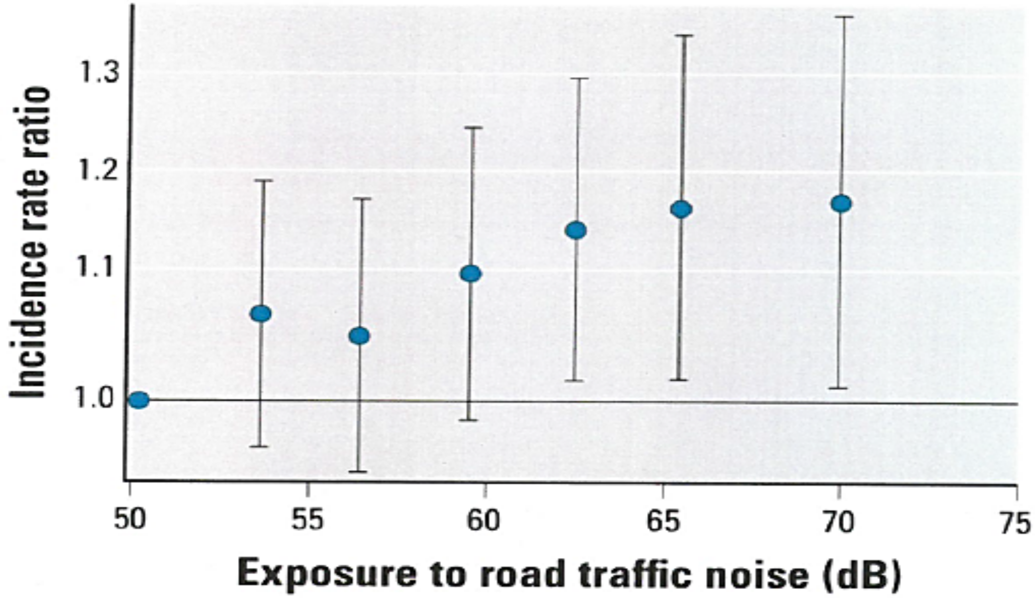
- 14 studies on road traffic noise and IHD
  RR = 1.08 (95% CI 1.04-1.13)
  per 10dB L_{DN} increase
  (Babisch, 2014)

Combined exposure to noise from traffic and at work as well as job strain in relation to the risk of myocardial infarction



From: Selander et al. 2011

Road traffic noise and incidence of Diabetes mellitus
(Sørensen et al, 2013)



Association between exposure to road traffic noise (L_{den}) at the residence at the time of diagnosis and all incident diabetes adjusted for age; sex; BMI; waist circumference; smoking status, duration, and intensity; environmental tobacco smoke; intake of fruits, vegetables, saturated fat, and alcohol; sport; bicycling and walking; school attendance; occupational status; municipality socioeconomic status; railway and airport noise; air pollution; and calendar year. The vertical whiskers show incidence rate ratios (IRR) with 95% CIs at the median of six exposure categories (52–55, 55–58, 58–61, 61–64, 64–67, > 67 dB) when compared with the reference category of ≤ 52 dB.

Mental Health and Cognitive Ability

Road Traffic Noise and Mean Anxiety Score

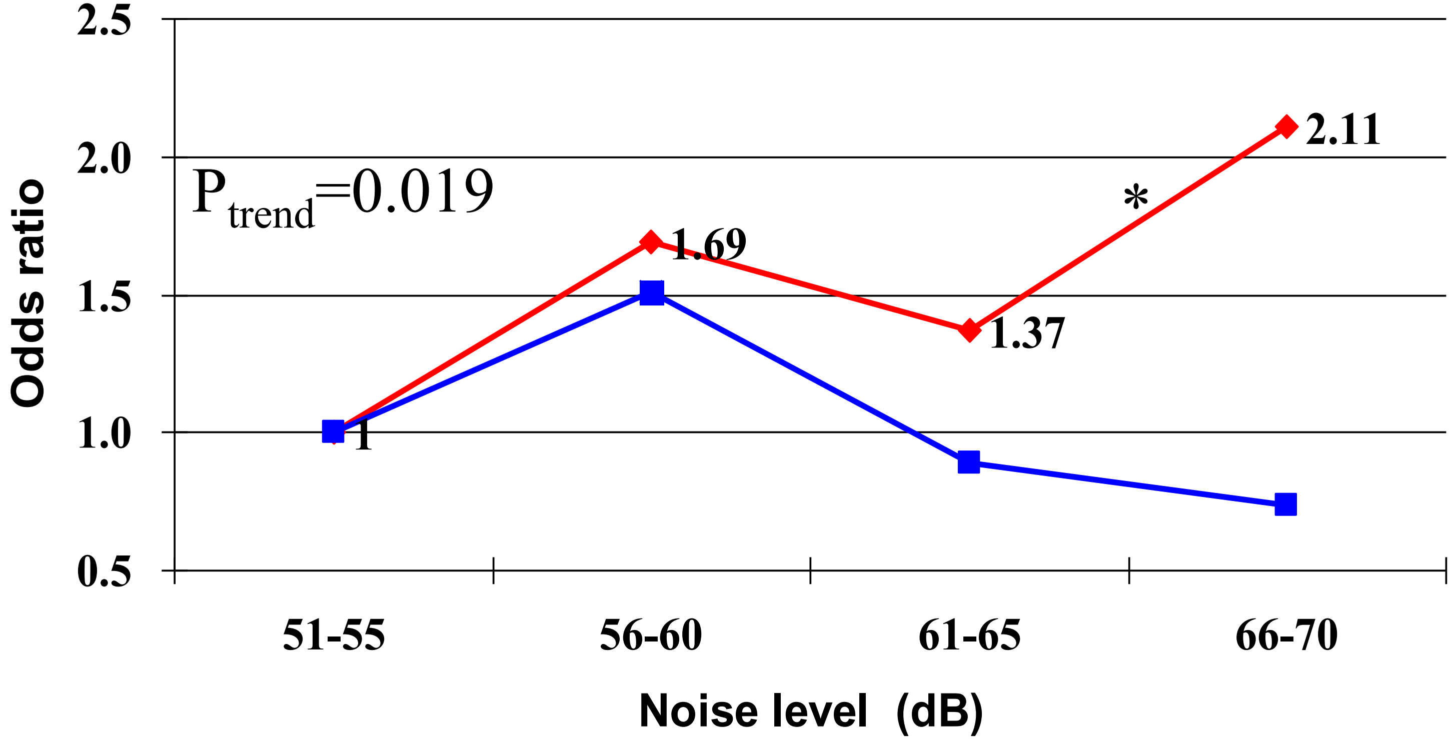
Caerphilly Study

	Noise level (db(a))			
Anxiety Symptoms	51-55	56-50	61-65	66-70
(N=1853)	4.70	5.20	4.89	5.02*

Adjusted for age, social class, noise sensitivity and baseline anxiety
*P<0.03

(Stansfeld et al, 1996)

Odds ratio of GHQ caseness at follow-up by noise level for sensitive and insensitive groups



Aircraft and Psychiatric Disorder: Elmas Survey (n=71)

Composite International Diagnostic Interview

	Control	Exposed	OR	CI
Generalised Anxiety Disorder	11.6	21.1	2.0	1.0-4.2
Generalised Anxiety Disorder nos	4.2	11.2	2.9	1.0-4.1
Major Depressive Disorder	14.7	9.8	0.7	0.6-1.2
Major Depressive Disorder nos	7.0	12.6	1.9	0.8-6.0

No measurement of noise levels; response rate low

(Hardoy et al, 2005)

Odds Ratios (OR) (95% CIs) of medication use related to aircraft and road traffic noise per 10 dB increase

Medication group	Noise source	OR (95% CI)	N
Anxiolytics	$L_{Aeq\ 16h}$ Aircraft L_{night} Aircraft $L_{Aeq\ 24h}$ Road traffic	1.28 (1.04 to 1.57) 1.27 (1.01 to 1.59) 1.06 (0.84 to 1.33)	4642 4641 4642
Hypnotics	$L_{Aeq\ 16h}$ Aircraft L_{night} Aircraft L_{Aeq}24h Road traffic	0.96 (0.76 to 1.22) 0.90 (0.70 to 1.14) 1.28 (0.96 to 1.71)	4642 4641 4642
Antidepressants	$L_{Aeq\ 16h}$ Aircraft L_{night} Aircraft $L_{Aeq\ 24h}$ Road traffic	1.07 (0.90 to 1.26) 0.96 (0.81 to 1.13) 0.97 (0.78 to 1.21)	4642 4641 4642

(Floud et al 2010)

Relation between air traffic noise exposure and morning saliva cortisol levels among 439 subjects in six European Countries*

		All		Women		Men
$L_{Aeq, 24h}$(dB)	No.	Coefficient (95% CI)	No.	Coefficient (95% CI)	No.	Coefficient (95% CI)
Categorical						
<50**	174	__	97	__	77	
$\geq$ 50 to <60	142	1.04 (-1.61 to 3.68)	77	2.16 (-1.26 to 5.59)	65	0.06 (-3.64 to 3.76)
$\geq$ 60	123	1.83 (-0.90 to 4.35)	56	6.07 (2.32 to 9.81)	67	-2.00 (-5.61 to 1.61)

*All analyses adjusted for road traffic, country, age, sex, employment status, occupational status, medication use, BMI, alcohol, diet, remedy during night and other noise sources in living environment.

** Reference category, arithmetic mean cortisol level: all = 19.13 nmo/L, women = 17.7 nmol/L, men = 20.92 nmol/L.

(Selander et al, 2009)

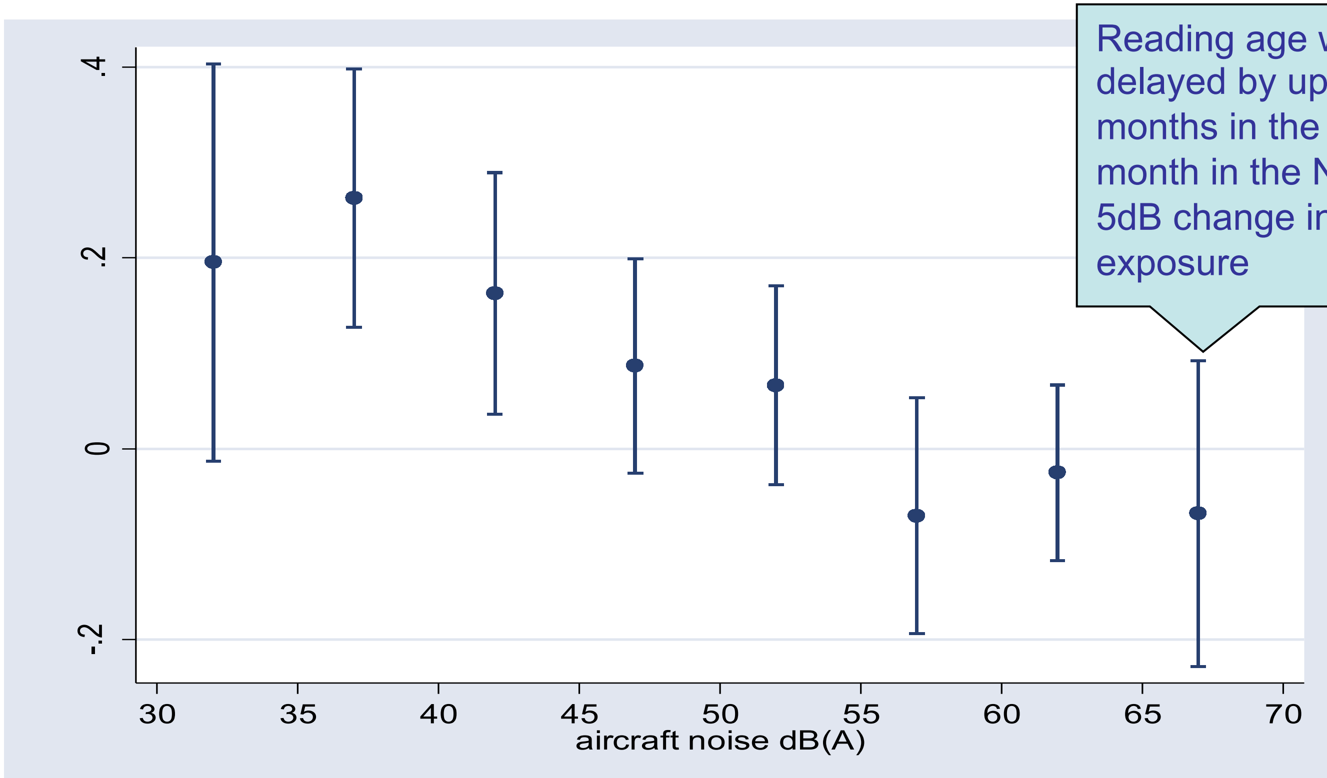
Summary of studies: adults

	Studies	Association	Quality
Psychiatric hospital admissions	3	+-	3
Psychological symptoms	1	+-	3
Community studies (screening questionnaire)	6	+-	2-3
Interview based study	1	+	2
Medication	2	+-	4

Summary of results – studies of children

- Some evidence that aircraft noise impairs quality of life in children
- Little evidence that aircraft noise is related to formal psychological disorders

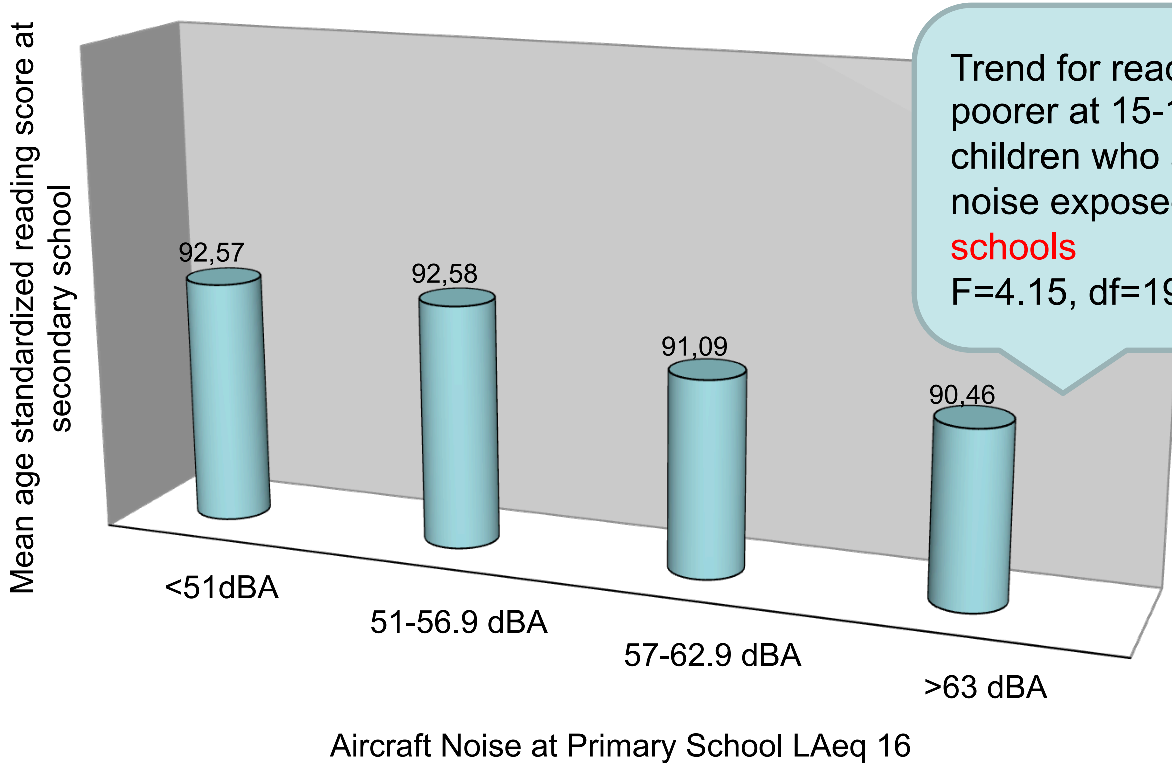
Exposure-effect relationship between aircraft noise at school and reading comprehension



Reading age was delayed by up to 2 months in the UK and 1 month in the NL for a 5dB change in noise exposure

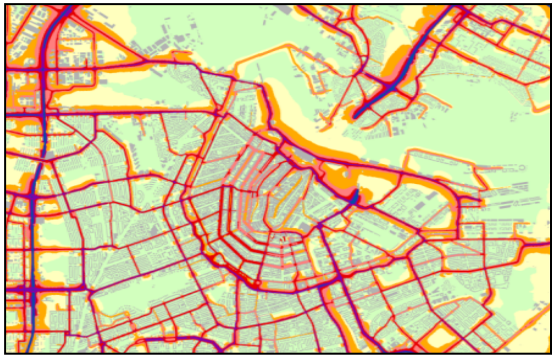
•Increasing aircraft noise exposure was associated with impairment of reading comprehension (B=-0.008, 95% CI -0.014 to -0.002, p=0.001) (Stansfeld et al, 2005; Clark et al, 2006)

Aircraft noise at primary school and secondary school reading comprehension

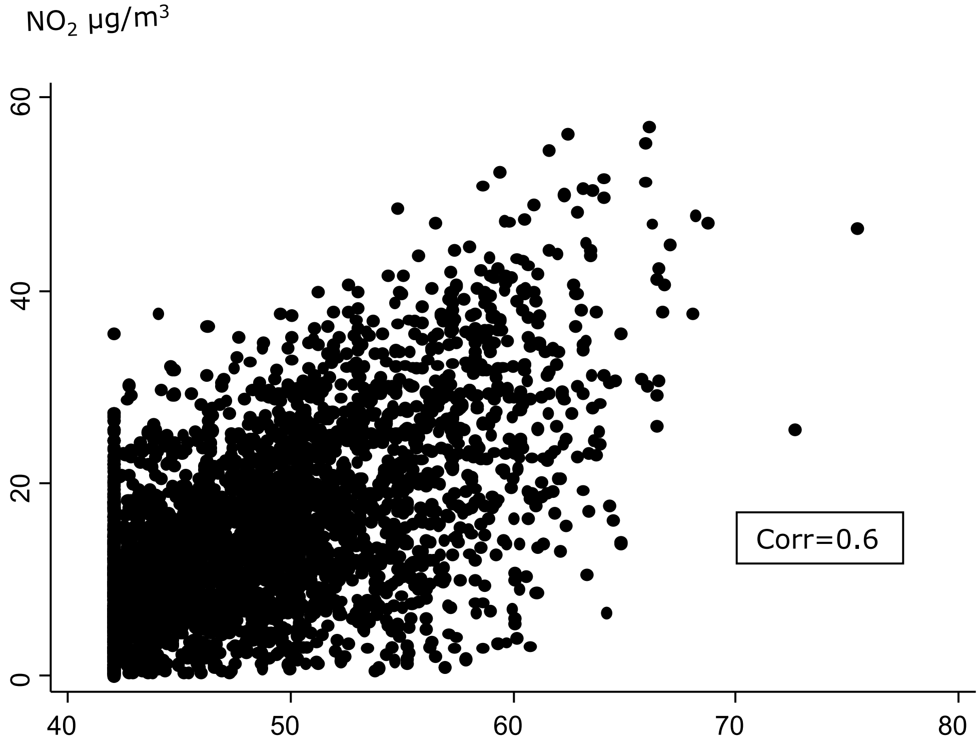


Trend for reading to be poorer at 15-16y for children who attended noise exposed primary schools
F=4.15, df=19, p=0.0001

Combined exposure to noise and air pollution



- Living near major road & adverse effects
  (e.g. Hoek et al., 2002; Maheswahran, 2003; Hoffmann et al., 2007)
- Road traffic source of both noise & air pollution
- Conclusion often drawn:
  causal factor: air pollution
- However: adverse health effects have been associated with both noise & air pollution (-> cardiovascular effects)
- To date: limited number of studies available
  (E.g. Only some studies met criteria of having independent variables for both noise and air pollution and physiological outcome: e.g. Beelen et al 2009, de Kluizenaar et al 2007, Selander et al 2009)



Correlation between individual long-term exposure to air pollution (NO2 µg/m3) and noise (dB *L*Aeq,24h) from road traffic in a case-control study on MI from Stockholm

(Selander et al. 2009)

Air pollution, road noise and cardiovascular mortality: The Netherlands Cohort Study on Diet and Cancer

	Cardiovascular	IHD	Cerebrovascular	Heart Failure
	RR 95% CI	RR 95% CI	RR 95% CI	RR 95% CI
Assessed separately				
Background black smoke	1.11 0.96-1.28	1.01 0.83-1.22	1.39 0.99-1.94	1.75 1.00-3.05
Traffic intensity	1.05 0.99-1.12	1.11 1.03-1.20	0.82 0.68-1.00	1.07 0.86-1.34
Traffic noise >65 dBA	1.25 1.01-1.53	1.15 0.86-1.3	0.88 0.52-1.50	1.99 1.05-3.79
Assessed together				
Background black smoke	1.11 0.95-1.28	1.01 0.83-1.22	1.41 1.01-1.97	1.76 1.01-3.08
Traffic intensity	1.06 0.99-1.13	1.12 1.04-1.21	0.90 0.74-1.10	1.02 0.79-1.32
Traffic noise >65 dBA	1.17 0.94-1.45	1.01 0.74-1.36	0.95 0.55-1.66	1.90 0.96-3.78

Adjusted for age, gender, smoking status and area level indicators of socioeconomic status
'Associations between black smoke concentrations and traffic intensity on the nearest road with specific CVS causes of death were insensitive for adjustment by traffic noise and were not explained by traffic noise in this study'

(Beelen et al, 2008)

Groningen study: random population sample, modelled road traffic noise and hypertension

TABLE 3

Odds Ratios (ORs) for a 10-dB Increase of Road Traffic Noise Exposure (Day-Evening-Night Level; L_{den}) for Self-Reported Use of Medication for Hypertension in Prespecified Subgroups of the City of Groningen Sample

Group[a]	*N*	OR (Unadjusted)	OR (Age, Sex Adjusted)	OR (Full Model)	OR (Full Model + PM10)
All	38849	1.31 (1.25–1.37)**	1.01 (0.96–1.06)	1.01 (0.96–1.06)	1.03 (0.96–1.11)
Sex					
Male	17652	1.22 (1.14–1.31)**	0.99 (0.92–1.06)	0.99 (0.92–1.07)	1.03 (0.92–1.15)
Female	21197	1.38 (1.30–1.46)**	1.03 (0.97–1.10)	1.02 (0.95–1.09)	1.03 (0.94–1.13)
Age (yrs)					
<45	15562	0.96 (0.81–1.15)	1.00 (0.84–1.19)	1.00 (0.84–1.19)	1.12 (0.90–1.40)
45–55	9637	1.13 (1.02–1.26)**	1.10 (0.99–1.22)*	1.08 (0.97–1.20)	1.19 (1.02–1.40)**
55–65	7089	1.10 (1.01–1.20)**	1.08 (0.99–1.18)*	1.07 (0.98–1.17)	1.02 (0.90–1.17)
>65	6561	0.95 (0.88–1.03)	0.94 (0.87–1.01)	0.94 (0.87–1.01)*	0.93 (0.83–1.04)
Noise (*Lden*, dBA)					
<55	23134	1.40 (1.23–1.61)**	1.02 (0.88–1.19)	1.06 (0.91–1.23)	1.09 (0.94–1.27)
≥55	15715	1.31 (1.16–1.48)**	1.21 (1.06–1.39)**	1.21 (1.05–1.38)**	1.31 (1.08–1.59)**
UAC (mg/L)					
<10	29363	1.36 (1.29–1.44)**	1.04 (0.99–1.11)	1.03 (0.97–1.09)	1.03 (0.95–1.12)
≥10	9485	1.19 (1.10–1.29)**	0.93 (0.85–1.02)	0.94 (0.86–1.04)	1.02 (0.89–1.17)

*Indication of a trend ($P < 0.1$).

**Significant relationship ($P < 0.05$).

[a]Odds ratios from logistic regression in each subgroup are shown, for different models: (1) unadjusted; (2) adjusted for age and sex; (3) adjusted for age, sex, smoking, family history of CVD, SES; (4) and the same model including adjustment for air pollution (PM10).

dB = decibel; CVD = cardiovascular disease; UAC = urinary albumin excretion.

(De Kluizenaar et al, 2007)

Separating effects of air pollution and noise

- Meteorology more associated with air pollution than noise
- Noise varies less day to day than air pollution
- There may be different biological pathways for noise and air pollution effects
- Differences in dispersion: Quiet sides of buildings, barriers may affect noise exposure more than air pollution
- Rail and aircraft noise where noise may be a more prominent exposure than air pollution

(ENNAH, 2011)

Night Noise Guidelines for Europe

40dB Lnight outside should be the target guideline to protect the public including vulnerable groups: children, the elderly and the chronically ill

55dB should be adopted as an interim target for those countries where 40 dB cannot be adopted in the short term for various reasons

(World Health Organisation, 2009)

Evidence for noise-health relationship

Effect	Passchier-Vermeer& Passchier (2000)	Babisch (2004, 2006, 2009)	WHO (2009)	EEA (2010)
	Classification of the evidence			
Annoyance	sufficient	-	sufficient	sufficient
Hypertension	sufficient	(inadequate)/ limited/ sufficient (aircraft)	limited	sufficient
Cardiovascular disease (inc. ischemic heart disease and myocardial infarction)	sufficient	(limited)/ sufficient	limited	sufficient
Self reported sleep disturbance	sufficient	-	sufficient	sufficient
Awakening	sufficient	-	sufficient	sufficient
Sleep (arousal, motility, sleep quality)	sufficient	-	sufficient	sufficient
Heart rate, body movements during sleep	sufficient	-	sufficient	-
Hormonal changes during sleep	limited	limited	limited	-
Performance, fatigue next day	limited	-	limited	-
Stress hormones	limited	-	limited	sufficient
Learning, memory, performance	sufficient	-	-	sufficient
Immune effect	limited	-	-	-
Birth weight	limited	-	-	-
Well being	limited	-	limited	sufficient

Environmental noise and the burden of disease

The WHO has estimated that

DALYS lost from environmental noise:

61,000 years - IHD

45,000 years - cognitive impairment in children

903,000 years - sleep disturbance

654,000 years - annoyance

Based on exposure response relationships, exposure distribution, prevalence of disease and disability weighting

1 million healthy life years lost every year from traffic-related noise in Western Europe

(WHO, 2011)

(WHO, 2011

Conclusions

Environmental noise exposure is widespread in Europe and the urban areas of France are no exception

There is increasing evidence of the effects of aircraft and road traffic noise on hypertension, myocardial infarction, stroke and mortality

There is also evidence that noise affects children's cognitive performance and possibly mental health

It is already known that there are large effects on annoyance and sleep

The health case for policy to reduce environmental noise is now substantial

Acknowledgements

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