



# NORAH - Noise-Related Annoyance, Cognition and Health

## Effects of aircraft noise on mental health

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**Dirk Schreckenberg**

ZEUS GmbH

Centre for Applied Psychology,  
Environmental and Social Research

D-58093 Hagen, Germany



*Co-authors:* 43 scientists from 11 institutions (universities, research organizations, consulting companies)



- **Introduction:**
  - Background
  - Work packages of the NORAH study
  - Conceptual model
- **Annoyance, health-related quality of life** (NORAH WP1)
  - Study design
  - Results on annoyance
  - Results on self-reported mental well-being
- **Health risks: Depression** (NORAH WP2)
  - Study design
  - Results on risk of developing depression
- **Conclusions**





1997 **Announcement:** Request of airport expansion.  
4<sup>th</sup> runway, 200'000 additional flights p.a.

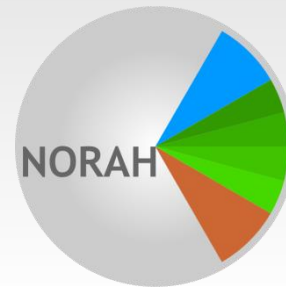
1998 – 2000 **Mediation group.** One of the agreements:  
➤ Night flight ban between 11pm - 5am  
after opening of the 4<sup>th</sup> runway



2001 – 2007 **Regional Planning and Zoning Procedures**  
➤ Construction of the new runway Northwest  
➤ 17 flights 11pm – 5am; 133 flights 10-11pm, 5-6am  
➔ **Public debate:** 'violation of mediation agreements

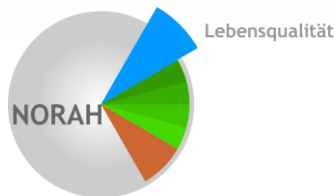
04/2011 **NORAH Study** - commissioned by the  
- 12/2015 Environment & Community Center (UNH),  
a wholly-owned subsidiary of the federal state of Hessen

10-11/2011 **4<sup>th</sup> runway opened & night flight ban introduced**  
(ban: voluntary till 03/2012, court decision confirms in 03/2012)

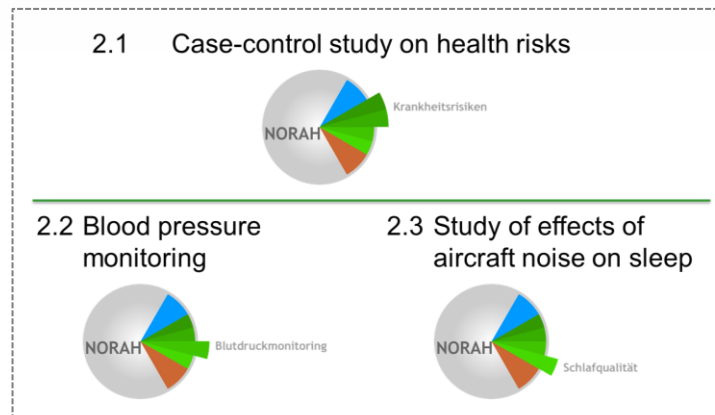


## WP0: Acoustics

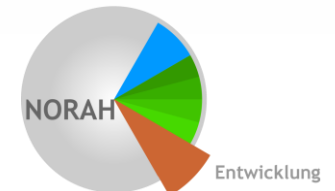
### WP1: Annoyance & HQoL



### WP2: Health



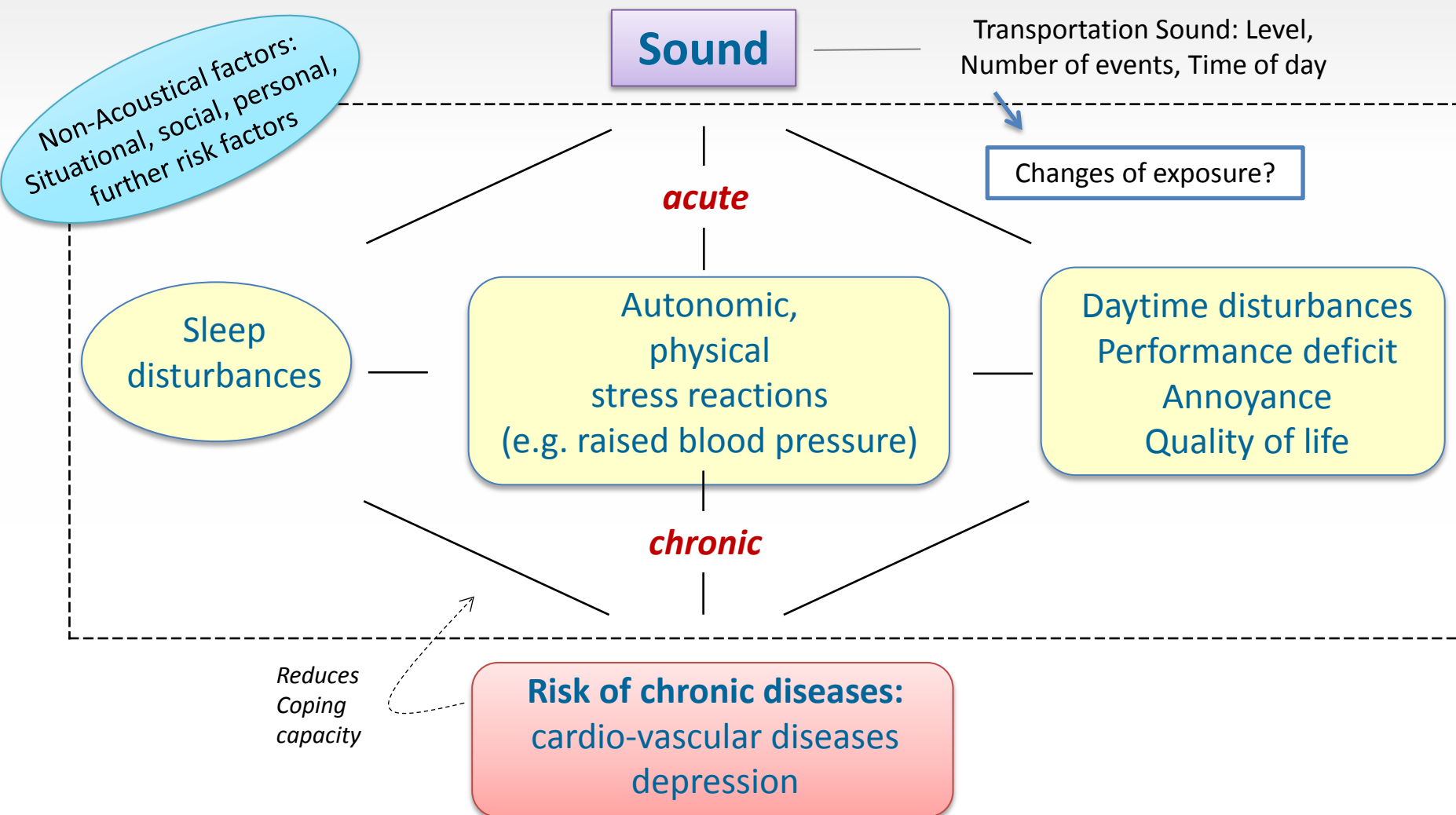
### WP3: Children's cognition, HQoL



# Conceptual Model: Stress model



Transportation noise leads to stress, chronic noise can jeopardise health



# Surveys in NORAH WP 1

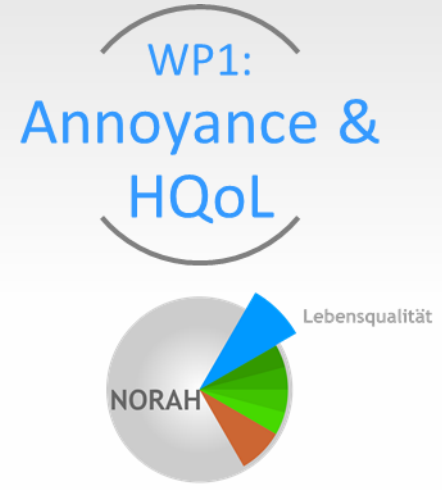
## referring primarily to aircraft noise



Stratified random sample within 40 dB  $L_{\text{day/night}}$  contours

Telephone interviews (optional: online)

- annoyance, disturbances
- health-related quality of life (physical, mental)
- non-acoustical factors
- socio-demographic



Acoustical calculations  $L_{pAeq}$ ,  $L_{den}$ ,  $L_{Amax}$ ,  $NA_x$

- aircraft
- railway
- road traffic

according to German noise calculation models

Study	Airport	2011	2012	2013	Sample N
Panel	Frankfurt	x	x	x	3 508 taking part in all waves
Cross-sectional	Berlin-Brandenburg		x		5 548
	Cologne/Bonn			x	2 955
	Stuttgart			x	1 979

4<sup>th</sup> runway night curfew

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# Results

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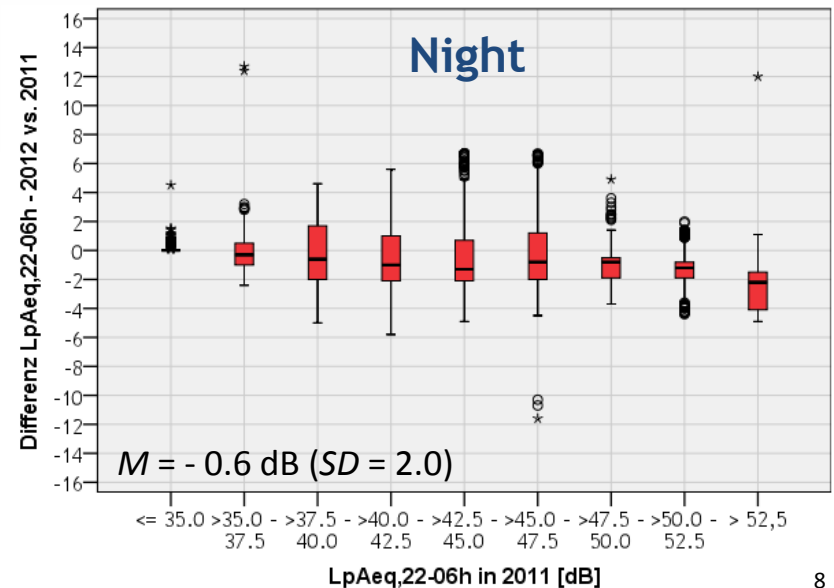
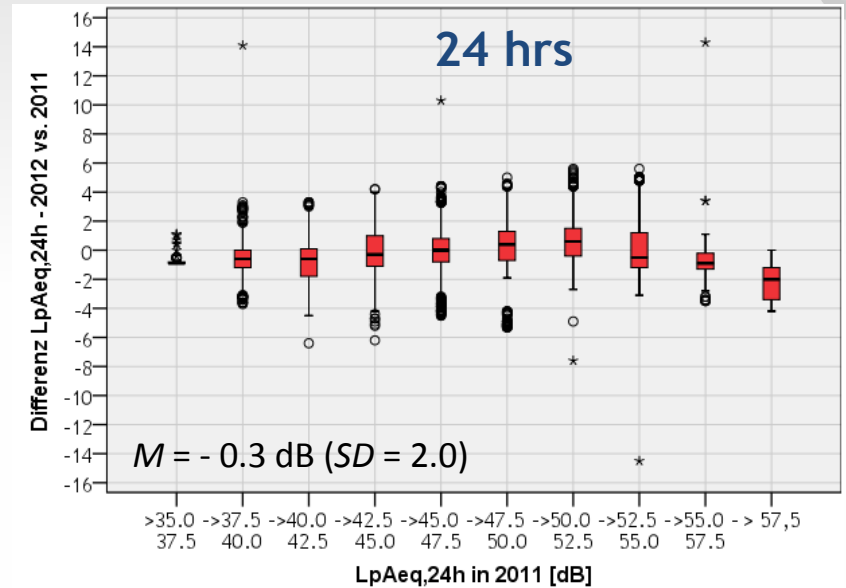
## Change in continuous sound levels 2012 – 2011

2011: Range in  $L_{pAeq,24hrs}$ : 36 – 61 dB

- $L_{pAeq,24hrs}$  has changed mostly between  $\pm 2$  dB
- Outliers are between  $\pm 6$  dB
- Extreme values between  $\pm 14.5$  dB

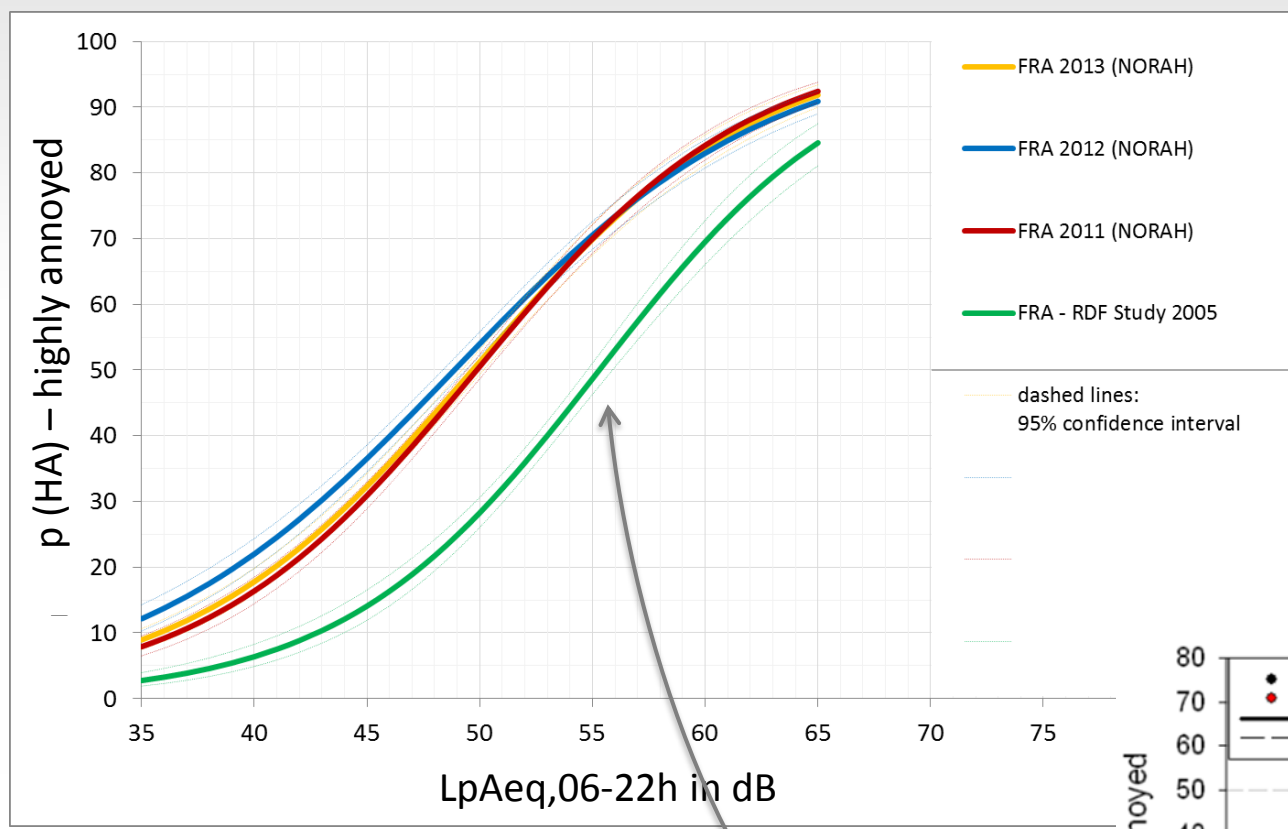
2011: Range in  $L_{night}$ :  $\leq 35 - 57$  dB

- $L_{night}$  (10pm – 6am) has changed mostly between  $\pm 2$  dB
- Outliers are between  $\pm 6$  dB
- Extreme values betw.  $\pm 12-13$  dB



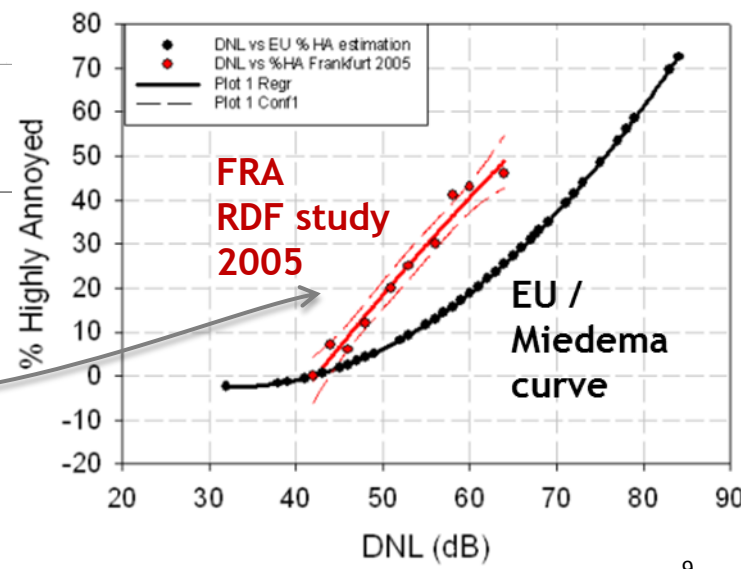


# %HA at Frankfurt Airport: NORAH 2011–13 versus RDF 2005

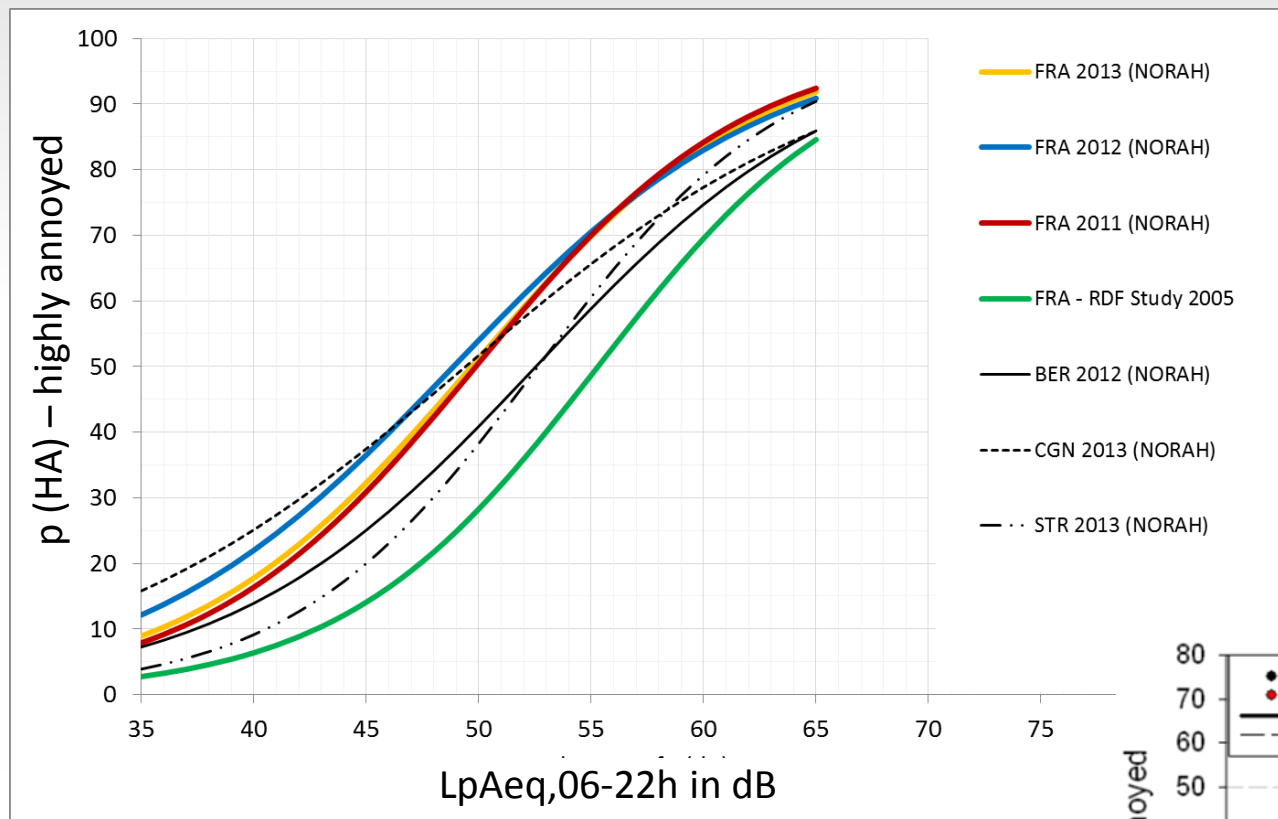


FRA = NORAH - Frankfurt: 2011 | 2012 | 2013

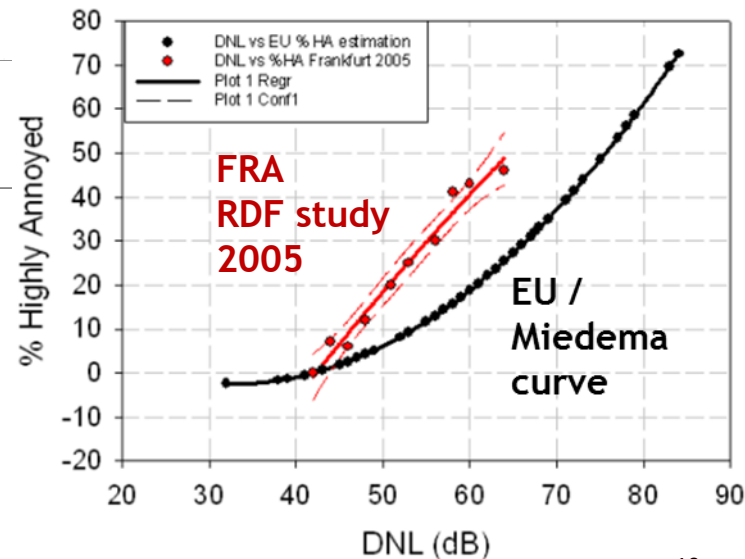
RDF = Aircraft Noise Study, Frankfurt, 2005



# all NORAH airports versus RDF 2005



- FRA** = NORAH - Frankfurt: 2011 | 2012 | 2013
- CGN** = NORAH - Cologne/Bonn
- BER** = NORAH - Berlin-Brandenburg
- STR** = NORAH - Stuttgart
- RDF** = Aircraft Noise Study, Frankfurt, 2005



# FRA: Aircraft noise annoyance 2011 – 2013

Method: Multiple Indicator Latent Growth Curve Models (LGCM)

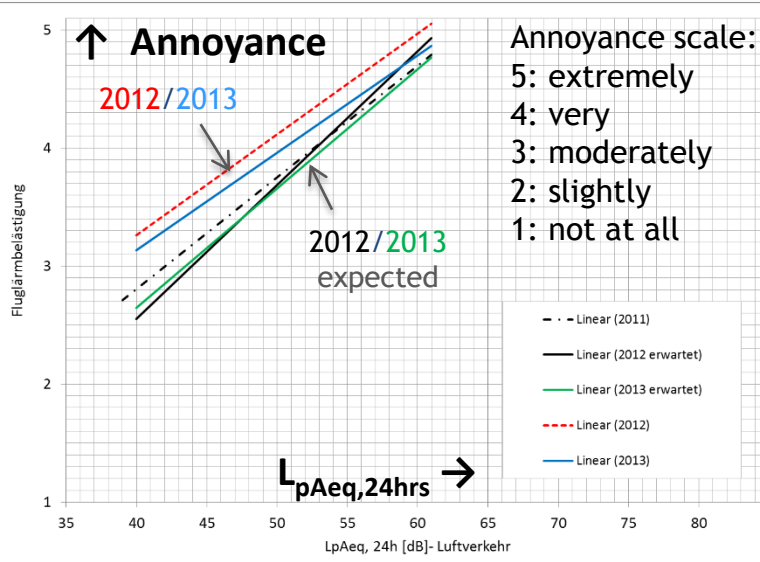
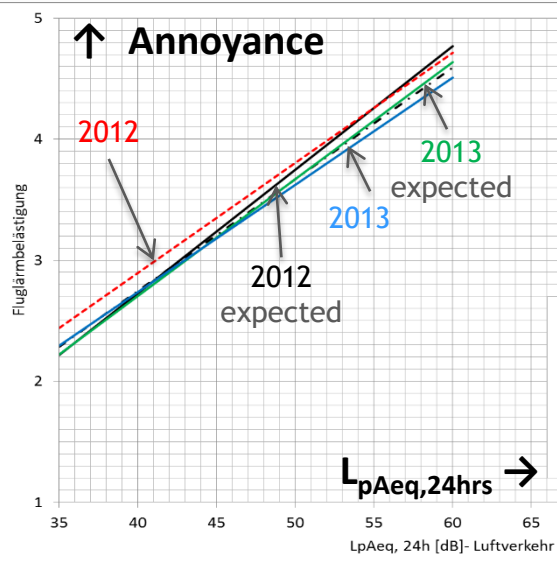
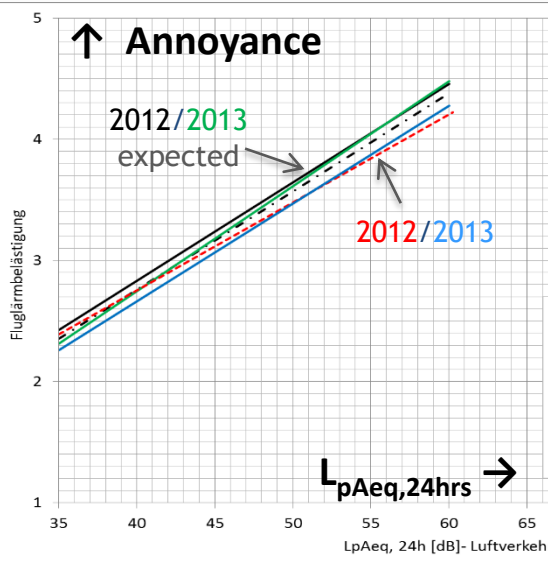


## Groups of change in exposure ( $L_{pAeq,24hrs}$ ) 2012 versus 2011

'Decrease > 2 dB' (15%)

'Stable  $\pm$  2dB' (74%)

'Increase > 2 dB' (11%)

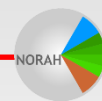


Annoyance scale:  
 5: extremely  
 4: very  
 3: moderately  
 2: slightly  
 1: not at all

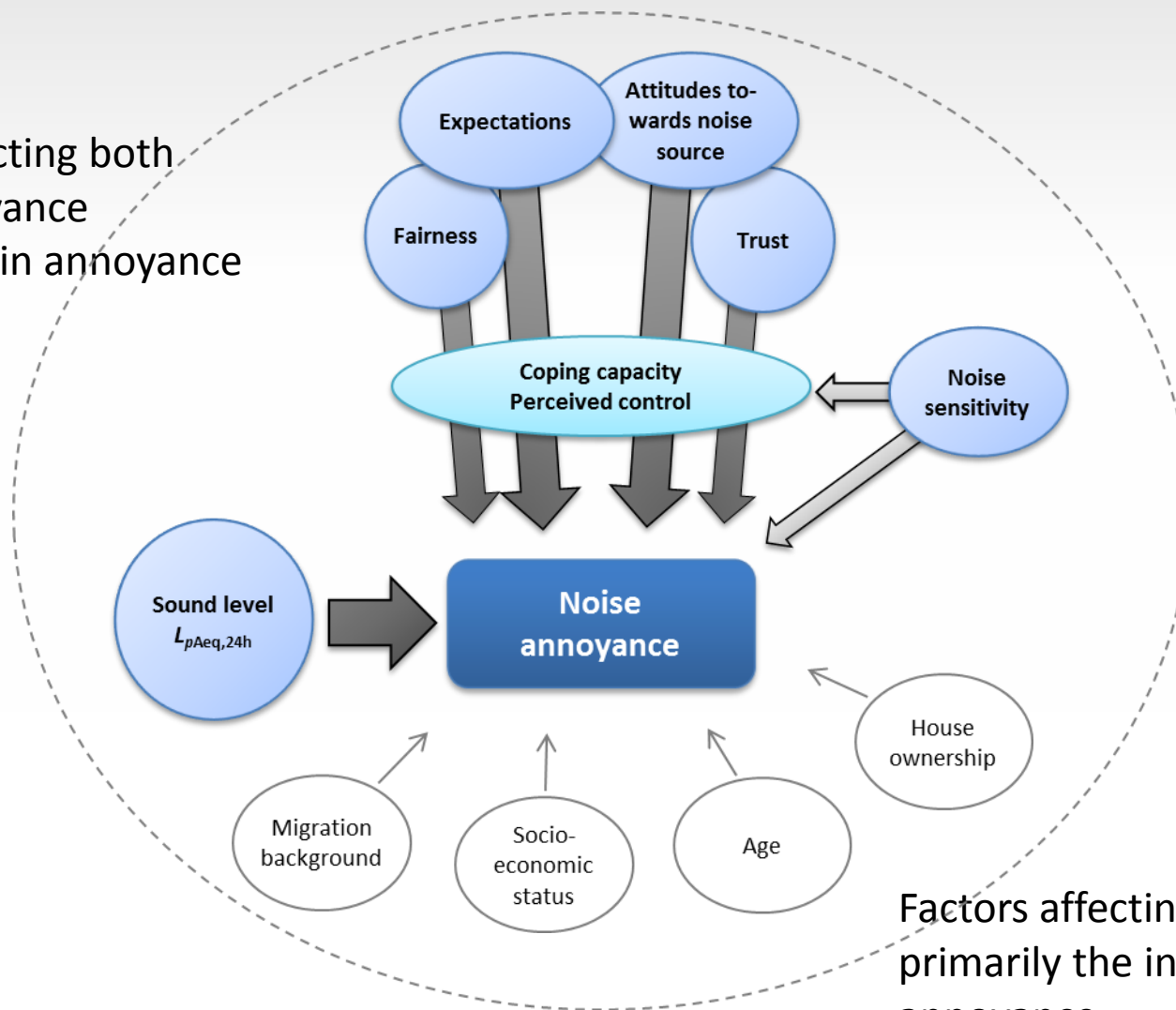
Annoyance in 2012/13  
 a little bit lower  
 than expected

Annoyance in 2012  
 slightly higher  
 than expected,  
 in 2013 mixed

Annoyance in 2012/13  
higher  
 than expected




Factors affecting both initial annoyance and change in annoyance



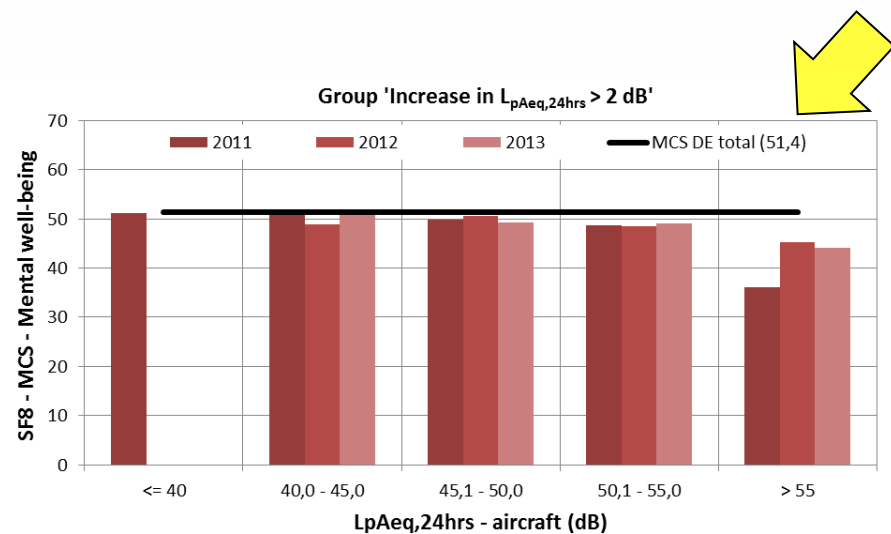
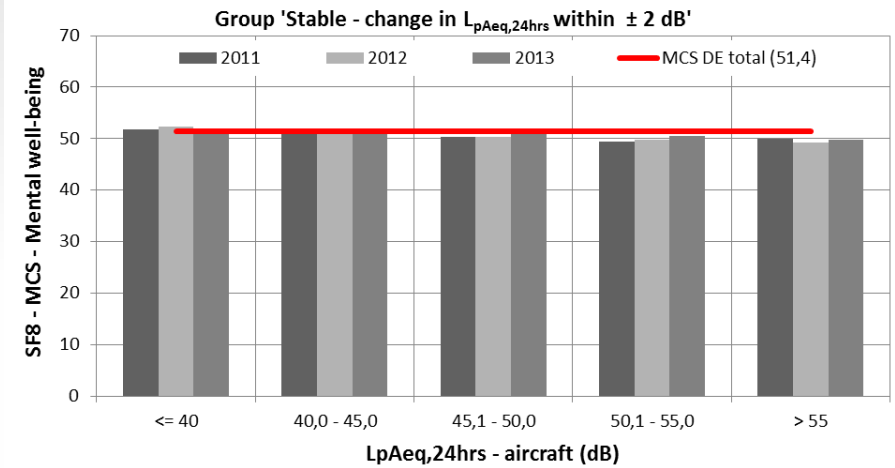
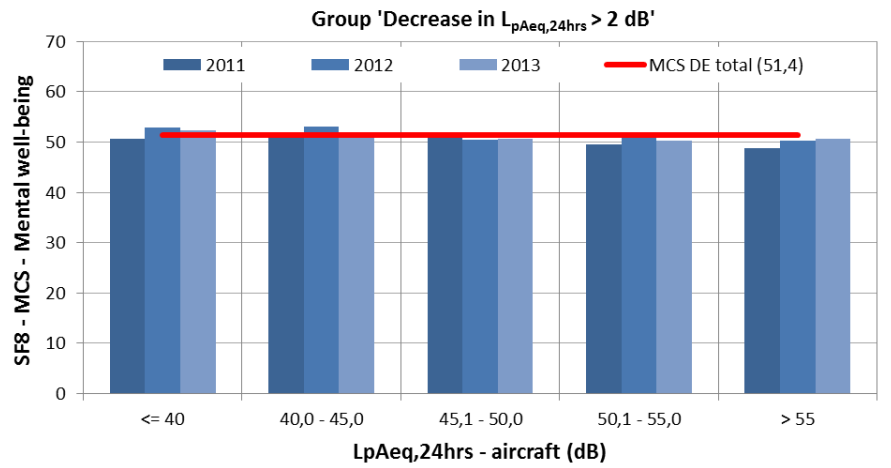
Factors affecting primarily the initial annoyance

# FRA 2011 – 2013: Mental well-being (MCS) as assessed with standardized SF8 questionnaire



- Judgments of health-related quality of life (HQoL) refer to ...
  - General health, physical functioning and role, bodily pain, vitality, social functioning, emotional role, mental health
- The judgments are summarized to two scores:
  - **MCS** mental component summary 
  - **PCS** physical component summary
- Analysis:
  - In statistical models (regressions) the scores MCS and PCS were linked to address-related sound levels for aircraft, road traffic, and railway noise.
  - Models were adjusted for mode of survey, gender, age, period of residence, hours out of home, house ownership, socio-economic status, migration background, noise sensitivity, BMI, exercise, sound levels other transportation modes.

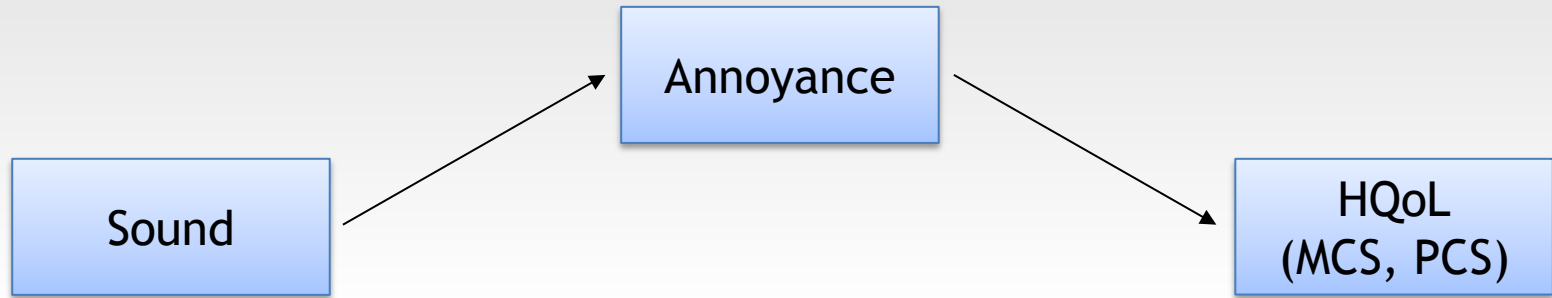
# FRA 2011 – 2013: Mental well-being (MCS) as assessed with standardized SF8 questionnaire



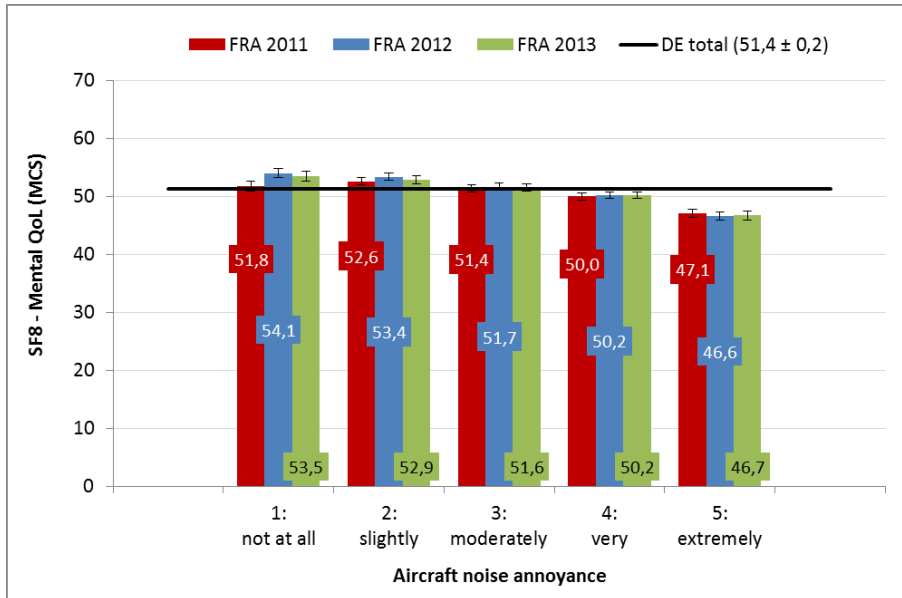
■ 2011    ■ 2012    ■ 2013  
■ 2011    ■ 2012    ■ 2013  
■ 2011    ■ 2012    ■ 2013

- Correlation between sound level and MCS rather low, *BUT*:
- ... particularly in Group 'Increase in  $L_{pAeq,24hrs}$ '
- ... mental well-being decreased with increasing sound levels

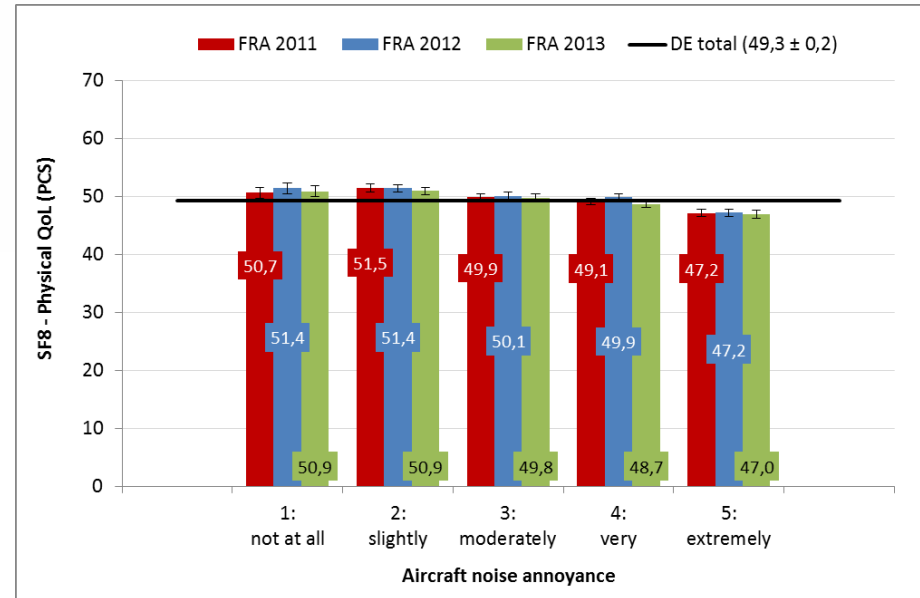
# Annoyance mediates the association between sound level and self-reported HQoL (MCS, PCS)



Mental well-being  
- MCS -



Physical well-being  
- PCS -



# Changes in mental well-being since opening of the new runway



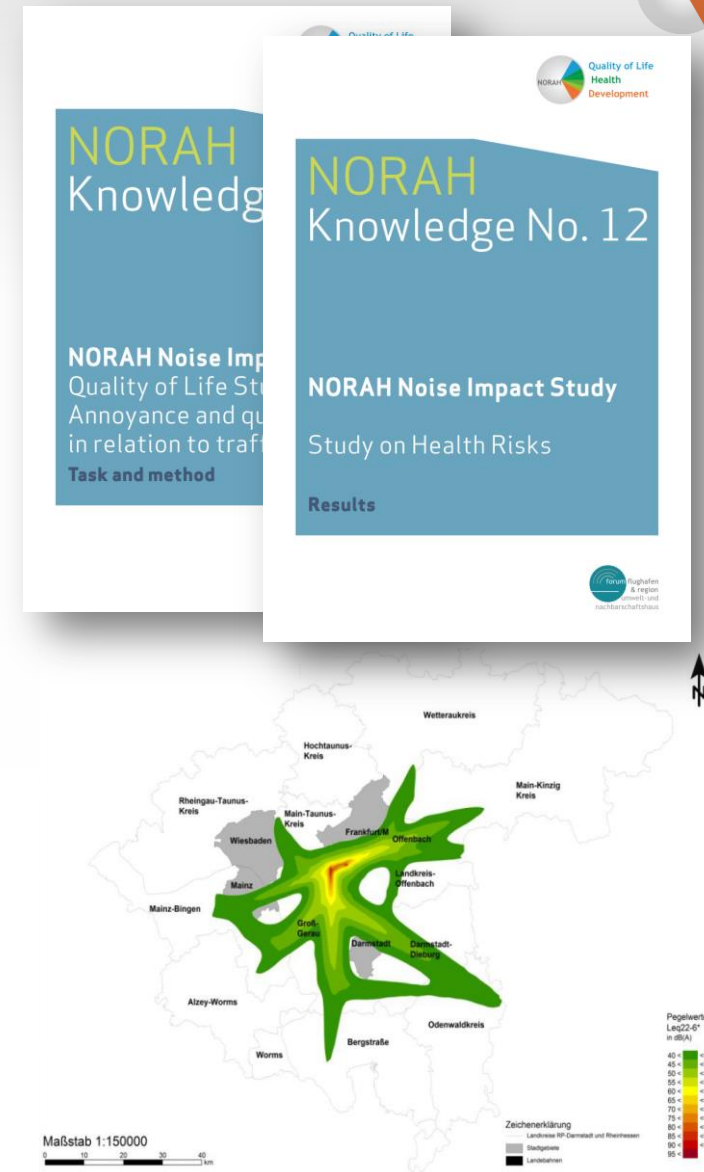
- Changes in mental well-being follows changes in noise annoyance
- The (indirect) relationship between sound levels and mental health is generally weak, but ...  
... gets stronger after the opening of the new runway in the group suffering from an increase in aircraft noise exposure after runway opening.
- It seems that noise becomes relevant for mental health particularly when the noise situation worsen.



# Case-control study on health risks at Frankfurt Airport (Seidler et al., 2015)



- Analysis of **health insurance data** ('claims' data) on ambulant and inpatient diagnoses from 2006 to 2010.
- Partly **supplemented by survey** among with insurants (individual risk faktors)
- Linked with **address-related** average and maximum **sound levels** for aircraft, road traffic, railway noise from 1996 – 2005
- In total: **1 026 658 insurants** aged  $\geq 40$  years
- **Depression**: 77 295 insurants
- **Analysis** of noise-related health risks:
  - Logistic regression with sound levels
  - adjusted for age, gender, education, occupation, social status (aggregated insurance data).

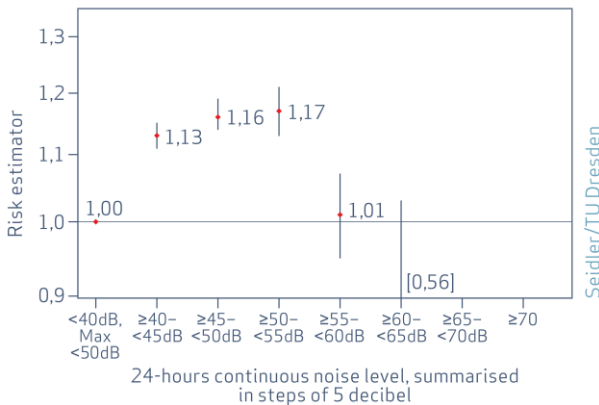


# Association between transportation noise and depression

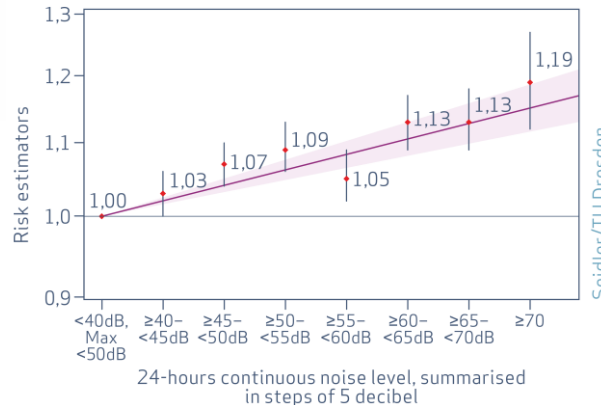


- Aircraft:** Inversed 'U'-shaped:  
 8,9% increase in risk of depression per 10 dB in  $L_{pAeq,24hrs}$ ,  
 but decrease in higher sound level classes.
- Road:** 4,1% increase per 10 dB in  $L_{pAeq,24hrs}$
- Rail:** Inversed 'U'-shaped:  
 3,9% increase in risk of depression per 10 dB in  $L_{pAeq,24hrs}$ ,  
 but decrease in higher sound level classes.

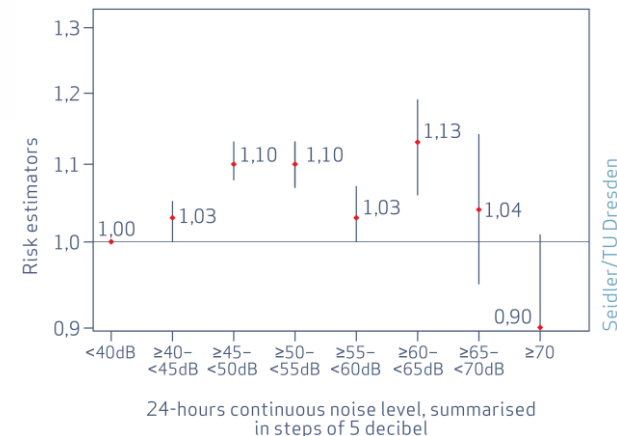
Depression and aviation noise



Depression and road noise

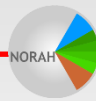


Depression and railway noise



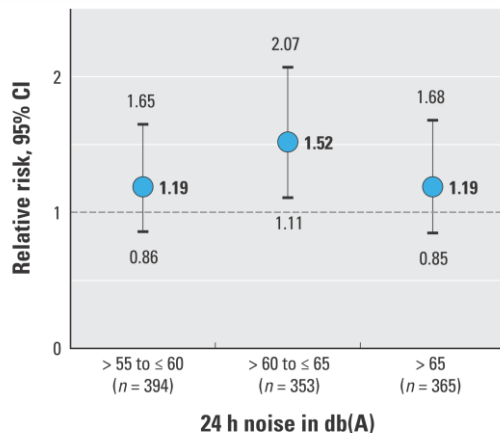
Source: Seidler et al. (2015); [http://www.laermstudie.de/fileadmin/files/Laermstudie/NORAH\\_Knowledge\\_12.pdf](http://www.laermstudie.de/fileadmin/files/Laermstudie/NORAH_Knowledge_12.pdf)

# Recent studies about transportation noise and depression



## Heinrich Nixdorf Recall Study *Orban et al., 2016*

Baseline (2000 - 2003) and 5-yrs-follow-up of ongoing HNR Health study in Ruhr Region, Germany



**Figure 2.** Relative risks and 95% confidence intervals of high depressive symptoms at follow-up in association with exposure to different categories of 24-hr noise compared with the lowest noise category [ $\leq 55$  dB(A);  $n = 1,986$ ], adjusted for baseline age, sex, education, income, economic activity, neighborhood-level socioeconomic status, and traffic proximity (Model 1). dB(A), A-weighted decibels.

Depressive symptoms (after baseline)

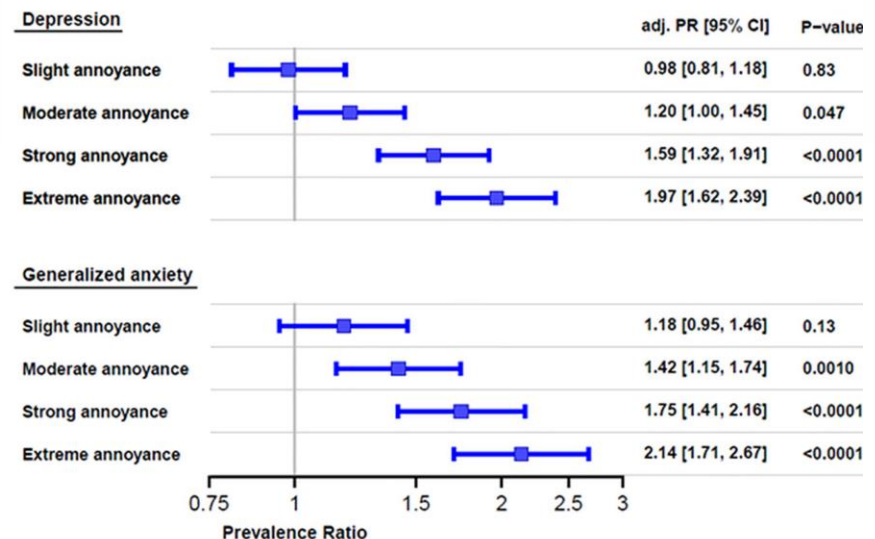
- CES-D
- antidepressant medication

vs. modelled  $L_{den}$  – road traffic

## Gutenberg Health Study GHS *(Beutel et al., 2016)*

Cross-sectional data from cohort study in Rhine-Main region (Mainz), Germany, 2007 – 2012

- Depression: PHQ-9
- Anxiety: GAD-7
- Noise annoyance: ICBEN 5-point



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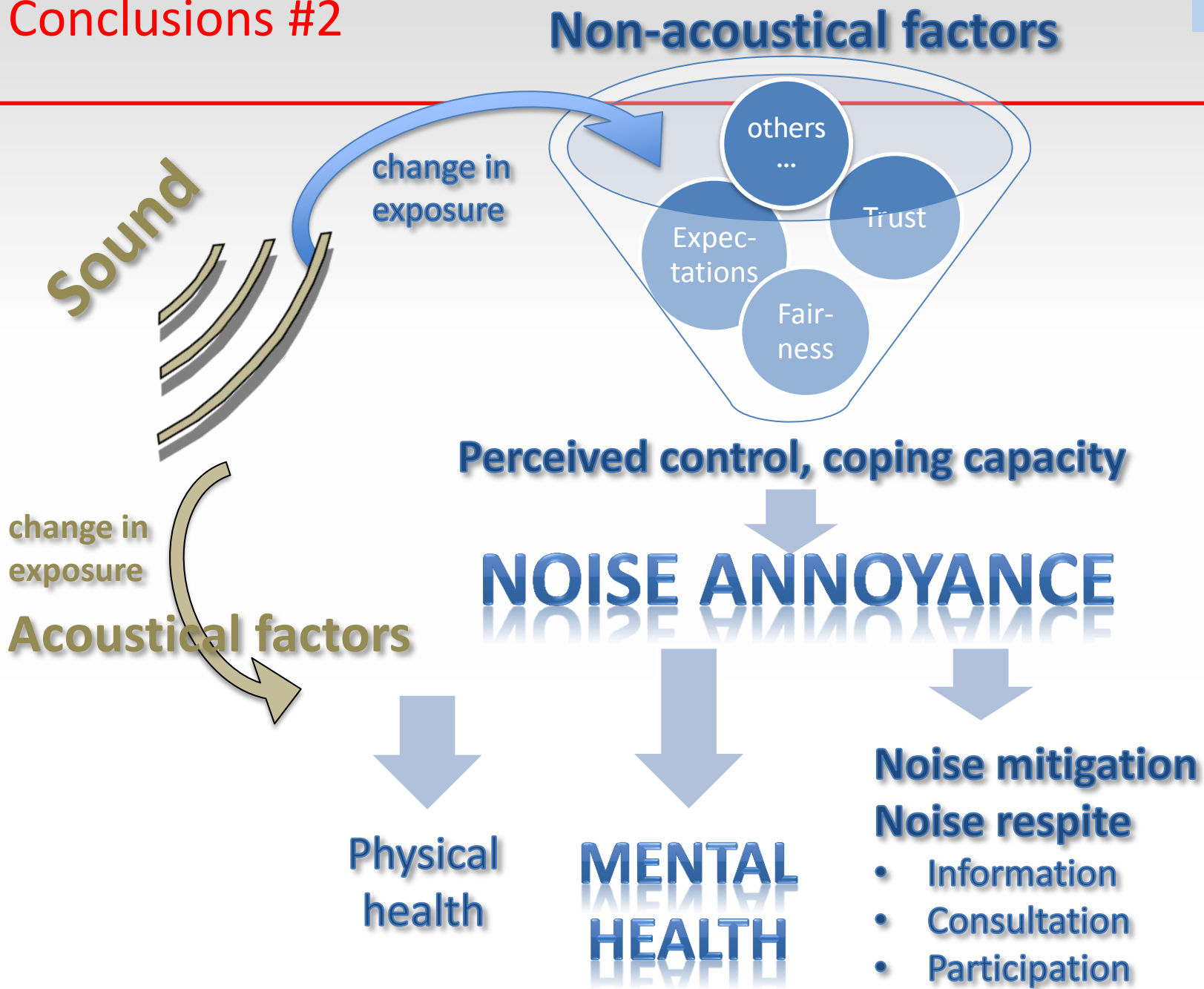
# Conclusions

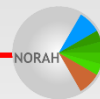
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- Exposure-response curves for **aircraft noise annoyance** against  $L_{pAeq}$  **moved higher up** since RDF-Studie 2005
  - Partly a 'change' effect due to the airport expansion
  - Partly a general trend in time?
- Aircraft **noise annoyance** is associated **mental health**: Higher annoyed people report less mental well-being (similar for road traffic and railway noise).
- Correspondingly, in NORAH and other recent studies an association between transportation noise and the **risk of developing a depression** was found.
  - Linearity of the relationship is unclear.





Thank you very much  
for your attention!

Any questions?

Dirk Schreckenberger  
+49 2331 4787 194  
schreckenberger@zeusgmbh.de