NORAH - Noise-Related Annoyance, Cognition and Health

Effects of aircraft noise on mental health

Seminar on Aircraft Noise and Mental Health, 4th July, Westminster

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Agenda

• Introduction:
  – Background
  – Work packages of the NORAH study
  – Conceptional 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
<table>
<thead>
<tr>
<th>Year Range</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>1997</td>
<td><strong>Announcement:</strong> Request of airport expansion. 4th runway, 200,000 additional flights p.a.</td>
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<tr>
<td>1998 – 2000</td>
<td><strong>Mediation group.</strong> One of the agreements: Night flight ban between 11pm - 5am after opening of the 4th runway</td>
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<tr>
<td>2001 – 2007</td>
<td><strong>Regional Planning and Zoning Procedures</strong> Construction of the new runway Northwest. 17 flights 11pm - 5am; 133 flights 10-11pm, 5-6am. <strong>Public debate:</strong> 'violation of mediation agreements'</td>
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<tr>
<td>04/2011 - 12/2015</td>
<td><strong>NORAH Study</strong> - commissioned by the Environment &amp; Community Center (UNH), a wholly-owned subsidiary of the federal state of Hessen</td>
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<td>10-11/2011</td>
<td><strong>4th runway opened &amp; night flight ban introduced</strong> (ban: voluntary till 03/2012, court decision confirms in 03/2012)</td>
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Work-Packages of the NORAH study

WP0: Acoustics

WP1: Annoyance & HQoL

WP2: Health

WP3: Children's cognition, HQoL

2.1 Case-control study on health risks
2.2 Blood pressure monitoring
2.3 Study of effects of aircraft noise on sleep
Transportation noise leads to stress, chronic noise can jeopardise health.

Conceptual Model: Stress model

Sound

Transportation Sound: Level, Number of events, Time of day

Changes of exposure?

Non-Acoustical factors: Situational, social, personal, further risk factors

Sleep disturbances

Acute

Autonomic, physical stress reactions (e.g. raised blood pressure)

Chronic

Daytime disturbances
- Performance deficit
- Annoyance
- Quality of life

Risk of chronic diseases:
- cardio-vascular diseases
- depression

Reduces Coping capacity

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Surveys in NORAH WP 1 referring primarily to aircraft noise

Stratified random sample within 40 dB L_{day/night} contours
Telephone interviews (optional: online)
- annoyance, disturbances
- health-related quality of life (physical, mental)
- non-acoustical factors
- socio-demographic

WP1: Annoyance & HQoL

Acoustical calculations $L_{pAeq}$, $L_{den}$, $L_{Amax}$, $NA_x$
- aircraft
- railway
- road traffic according to German noise calculation models

<table>
<thead>
<tr>
<th>Study</th>
<th>Airport</th>
<th>2011</th>
<th>2012</th>
<th>2013</th>
<th>Sample N</th>
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<tbody>
<tr>
<td>Panel</td>
<td>Frankfurt</td>
<td>x</td>
<td>x</td>
<td>x</td>
<td>3 508 taking part in all waves</td>
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<tr>
<td>Cross-sectional</td>
<td>Berlin-Brandenburg</td>
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<td>5 548</td>
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<td></td>
<td>Cologne/Bonn</td>
<td>4th runway night curfew</td>
<td>x</td>
<td></td>
<td>2 955</td>
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<tr>
<td></td>
<td>Stuttgart</td>
<td></td>
<td></td>
<td>x</td>
<td>1 979</td>
</tr>
</tbody>
</table>
Results
FRA Panel:
Change in continuous sound levels 2012 – 2011

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

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

2011: Range in $L_{night}$: ≤ 35 – 57 dB

- $L_{night}$ (10pm – 6am) has changed mostly between ± 2 dB
- Outliers are between ± 6 dB
- Extreme values between ± 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

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%HA – 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 RDF study 2005
EU / Miedema curve
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%)

'Increase > 2 dB' (11%)

'Increase > 2 dB' (11%)

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

Annoyance scale:
5: extremely
4: very
3: moderately
2: slightly
1: not at all
FRA: Aircraft noise annoyance 2011 – 2013
Results of LGCM: Factors influencing the change in aircraft noise annoyance

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

- 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 ≥ 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 $L_{\text{pAeq,24hrs}}$, but decrease in higher sound level classes.

- **Road:** 4.1% increase per 10 dB in $L_{\text{pAeq,24hrs}}$.

- **Rail:** Inversed 'U'-shaped: 3.9% increase in risk of depression per 10 dB in $L_{\text{pAeq,24hrs}}$, but decrease in higher sound level classes.

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

- Depressive symptoms (after baseline)
  - CES-D
  - antidepressant medication

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

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 (< 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.
Conclusions
Conclusions #1

- 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.
Conclusions #2

Non-acoustical factors

Sound

change in exposure

Acoustical factors

change in exposure

Perceived control, coping capacity

Noise annoyance

Noise mitigation

- Information
- Consultation
- Participation

Physical health

Mental health
Thank you very much for your attention!

Any questions?

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