



## NORAH Overview

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### ABSTRACT

NORAH (Noise Related Annoyance, Cognition and Health) is a multidisciplinary research project and aimed at providing a broad and scientifically reliable description of the effects of air, road and rail traffic noise on the health and life quality of residents in the vicinity of airports. Ten scientific institutes participated (2011-2015) and performed surveys, secondary health data analyses, sleep quality registrations, blood pressure registrations, and special tests on children at school. Most of the sub-studies used address-specific noise exposure calculations of different reference times for air, road, and rail traffic. The presentation informs about the aims of the commissioners, the main research questions, the scientific quality control, and the general designs of the sub-studies.

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### 1. INTRODUCTION

If the operators of a large transportation infrastructure (e.g., a commercial airport, or a railway company) intend to change the infrastructure, they must await large public concern, especially in case of enlarging the transport capacity, and more so in case of airports. This has been true for the International Frankfurt Airport in Germany, and it still is true. When the airport company intended to build a new runway (“Startbahn West”) in the early 70s of last century, there were large and enduring public protests, including protest camps, a bomb exploding, and two policemen killed, even after opening the new runway in 1984. Thirteen years later (1997), the airport company asked for an additional expansion, including a new runway for landing operations. This time, the company declared it intends to build the new runway only in accord with the majority of people living around the airport. A so-called mediation process took place between 1998 and 2000, involving people from the airport, from environment groups and local communities. At the end, the mediation group proposed a compromise, including the construction of the new runway, increasing the number of flights, and a night flight ban between 11 pm and 5 am. This was accepted by all groups involved in the mediation process. However, in 2007 the county administration of Hesse allowed for 17 flights during the night in 2007, and the public protest against the new runway rose again. The opening of the new runway was scheduled for October 2011.

In view of this conflict situation, the parliament of Hesse performed an expert hearing about noise effects in 2010, and declared at the end, it would support a large multidisciplinary research project on the effects of traffic noise, and the airport company, together with the airline Lufthansa and 8 local communities joined the group of financial supporters. Common workshops discussed the research questions, and a formal European call for proposals was published, won by a team of 11 scientific groups made up of acousticians, psychologists, medical doctors, and statisticians. This team gave their common project “Noise Related Annoyance, Cognition, and Health”, NORAH. They will present the major results in the following presentations. My task is simply to introduce the major aims and methods here.

### 2. RESEARCH AIMS AND METHODS

#### 2.1 Aims

The multidisciplinary research project NORAH was aimed at providing a broad and scientifically reliable description of the effects of air, road and rail traffic noise on the health and life quality of

affected residents. Although the main questions centered about the effects of aircraft noise, it was often intended to compare aircraft noise effects with effects from road and railway traffic noise. The following content areas were considered: annoyance and quality of life (module 1), health (module 2, including blood pressure regulation, cardiovascular diseases, breast cancer, depression and sleep disturbances) as well as cognitive development of school children (module 3). Where possible, effects of the changes due to the implementation of a new runway at Frankfurt International Airport were considered, as well as the implementation of a night curfew between 11 pm and 5 am, as well as the rerouting of flights. An additional aim was to compare exposure-response relations between 4 different civil airports: Frankfurt International Airport (the largest airport in Germany, a high-rate change airport with a night curfew), Berlin-Schönefeld (a smaller international airport, awaiting a high-rate change), Cologne/Bonn International Airport (a low-rate change airport with considerable night traffic), and Stuttgart (a smaller low-rate change international airport with a night time curfew between 11:30 pm and 6:00 am).

## 2.2 Research Questions

The primary research questions were

1. Are the noise effects in the Rhine-Main region in principle, comparable with those in other German regions, and what influence road, rail and air traffic noise has on the population?
2. Which influence had the changes in airport operations in autumn 2011 on the quality of life in the environs of the airport? Especially, does the annoyance expressed by the residential population near airports in expansion situations differ from that expressed by people near steady-state (or "low-rate change") airports?

Within the area of the three major groups of studies (modules), the major research questions were:

1. Module 1 ("Annoyance and quality of life")
  - a. Are well-known exposure-response relationships between acoustic and psychological variables, i.e. the so-called European Standard Curves for residential annoyance (Miedema & Oudshoorn, 2001), still up to date? This question relates to all three types of transportation noise (aircraft, road, and rail).
  - b. How does the high-rate change of Frankfurt Airport (a new runway, the rerouting of flights, and night curfew) influence the annoyance judgments, reported sleep disturbances, and reported quality of life of the residents in the Rhine-Main region?
  - c. Which effects have the combinations of two transportation noise sources (aircraft plus road, and aircraft plus rail) on the total annoyance of residents?
  - d. What are the statistical relations between noise annoyance and judgments about the health related quality of life?
  - e. How are personal, social and situational factors related to the effects of transportation noise?
2. Module 2 ("Health") generally asked to which extent chronic noise from air, rail and road traffic has an influence on the health of the persons concerned – particularly on the adult residents of the Rhine-Main region. The general research question was split up into three different research areas: Secondary data-based case-control study with detailed survey on health risks, "
  - a. The secondary data based case-control study investigated the effects of chronic acoustic exposure to noise from road, rail and air traffic on the health of the residential population in the Rhine-Main region. The study focussed on cardiovascular diseases (myocardial infarction, heart failure, stroke), mental illnesses (in particular unipolar depressive episodes) and cancer (especially breast cancer in women) as they are registered in the accounting and prescription data of health insurance companies.
  - b. The additional detailed survey assessed the significance of important confounders – here in particular the health behaviour (e.g. body mass index, smoking, alcohol) and social status. To do this, the risk estimates without consideration of these important confounders had to be compared with the risk estimates with consideration of these confounders registered in the survey. This comparison allows important statements on the extent and direction of possible distortions of the traffic noise-related risk estimates in the (exclusively) secondary data-based case-control study; the detailed survey thus allows more reliable statements on the level of the "true" risk estimates in the

- secondary data-based analysis. A secondary question of the detailed survey asked for the comparison between cardiovascular diseases and traffic noise-related indoor noise levels and outdoor levels.
- c. The sub-study Blood Pressure Monitoring generally asked whether there is any relation between chronic noise exposure to any of the three transportation noise sources and chronic blood pressure. It was assumed that a chronic traffic noise exposure leads to a higher rate of disease, complaints and measurable physical reactions in the area of the autonomous nervous system which are reflected in the blood pressure level. This is based on the fact that cardiovascular diseases are closely linked with blood pressure regulation.
  - d. A further question related to the influence of chronic acoustic exposure to transportation noise on the overall cardiovascular risk and the closely linked 10-year heart attack risk.
  - e. The Sleep Study was exclusively related to the disturbance of sleep due to actual night-time overflights from Frankfurt Airport. A main question was whether the formerly established exposure-effect curves compiled for air traffic related wake-up reactions from Cologne/Bonn could be transferred to airports with different night-time operations. Unlike the other sub-studies of the NORAH joint research project, "exposure" here refers primarily to the acute acoustic exposure to air traffic noise measured in the bedroom of the residents in the proximity of the airport.
  - f. The sleep study further asked, whether the exposure-effect curves for air traffic noise-related wake-up reactions at Frankfurt/Main airport changed over the course of time between 2011 and 2012. In October 2011 changes in the nocturnal operations of the airport came into effect (introduction of the night flight curfew and partial shifting of flight movements to the daytime or night-time shoulder hours), and this is why measurements of sleeping patterns were carried out before and after the operational changes.
  - g. In connection with the operational changes at Frankfurt Airport, the question arose as to whether these had a different or similar effect on the sleep of people who habitually go to bed or get up relatively early or relatively late. A third aim was, therefore, to compare the air traffic noise-related wake-up reactions at Frankfurt Airport between persons who go to bed earlier or later and get up accordingly earlier or later.
  - h. A further question of the sleep study was if and how the complicated polysomnography (PSG) could be replaced by a more simple method, and still allows the analysis of air traffic noise-related wake-up reactions in a larger number of persons with the exclusive measurement of the electrocardiograph (ECG) and the body movements.
3. Module 3 (Cognitive development and quality of life of children) concentrated on chronic aircraft noise effects on the acquisition of reading skills and the development of reading-relevant speech skills as well as the quality of life of primary school children who were exposed to acoustic burdens due to air traffic noise both at school and at home.
    - a. The most important question was whether there are exposure-response effect relationships between the extent of the contemporary chronic aircraft noise exposure at Frankfurt Airport and various cognitive development parameters or measures of the quality of life of the children.

Neither of these primary questions could be answered by the analysis of existing scientific literature,

## 2.3 Methods

According to the research questions, different methods were applied. In the case of noise annoyance and quality of life, systematic surveys were conducted: a panel study made up of three waves between 2011-2013 in the area of Frankfurt Airport, cross-section studies in the vicinity of the airports Cologne/Bonn, Berlin-Schönefeld, and Stuttgart. Cross-section studies were also carried out to compare the effects of road, rail and air traffic noises and on the combination of air and road traffic and air and rail traffic noises.

In the case of cardiovascular health risks, breast cancer, and depressive episodes, a secondary

data-based case-control study with detailed survey was performed in the administrative district of Darmstadt, the rural districts of Mainz-Bingen and Alzey-Worms, as well as in the cities of Mainz and Worms.

With respect to the long-term effects of traffic noise on blood pressure regulation, daily self-administered blood pressure measurements were registered for three weeks in two waves (2012 and 2013) with residents in the vicinity of the Frankfurt Airport ("blood pressure monitoring").

In order to study the short-term effects of night-time air traffic noise on the sleep of residents, sleep quality investigations were carried out in the years 2011-2013 in the homes of residents in the vicinity of Frankfurt Airport.

The effects of chronic exposure to aircraft noise on the cognitive performance and quality of life of school children near Frankfurt Airport were studied by means of performance tests (especially reading tests) with children, as well as surveys with children, parents, and teachers.

Address-specific equivalent continuous sound levels of different reference times for air, rail and road traffic noise were available for all study participants (except for participants in the sleep study where the participants' own measurements were used) (to some extent, maximum levels as well as the numbers of loud events) and were used in the evaluations. The aircraft noise data were calculated on the base of radar data.

### 3. SCIENTIFIC QUALITY CONTROL

In view of the (ongoing) controversial public discussion about the expansion of Frankfurt International Airport at the one hand, and of the diverse interests of the diverse stakeholders and financial contributors to NORAH, the sponsor established an independent committee of external experts to discuss and guide the research team. The external expert group consisted of 11 acousticians, psychologists and medial professors from Germany, Switzerland, and the Netherlands. In addition, four internal experts discussed the research questions, research methods, and statistical analyses with the NORAH team.

### 4. CONCLUSIONS

To our knowledge, the multi-disciplinary NORAH research project is the most comprehensive study about the effects of transportation noise until today. An abridged report is presented by Guski & Schreckenber (2015), detailed reports are given by Eikmann et al., 2015 (blood pressure study), Klatte et al., 2014 (children study), Möhler et al., 2015 (acoustics), Müller et al., 2015 (sleep study), Seidler et al. 2015 (secondary data based case-control study with additional survey), and Schreckenber et al., 2015 (annoyance and quality of life).

Moreover, it was for the first time in a noise impact study, that an estimation of the uncertainties or reliability of the calculated acoustic characteristic values was done. It was made by a detailed error analysis taking into account the uncertainties of the input and model parameters separately for the investigated noise source types. The influence of the uncertainty on the results of the exposure-effect relationship was shown in an example.

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