



Quality of Life
Health
Development

NORAH

Knowledge No. 3

NORAH Noise Impact Study

An overview

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An overview

“NORAH Knowledge” provides information on the methods and results of the NORAH noise impact study. The aim of this series is to communicate to as many people as possible what exactly NORAH researched. This is why there is an explanation in the glossary at the end for all terms marked “glossary”.

If you would like to receive further issues of “NORAH Knowledge”, please use the enclosed order form.

The NORAH Study examines the effects of aircraft, road and rail noise on people.



NORAH (“Noise-Related Annoyance, Cognition, and Health”) is the most extensive investigation into the effects of exposure to aircraft, road and rail traffic noise that has ever been carried out in Germany. It was conducted by nine independent scientific institutes from all over Germany. The client was the Umwelt- und Nachbarschaftshaus, a subsidiary of the state of Hessen and part of the “Forum Flughafen und Region”. Alongside the state of Hessen, communities, Fraport AG and Lufthansa were also involved in the financing.

The NORAH Study examines the long-term effects of traffic noise (see [glossary](#)) on health, quality of life and child development in the Rhine-Main Region. At the same time it is dedicated to some of the most topical issues currently being addressed by international noise impact research. In order to learn more about how people respond to traffic noise, the NORAH scientists examined, among other things, the medical histories of more than one million people, and reconstructed the noise exposure of the last 18 years at 900,000 addresses in the Rhine-Main Region. A total of five sub-studies form the core of the NORAH Study. Each of them builds on the current international state of research, and attempts to understand more precisely how traffic noise affects people in the long term. In this issue of NORAH Knowledge we would like to give you an overview of the questions the NORAH Study is examining and of how the scientists are proceeding with their research.

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Further information on the NORAH Study can be found on the Internet at www.laermstudie.de.

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What is the NORAH Study investigating?

The NORAH Study investigates the effects of aviation, road and rail noise on the health and quality of life of the population. This is no simple task, for at least three reasons: on the one hand, every individual is exposed to traffic noise ([glossary](#)) to a different extent. On the other hand, people are subject to many different influences at the same time and thirdly react differently to these exposures. Nonetheless, today we have scientific methods with which we can reliably investigate how people react when they have to suffer noise exposures in the long term. Many different studies in the last decades have contributed towards developing these methods. The NORAH Study builds on this knowledge. Some of the methods have been further developed by the scientists.

From a historical point of view: noise impact research

The beginnings of noise impact research date back as far as the 17th century. Then the research was aimed at examining the hearing of millers and cannoneers. Scientists have only been dealing with the effects of traffic noise on people since the start of the 20th century. Since then the volume of traffic has increased substantially and with this the importance and the scope of noise impact research. Several extensive studies since the 1990s have confirmed that a permanent high level of noise ([glossary](#)) has a negative impact on health. But many questions remain unanswered: for example how much noise has which effect, and whether some people are more at risk than others. The NORAH Study is attempting to answer these outstanding questions.



foto-rolf/istockphoto



German Road Safety Council (DVR)



Deutsche Bahn

Focus on health, quality of life and development

The NORAH Study is made up of five sub-studies and an acoustics database. The five sub-studies look at various urgent questions in noise impact research:

- ▶ The Quality of Life Study deals with the burden on people under the influence of traffic noise.
- ▶ The Study on Health Risks examines the connection between exposure to traffic noise and various severe disorders.
- ▶ In the Sleep Study the scientists are trying to find out how aircraft noise influences the sleep of the study subjects and what effect the ban on night flights in the Rhine-Main Region has on people's sleep.
- ▶ The Blood Pressure Study is concerned with the effects of long-term traffic noise exposure on blood pressure and the risk of cardiovascular disorders.
- ▶ The Child Study looks at the intellectual abilities and the quality of life of children under the influence of chronic aircraft noise.
- ▶ All sub-studies are closely interlocked with an extensive acoustics database: acoustics experts use this to calculate – in anonymised form – the current and, in some cases, the past traffic noise exposure for every individual study subject.

Sound is not the same as noise

When planes fly or cars or trains drive, this gives rise to sound ([📘 glossary](#)). The duration and intensity of the sound can be precisely calculated or measured. But not every sound is noise. Only when a person perceives the sound and feels bothered by it do scientists speak of noise. This is why noise ([📘 glossary](#)), in contrast to sound, is a subjective value. This means that not every person is bothered to the same extent by the same sound level ([📘 glossary](#)). This is why acoustic experts, medical experts, epidemiologists ([📘 glossary "Epidemiology"](#)) and psychologists are collaborating closely in noise impact research. Only by working together will they be able to find answers to the questions as to the effects of noise.

Directors of the overall study:

Prof. Dr. Rainer Guski, Working Group for Environment and Cognition Psychology, Ruhr University of Bochum

Dipl.-Psych. Dirk Schreckenber, Centre for Applied Psychology, Environmental and Social Science (Hagen)



Guski



Schreckenber

From the idea to the study: the history of NORAH

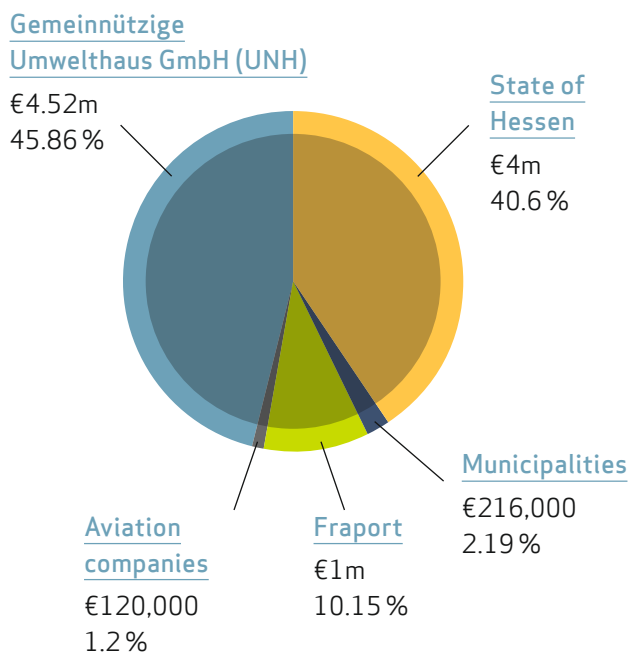
The NORAH Study was born on the 23 April 2010. On that evening, the Airport and Region Forum invited people to attend an expert discussion on the subject of “the current status of noise impact research”. The experts on the podium – including psychologists, medical experts and epidemiologists ([glossary “Epidemiology”](#)) – were quick to agree that there are still too many scientific questions unanswered. This gave rise to a plan to carry out a new study in order to close the most urgent research gaps. After that, everything happened very quickly: a steering committee was formed and, soon afterwards, an advisory board with three representatives from the communities and three from the aviation industry as well as one representative from each of the Federal Government, the Umwelt- und Nachbarschaftshaus and the Öko-Institut (see information graphic on page 12).

Who finances NORAH?

A study with the scope of NORAH yields important new insights for the communities, the government, the private sector and science. But it also costs money – in this case €9.85m. The bulk of these costs are borne by the state of Hessen, some of them directly, some of them through the Gemeinnützige Umwelthaus GmbH as its subsidiary. Around 11.4 percent of the budget comes from Fraport AG and aviation companies such as Lufthansa. In addition to this, eight individual communities in the surrounding region are financially involved in NORAH, as well as the “Initiative Zukunft Rhein-Main”, an amalgamation of several communities and associations. The communities are engaged because it is also of great interest for their citizens to receive reliable data on the effects of aircraft noise. Important to know: despite the financial participation, none of the contributors were able to commission sub-studies going beyond the jointly developed study design ([glossary](#)).

The development of the study design

Representatives of the communities and the aviation industry engaged in workshops in which they formulated their wishes regarding the questions to be asked in the study. This went into the Europe-wide tender of the study design in September 2010. Two providers received the contract. Their proposals were then discussed again by independent experts, communities and representatives of the aviation industry. At the same time, in December 2010, the Hessen Parliament decided to finance a major part of the planned study. In the same month the Umwelt- und Nachbarschaftshaus tendered for the execution of the study throughout Europe. In April 2011 the contract was awarded to the best bidder, a consortium under the direction of the Ruhr University of Bochum. The “baptism” followed one month later. The scientists and advisory board jointly decided on a name for the study, “Noise-Related Annoyance, Cognition, and Health”, in short: NORAH.



How the NORAH Study ensures its scientific quality

All the members of the NORAH research consortium are experienced and established scientists who can vouch for the quality and neutrality of the NORAH results. In addition to this, external scientists regularly check the methods and the results of the study. Since November 2010, the ten experts of the Wissenschaftlicher Beirat Qualitätssicherung (Scientific Advisory Board on Quality Assurance – WBQ) have been checking the work reports, methods and results of the NORAH consortium. Parallel to this, the scientists carrying out the study have also subjected themselves to internal quality assurance: four other experts accompany the NORAH scientists in their work and check all methods and results thoroughly before they are passed on to the client.

AT A GLANCE

Study design and quality assurance

Communities, aviation industry, the Land of Hessen, the Federal Government and the Öko-Institut were involved in the development of the NORAH Study. Two Europe-wide tendering procedures preceded the execution of the NORAH Study. Two independent scientist groups with a total of 14 experts examine the scientific quality of the study.

The investigation area

The investigation area of the NORAH Study is mainly based on the level of noise exposure: it includes the area around Frankfurt Airport in which the long-term energy equivalent sound level (see [glossary](#)) from aviation in the reference year 2007 was over 40 dB. This area extends around 100 km from east to west and around 65 km in the north–south direction. The Study on Health Risks is not restricted to specific noise levels and covers an even greater area: the investigation area here is around 150 kilometres from east to west and 120 kilometres in the north–south direction. The investigation areas around the airports Berlin Brandenburg, Cologne/Bonn and Stuttgart are also based on the noise exposure: here there is a long-term energy equivalent sound level day or night of at least 40 dB (A).

The results of NORAH, however, also apply in principle at all locations that were not investigated as long as the noise situation in terms of number, loudness and time of day of the noise events is similar to locations in the investigation area.



The NORAH acoustics database

Acoustics plays an important role in noise impact research. In order that scientists can make statements on how much noise ([glossary](#)) has which effect in the long term, they have to find out how much noise their – often thousands of – study subjects hear on a daily basis, and how the noise exposure has developed over previous years. The NORAH acoustics experts have managed to further refine the methods from past noise impact studies so that they can now calculate precisely how much noise the study subjects were exposed to from aviation, road and rail traffic in the past and during the investigations. For the sub-study on health risks the acoustics data extend back over 18 years.

Reconstructing sound from the past

It is, of course, impossible to measure a long-faded sound event ([glossary](#)) – but it can be calculated. The data for the aviation noise calculations of NORAH come from the radar records of the Deutsche Flugsicherung (DFS) at Frankfurt Airport. They provide information on the flight route, altitude and size of each plane that overflew the Rhine-Main Region over the last 18 years. From this data the NORAH acoustics experts were able to calculate sound events. Data on rail traffic was provided by Deutsche Bahn, while the communities and regional authorities provided information on road traffic. All information went into the noise calculations of the NORAH scientists. The database thus contains information on when, where and at what altitude which traffic noise ([glossary](#)) occurred in the past.

Measurement station at Frankfurt Airport

Hills and houses “swallow” sound

In order to research the impact of noise, the scientists have to find out not only how much sound ([glossary](#)) occurred where, but also how much of it reached which study subject. This also depends on how the sound – in particular road and rail traffic noise – can propagate in the environment. In order to calculate exactly how much sound arrives at which address in the Rhine-Main Region, the scientists have therefore used a three-dimensional terrain model. This takes into account both buildings and natural elevations such as hills. The data on the elevations of the terrain and the buildings necessary for the model came from the ordinance survey authorities of the federal states. Combined with the data on the traffic noise sources, the NORAH scientists can identify exactly where which sound level ([glossary](#)) prevailed in the past. This information makes it possible to evaluate the noise exposures for all study subjects in anonymised form.

AT A GLANCE

The NORAH acoustics database

- Knows the aviation, rail and road traffic volume of the past 18 years.
- Uses three-dimensional terrain models to calculate the propagation of the traffic noise.
- Can establish the individual noise exposure and noise history for every individual study subject and evaluate this in anonymised form.



The Quality of Life Study

How does traffic noise ([glossary](#)) impact on the experienced noise exposure and quality of life? How do people react to changes in the noise exposure? These are the questions asked by the Quality of Life Study. It provides a comprehensive scientific data basis for the social debate on aviation noise.

How much noise has which consequences?

Noise ([glossary](#)) is not always the same. One house could have large passenger aircraft flying overhead by the minute, while another house is nowhere near an airport but directly on a main road. A focal task of the Quality of Life Study is to find out how burdened people feel by which volumes and types of noise. For this purpose the scientists divided the investigation area into a total of 30 regions depending on the current and expected aircraft sound level ([glossary](#)). They took roughly the same number of study subjects in each region. In total, more than 9,000 people took part in the Quality of Life Study.

In 2001 the study subjects were interviewed about their quality of life, living situation and noise exposure. This was followed by two further rounds of surveys in 2012 and 2013. The scientists also carried out interviews with people living near the airports Berlin Brandenburg, Cologne/Bonn and Stuttgart. These responses provided comparative values for the data collected in the Rhine-Main Region.

Various types of traffic noise

Several noise impact studies suggest that road, rail and aviation noise can lead to different burdens on health. It is still largely unclear how people react who are exposed to several types of traffic noise at the same time. The NORAH Study will also deliver some initial answers here. The survey on combined traffic noise is the second largest section of the Quality of Life Study. A total of around 7,000 people responded to the scientists' questions for this part of the study.

AT A GLANCE

The Quality of Life Study

- ▲ Surveyed more than 9,000 people in the Rhine-Main Region on their noise exposure and quality of life.
- ▲ Is carrying out research on another 7,000 study subjects regarding the consequences of the combination of various types of traffic noise for quality of life.
- ▲ Is examining over three years the effects of changes in the noise exposure on annoyance and quality of life.
- ▲ Is analysing for comparison purposes the noise exposure and quality of life in the area of the airports Berlin Brandenburg, Cologne/Bonn and Stuttgart.





The Study on Health Risks

Several scientific studies have confirmed it: noise ([glossary](#)) can make people ill. We still know too little, however, about the exact relationship between cause and effect. This is why the NORAH Study is also looking at the connection between noise exposures and the risk of developing certain illnesses. This sub-study focuses especially on the development and causes of cardiovascular disorders.

Illnesses in the vicinity of airports

Does constant noise exposure increase the risk of suffering cardiovascular disorders, depressions or breast cancer? And if yes, by how much is the risk increased at which noise exposures? In order to find answers, the scientists are examining anonymized health data from more than one million persons insured with several statutory health insurance bodies in the Rhine-Main Region. They link these data with the individual noise exposure of the persons concerned in the last 18 years. This is a so-called case-control study: persons who have fallen ill (the “cases”) are compared in terms of their noise exposure with healthy “control persons” ([glossary](#)). The health risks can then be calculated from this comparison.

Cardiovascular disorders in the focus of the noise researchers

Several studies have come to the conclusion that noise can increase the risk of suffering a cardiovascular disorder. But other factors can also contribute to this, for example obesity or tobacco consumption. In order to better distinguish the effect of noise from other risk factors, the NORAH scientists also carried out a more detailed survey: within this framework the scientists wanted to know from a section of the insured persons which other risk factors for cardiovascular disorders were already present for people who had fallen ill. For these interviews the NORAH team selected four groups from the insured persons:

- ▶ people who, according to the health insurance data, have suffered a heart attack, or who suffer from a severe coronary disorder
- ▶ people who have had a stroke in the recent past
- ▶ people who have been suffering from insufficiency of the heart for some time
- ▶ people who do not suffer from these disorders, the so-called control persons.

AT A GLANCE

The Study on Health Risks

- ▶ Investigates traffic noise ([glossary](#)) as a risk factor for heart disease, depression and breast cancer.
- ▶ Analyses health insurance data of over one million insured persons in the Rhine-Main Region.
- ▶ Calculates the individual noise exposure for almost every person who has fallen ill.
- ▶ Asks people with heart disorders about any other risk factors that apply to them. This allows a more precise analysis of traffic noise as a risk factor.

The Sleep Study

Adequate, undisturbed sleep is very important for people to stay fit and healthy. Studies suggest that frequent sleep disturbances can lead to chronic disorders in the long term. In the Sleep Study, the scientists pursue the question as to how the aviation noise exposure in the Rhine-Main Region at night affects the quality of people's sleep.

How well do people sleep in the Rhine-Main Region?

In three investigation phases from 2011 to 2013 the NORAH scientists took a closer look at the sleep of the study subjects. There was a year between each phase. The measurement period always fell in the summer: in the warm part of the year many people sleep with the window open, thus allowing a lot of noise into the bedroom.

For three or four nights in succession the scientists recorded the sleep of the study subjects in their own bedrooms – with devices like in a sleep laboratory. During the first two measurement phases, a NORAH assistant placed all of the necessary electrodes on the study subjects about an hour before they went to bed in order to be able to precisely record the sleep phases and the moments of waking up. A sound level meter ([glossary “Sound level”](#)) near the subject's ear simultaneously registered all nocturnal noises. With this information it was possible to examine how the sleeping study subjects reacted to which noise events. 49 people took part in the first phase in 2011, and as many as 84 people in the second measurement phase in 2012.



Knost, DLR

New measurement method developed

The first two measurement phases already provided the scientists with new findings. Among other things they found that the so-called “wake-up reaction” is the most reliable factor in determining the impact of noise ([glossary](#)) on sleep. With the data from 2011 and 2012 the NORAH team optimised a method for the simplified measurement of wake-up reactions: it only took ten minutes in the evening to fit the devices and complete the questionnaires. The daily support of the NORAH assistants was no longer necessary. 182 persons took part in this third phase for three nights.

AT A GLANCE

The Sleep Study

- ▶ Recorded the sleep quality of the study subjects for three to four nights in three measurement phases between 2011 and 2013.
- ▶ Registered parallel to this the sounds that reached the ear of the individual study subjects.
- ▶ Was able to determine the so-called wake-up reaction as the most reliable measurement value.

The Blood Pressure Study

Elevated blood pressure is a considerable risk to health. Among other things it is an indicator for strokes, heart attacks and other cardiovascular disorders. Studies suggest that noise exposure can also cause high blood pressure. But there is still a lack of more precise data on this link – for example on which types of traffic noise have which effect, or how blood pressure changes can influence the risk of cardiovascular disorders. In the Blood Pressure Study the NORAH scientists are trying to answer some of these unanswered questions.

Extensive blood pressure monitoring

The NORAH team was able to assemble more than 1,300 people in the Rhine-Main Region to take part in the Blood Pressure Study. The task of the study subjects: to have their blood pressure measured every day for three weeks in two measurement phases between 2012 and 2014. There was one year between the phases. The measurement values were transmitted directly to the scientists by telemedical means from the measurement devices. In addition to this, the NORAH assistants asked every study subject about further risk factors for high blood pressure and cardiovascular disorders, including height, weight and exercise habits, as well as alcohol and tobacco consumption.



zur Nieden

The questions of the scientists

In this sub-study the scientists want to address two complexes of questions:

1. Do people who are permanently exposed to a high level of traffic noise ([see glossary](#)) have higher blood pressure and/or a higher risk of cardiovascular disorders than others?
2. Do blood pressure and/or the risk of cardiovascular disorders increase when the level of the aircraft noise changes?

As in the other sub-studies the scientists were able, thanks to the acoustics database, to precisely calculate the current and past noise exposure of the individual study subjects. By bringing the noise data for the respective measurement time together with the blood pressure values, they can answer the first complex of questions. Thanks to the one-year break between the phases, the scientists also receive answers to the second complex of questions. To do this they analyse whether changes of the noise exposure during the measurement break have any effect on the blood pressure of the study subjects.

AT A GLANCE

The Blood Pressure Study

- Was able to assemble more than 1,300 people to take part in the blood pressure monitoring project.
- Researches whether high traffic noise exposures and changes in traffic noise have an effect on blood pressure and the risk of cardiovascular disorders.
- Registered the blood pressure of the study subjects in two measurement phases of three weeks between 2012 and 2014.

The Child Study

The NORAH Child Study examines chronic effects of aviation noise on primary-school children, in particular the effects on the intellectual development and the quality of life of the children. At the centre of this is learning to read as well as certain linguistic skills which are important for learning to read. The scientists are also investigating how well the children feel at school and at home, and to what extent the aviation noise affects this well-being.

Learning to read and aircraft noise

The scientists are pursuing four main research questions in the Child Study:

1. Can a damaging influence of aircraft noise on intellectual abilities such as learning to read, linguistic skills, attention or memory in children in the Rhine-Main Region be verified?
2. How exactly does aircraft noise at school affect lessons?
3. To what extent does the aircraft noise influence the well-being of the children at school and at home?
4. How big is the influence of aircraft noise compared with other factors?

In order to find answers to these questions, the scientists surveyed a total of 1,243 schoolchildren in second grade at 29 primary schools with different levels of noise exposure around Frankfurt Airport. The young study subjects completed a series of tests. In addition to this, the children, their parents and the teachers also answered the scientists' questions on the well-being of the children. Other factors were used for the scientists' calculations, including the noise exposure of the children at home, the acoustics in the classroom, as well as a range of information on the living circumstances which could have an influence on the children's development.



Bergström

AT A GLANCE

The Child Study

- Examines the link between the aircraft noise exposure and the intellectual development and the quality of life of children.
- Evaluates tests completed by more than 1,200 second-grade schoolchildren at 29 primary schools.
- Surveys children, parents and teachers.

Who is involved in NORAH?



Glossary

Further explanations can be found in the glossary at www.laermstudie.de.

Long-term energy equivalent sound level

The long-term energy equivalent sound level (in short: L_{eq}) is a measure for the average noise exposure over a certain period in which frequency, duration and level of the individual sound events ([📖 glossary](#)) are taken into account. The L_{pAeq} is the basis for the establishment of noise protection ranges pursuant to the aviation noise act – divided according to day (6 a.m. – 10 p.m.) and night (10 p.m. – 6 a.m.). The L_{pAeq} is stated in decibels (dB).

Decibel

A decibel is a physical unit of measurement used, among other things, for the sound pressure level. The NORAH Study uses the so-called A-weighted sound pressure level. This means that when the sound event ([📖 glossary](#)) was measured, frequencies were weighted with a filter designed to replicate human hearing. The “A” in the expression L_{pAeq} is a reference to the use of the A-weighting.

Epidemiology

Epidemiology is the science that studies the patterns, causes, and effects of health and disease conditions in populations. Among other things, epidemiologists calculate with which probability and under which conditions disease can spread in a population.

Control persons

Every scientific study investigating how something affects people needs control persons. These persons are not affected or affected only to a minor degree by this “something” – e.g. noise or certain diseases. This allows scientists to compare differently affected groups and measure the effects of their investigation subject on people.

Noise

Noise is undesired sound.

Sound

Sound is generated by vibrations of a sound source.

Sound event

This term is used by physicists to describe an individual event in which sound is generated.

Sound level

This shortened expression usually refers to the sound pressure level – the physical quantity that describes the strength of the sound waves.

Study design

In order that a scientific study actually investigates what it is supposed to investigate, careful planning is necessary. Scientists refer to this as study design. It includes, among other things, the method of data acquisition as well as the type and scope of the data.

Traffic noise

Traffic noise is the unwanted sound from cars, aircraft or trains.

Legal Notice

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