



Quality of Life  
Health  
Development

# NORAH

## Knowledge No. 8

### **NORAH noise impact study**

Blood Pressure Study:  
Effects of aviation noise  
on blood pressure

### **Tasks and method**

# NORAH

## Knowledge No. 8

### NORAH Noise Impact Study

#### Blood Pressure Study: Effects of aviation noise on blood pressure

#### Tasks and method

“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 is researching. 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 investigates the effects of aviation, road and rail noise on people.



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

The NORAH Study examines the long-term effects of traffic noise on health, quality of life and early childhood development in the Rhine-Main Region. The initiator of the study is the Airport and Region Forum (ARF). The scientists were accompanied from the start by an external Scientific Advisory Board for Quality Assurance (WBQ). This is what distinguishes NORAH from similar, predecessor studies. The study addresses some of the most topical issues currently being dealt with by international noise impact research. It also covers a wider range of investigation aspects than previous studies. In order to find out more about how human beings respond to traffic noise, the NORAH scientists also looked at the medical histories of around one million people, and reconstructed the noise exposure at around 900,000 addresses in the Rhine-Main Region.

A total of five sub-studies form the core of the NORAH Study. Each one builds on the current international state of research. In this edition of “NORAH Knowledge” we present the tasks and the methods of the Blood Pressure Study, one of the five sub-studies.

## Contents

Traffic noise and blood pressure

→ page 2

Good to know: blood pressure and high blood pressure

→ page 4

How traffic noise could change blood pressure

→ page 5

Blood pressure measurements and questionnaire

→ page 6

Who took part in the Blood Pressure Study?

→ page 8

Blood pressure monitoring in pictures

→ page 10

The acoustics of the Blood Pressure Study

→ page 11

Well protected data

→ page 12

Further information on the NORAH Study is available on the Internet at [www.laermstudie.de](http://www.laermstudie.de). There you can also subscribe to the newsletter “NORAH Brief”.

### Contact

**Please address any questions about the NORAH Study to the Umwelt- und Nachbarschaftshaus:**  
Gemeinnützige Umwelthaus GmbH  
Rüsselsheimer Str. 100  
65451 Kelsterbach

<b>Tel</b>	06107 98868-0
<b>Fax</b>	06107 98868-19
<b>E-mail</b>	<a href="mailto:norah@umwelthaus.org">norah@umwelthaus.org</a>
<b>Internet</b>	<a href="http://www.laermstudie.de">www.laermstudie.de</a>

## TRAFFIC NOISE AND BLOOD PRESSURE

What do surprises, startling moments and sudden noises have in common? They all cause the heart to beat faster and increase the blood pressure ([📘 Glossary](#)). If this happens occasionally, and just for a few seconds at a time, it is harmless. It is quite different, however, if the blood is constantly pulsing through the body at high pressure. According to the World Health Organization (WHO), high blood pressure ([📘 Glossary](#)) is one of the main factors increasing the burden of disease in Germany. Cardiovascular disorders caused by congested blood vessels – a result of high blood pressure – are by far the most frequent cause of death in Germany. Previous studies suggest that traffic noise can also increase the blood pressure in the long term. The Blood Pressure Study within the framework of NORAH builds on these investigations. Among other things, the NORAH scientists want to find out to what extent aviation, road and rail traffic noise can increase blood pressure in the long term, and whether any effect can be verified on the so-called “PROCAM quick check” for identification of the 10-year heart attack risk ([📘 Glossary](#)) for the persons concerned. To do this, the NORAH team carried out blood pressure measurements on more than 800 people in the Rhine-Main Region in two three-week campaigns and, at the same time, calculated the individual noise exposure of all the study participants.

In this edition of “NORAH Knowledge” we explain how the Blood Pressure Study is structured, the questions the scientists are asking, and which methods they are employing to do this. The research questions of the NORAH scientists at a glance:

- ▶ Is there a measureable connection between traffic noise and the average blood pressure?
- ▶ If yes, which level of noise has which consequences for the blood pressure?
- ▶ Are there differences between the effects of aviation, road and rail noise?
- ▶ Does the effect change when several traffic noise types occur together?
- ▶ Does traffic noise influence the risk of heart attack ([📘 Glossary “10-year heart attack risk”](#))?

**According to the World Health Organization (WHO), high blood pressure is one of the main factors increasing the burden of disease in Germany.**

## The scientific team

Overall management of the Blood Pressure Study was the responsibility of Prof. Dr. Thomas Eikmann, while the public health specialist Dipl.-Ing. Anja zur Nieden, MPH, from the Institute for Hygiene and Environmental Medicine at the Faculty of Medicine of the Justus-Liebig University in Gießen, was responsible for the execution. In addition to this, a team of 79 project workers were active for two years in the Rhine-Main Region carrying out surveys on the study participants and taking care of them during the blood pressure measurements, the so-called blood pressure monitoring.



Doebbeling

Prof. Dr. Thomas Eikmann is responsible for the overall management of the Blood Pressure Study.



Doebbeling

Dipl.-Ing. Anja zur Nieden, MPH, is responsible for the execution of the Blood Pressure Study.

### Predecessor studies and unanswered questions

Several studies have already addressed the connection between traffic noise and blood pressure. Only a few of them – like NORAH – carried out blood pressure measurements. Several questions have remained unanswered in research up to now. The NORAH Study seeks to close these gaps in our knowledge.

- ▲ In investigations carried out from 2003 to 2005 in the proximity of six European airports, the HYENA study ("Hypertension and Exposure to Noise near Airports") found out that severe noise can increase the risk of high blood pressure. At around 5,000, the number of participants was very high. However – unlike NORAH – only one blood pressure measurement was taken per person, or the study participants simply stated that they had been diagnosed with high blood pressure by a doctor.
- ▲ In 2007 the doctors Martin Kaltenbach and Yasar Aydin published the results of a study on high blood pressure and traffic noise in the area around Frankfurt Airport. According to this, people who were frequently exposed to aviation noise had higher blood pressure than those with less frequent exposure to aviation noise. The 53 participants measured their own blood pressure over three months. In view of this relatively small number of participants and the simple noise categorization, the reliability of these results is doubtful.

## GOOD TO KNOW: BLOOD PRESSURE AND HIGH BLOOD PRESSURE

Doctors describe blood pressure ([Glossary](#)) as the pressure that arises due to the heartbeat and the associated transport of blood in the blood vessels. Blood pressure measurements always state two values, for example 120 over 60 (mmHg, "millimetres of mercury"). This is because the pressure in the blood vessels changes when the heart muscle contracts ("systolic") and when it is at rest between heartbeats ("diastolic"). Accordingly, the first – higher – value states the so-called systolic blood pressure, the second gives the diastolic pressure. A blood pressure of 120 over 80 is regarded as ideal.

As of 140 over 90 we talk about high blood pressure ([Glossary](#)) or "hypertension". If the blood pressure is high, this places a heavy load on the overall vascular system of the body, because the vessels are under high pressure. This can cause small cracks in the inner walls of the blood vessels and they become thick and hard. In the worst-case scenario, the blood vessel becomes completely congested. Common, severe disorders that can be triggered by hypertension include arteriosclerosis, strokes, heart attacks, coronary artery disease (CAD) and congestive heart failure.

### Seven facts about high blood pressure

- ▶ Almost every third adult in Germany is affected by high blood pressure.
- ▶ The older the person, the higher the risk: on average, every fifth person over the age of 40 is affected, and almost half of all Germans over 65.
- ▶ 88 percent of those who know about their illness are in therapy. 70 percent of these have their blood pressure under control. In the population as a whole, only 50 percent have the ideal blood pressure level.
- ▶ 140,000 people die every year from high blood pressure and its consequent disorders: that makes up 18 percent of all deaths in the country.
- ▶ Alongside obesity, high blood pressure is the second biggest risk factor in Germany for loss of healthy years of life. Only poor nutrition increases the risk even further.
- ▶ Women generally have lower blood pressure than men. Studies also show that they are more likely than men to be conscious of possible high blood pressure and of the need for therapy.
- ▶ Organic factors (for example kidney function problems, hyperactivity of the sympathetic nervous system, elevated insulin levels) as well as lifestyle and environmental factors (such as obesity, smoking, too much salt, heavy alcohol consumption, lack of exercise) can both increase the risk of high blood pressure. In many cases, the cause of high blood pressure remains unknown.

#### Sources:

Robert-Koch-Institut, Epidemiologisches Bulletin 5/2015

Plass, D. & T. Vos, C. Hornberg, C. Scheidt-Nave, H. Zeeb, A. Krämer: Entwicklung der Krankheitslast in Deutschland: Ergebnisse, Potenziale und Grenzen der Global Burden of Disease-Studie, in: Deutsches Ärzteblatt 38/2014



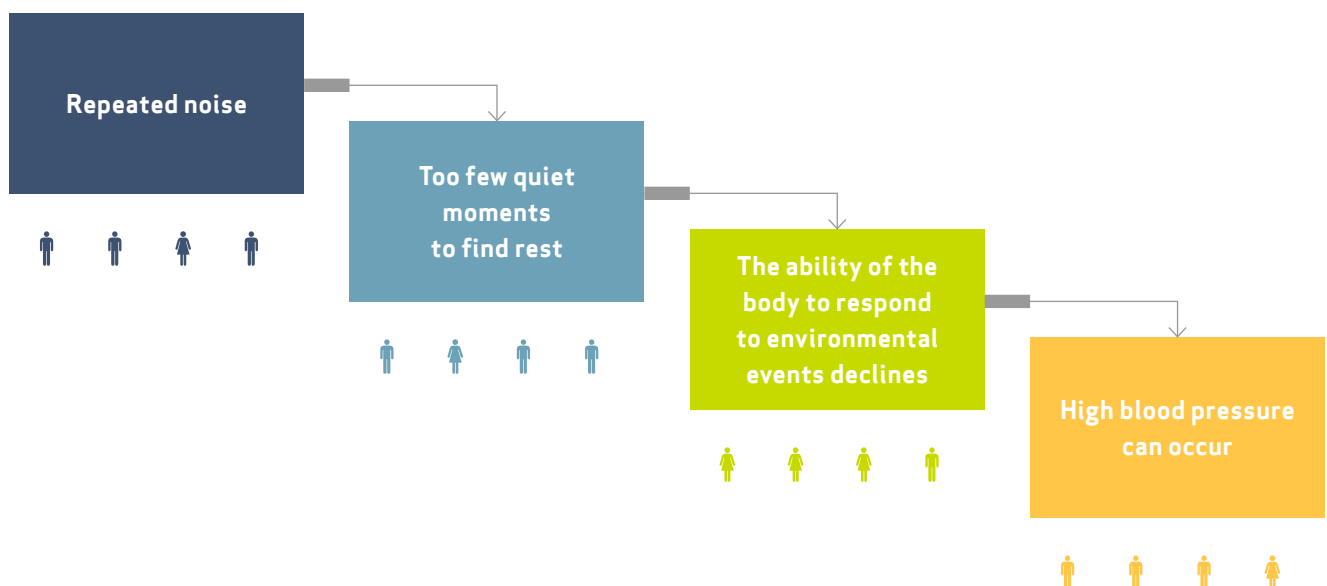
The heartbeat ensures that the blood continues to flow through the body. If it is pulsing constantly at high pressure through the blood vessels, this can result in severe cardiovascular diseases.

## HOW TRAFFIC NOISE COULD CHANGE BLOOD PRESSURE

Many of the causes for increased blood pressure ([Glossary](#)) are known, for example obesity or smoking. Negatively perceived stress – for example at work or in the family – can also increase the blood pressure in the long term, as has been confirmed in studies. This means that in people who are regularly under stress without sufficient opportunities to calm down, the blood pressure can remain high even when they are at rest, instead of falling back to a more healthy level.

It is certain that severe noise causes at least momentary stress in the body. We all know this, for example, from New Year's Eve: when we hear an unusually loud noise, the heart beats faster, the blood pressure rises, stress hormones are secreted. This allows the body to increase its ability to react to situations at short notice. For our ancestors many thousands of years ago, this biological mechanism could decide between life and death: under stress we are better able to respond to a threat by fight or flight. If we are constantly stressed, however, this can have negative consequences for our health – including, of course, a chronically elevated blood pressure. This is why the NORAH scientists are trying to find out whether frequent traffic noise also has an effect on the average blood pressure.

**From constant noise to high blood pressure – this is how doctors explain the occurrence of the disease.**





## BLOOD PRESSURE MEASUREMENTS AND QUESTIONNAIRE

In order to find out whether traffic noise has an influence on the blood pressure ([Glossary](#)), it is not sufficient merely to look at the blood pressure and the noise exposure. This is because there are numerous other factors that can influence the blood pressure – for example sport, obesity or certain previous illnesses. This is why special scientific care has to be taken that high blood pressure values are not incorrectly attributed to aviation noise when in reality they have entirely different causes. In order to reduce this risk as far as possible, the NORAH team collected further information about the study participants with the aid of a questionnaire. *You will find further information on the noise calculations for the Blood Pressure Study on page 11.*

### Three weeks of blood pressure monitoring

---

The core of the Blood Pressure Study is the large-scale blood pressure monitoring carried out by the NORAH scientists in the Rhine-Main Region: in two three-week campaigns, more than 800 study participants measured their own blood pressure every morning and evening. The researchers were especially interested in the morning blood pressure measurement, as this is not yet affected by the physical and mental demands of the day. The values measured in the evening were used mainly for the calculation of daily average values. This meant that the NORAH team could identify persons suffering from chronically high blood pressure without being aware of it.

To take the measurements, the NORAH scientists used so-called telemedical blood pressure measurement devices for the upper arm. These transfer the measured blood pressure values wirelessly via Bluetooth®, mobile phone and a protected Internet connection to a NORAH database ([Glossary “Telemedicine”](#)).

Parallel to this, the study participants noted down all of the measurement values at home in a list. This meant that the researchers had a double back-up for the measurement results. One year after the first measurement period, almost all of the study participants took part in a second three-week monitoring. On the basis of the second measurement phase, the scientist can determine whether the average blood pressure of a study participant has changed after a year and whether this is connected with the noise exposure.

### Questionnaire

---

Every individual has a different risk of suffering from high blood pressure ([Glossary](#)) or a so-called ischemic heart disease, caused by a constricted or congested blood vessel. In order to calculate the effect of the traffic noise on the participants, the scientists have to statistically “subtract” all of the other known risk factors. Only when they know exactly which other interference factors affect an individual, can they filter out the pure effect of the traffic noise on the blood pressure. It is also necessary to register these other factors in order to calculate the heart attack risk ([Glossary “10-year heart attack risk”](#)) of the participants.

Alongside the blood pressure values, the survey also provided further health information for the study which is important for assessing the risk of high blood pressure: this includes underlying disorders, height and weight of the persons as well as their exercise and dietary habits.



Study participants provided the following information in the questionnaire:

- ▶ Age, body measurements and gender. The project workers also measured the waist and hip size of the participants on site.
- ▶ Exercise and sporting activity.
- ▶ Noise sensitivity: this differs from person to person and can influence how much stress is triggered by noise.
- ▶ Medical history and medication: various diseases, for example diabetes, and certain medications can alter the blood pressure. The scientists also registered who had already had a medical diagnosis of high blood pressure or had suffered a cardiovascular disorder.
- ▶ Alcohol and smoking: how much do the study participants drink, which tobacco products do they consume, and how frequently? The questionnaire also registered former smokers.
- ▶ Family history: do close relatives suffer from high blood pressure or certain other diseases?
- ▶ Socioeconomic status and educational level: studies show that high blood pressure does not occur with the same frequency in all social groups. This is why the scientists registered, among other things, the professions and educational qualifications of the participants.

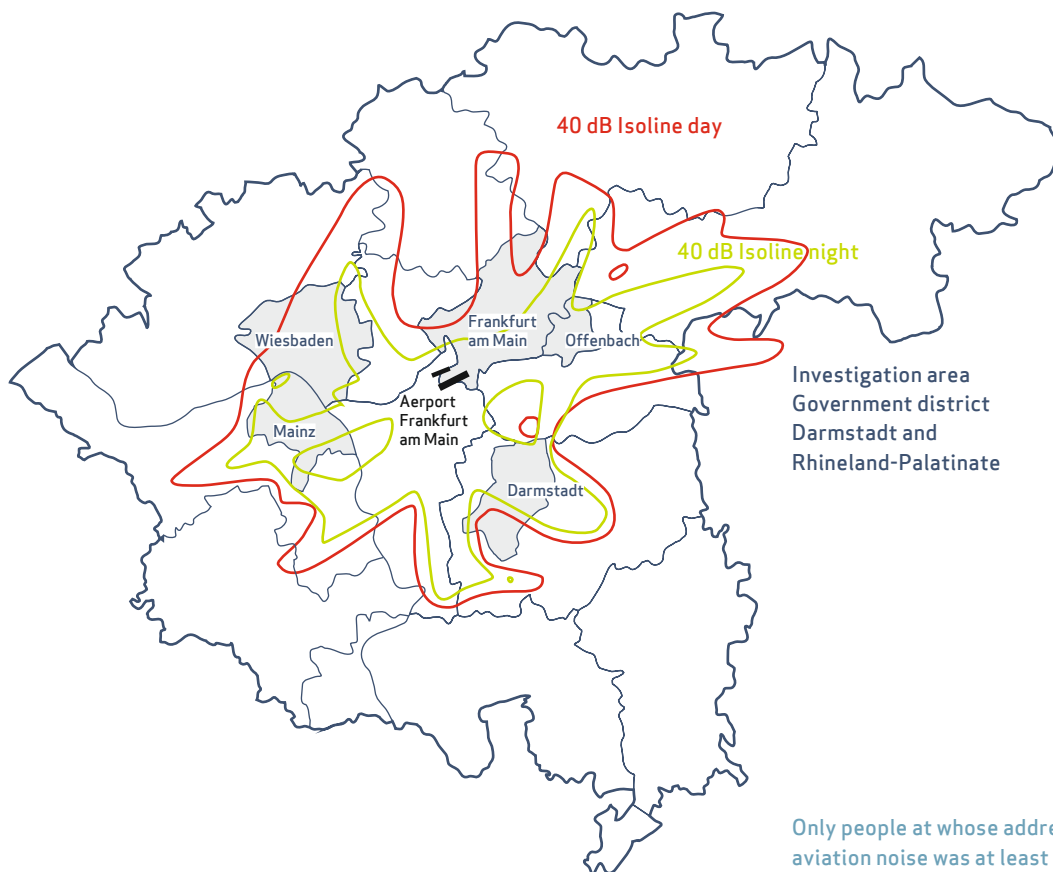
Blood pressure measurement			
11. Measurements of the investigator			
11.1 Result of blood pressure measurement left arm, INVESTIGATOR			
11.1.1	Time of measurement left arm UN	(HH:MM) le	
11.1.2	Blood pressure systolic Links UN	systolic le	
11.1.3	Blood pressure diastolic Links UN	diastolic le	
11.1.4	Pulse left UN	Puls le	
11.2 Result blood pressure measurement right arm, INVESTIGATOR			
11.2.1	Time of measurement right arm UN	(HH:MM) ri	
11.2.2	Blood pressure systolic Right UN	systolic ri	
11.2.3	Blood pressure diastolic Right UN	diastolic ri	

## WHO TOOK PART IN THE BLOOD PRESSURE STUDY?

More than 800 people in the Rhine-Main Region measured their blood pressure ([Glossary](#)) for the NORAH study. In order that the NORAH scientists could draw conclusions about the connection between traffic noise and blood pressure, it was also very important to know where the participants lived. Only by comparing people in regions with different levels of exposure to noise is it possible to determine whether the noise occurrence has an influence on the blood pressure.

## The investigation area

All of the participants lived in the vicinity of Frankfurt Airport. The investigation area, however, was not defined by the distance from the airport, but by the average level of aviation noise that could be heard: only people at whose addresses the average daily aviation noise was at least 40 decibels could take part in the study. At the loudest places at which people took part in the blood pressure monitoring there was a daily continuous noise level ([Glossary](#)) due to aviation noise of 57.2 decibels – this is the highest value registered for the investigations.



Only people at whose addresses the average daily aviation noise was at least 40 decibels could take part in the study (red line). Independent municipalities are highlighted in colour.

## The selection of participants

---

In order to investigate the effects of noise on the blood pressure, it was necessary to find sufficient participants from residential areas exposed to different levels of noise. This is why the scientists working on the NORAH Quality of Life Study had already divided the investigation area around Frankfurt Airport into “sound level classes” – regions with different levels of noise exposure. The approach to the participants for the Blood Pressure Study then took place in close collaboration with the scientists of the Quality of Life Study on the basis of data from the register of residents. Persons who had taken part in the Quality of Life Study could give their consent there to being contacted by the scientists of the Blood Pressure Study. Data from 844 study participants went into the final evaluations. Minors were not allowed participate. People working shifts at different times of the night and day, and who thus have no fixed sleeping and waking rhythm, were also excluded. If this rhythm is absent, it is not possible to attribute morning and evening blood pressure measurement values to noise. In contrast to other studies, the NORAH Blood Pressure Study did not exclude people taking medication against high blood pressure. The data of such persons, however, was evaluated somewhat differently.

## Time sequence

---

In the course of two three-week campaigns, the participants took their own blood pressure every morning and evening. As the project workers could only look after a limited number of people at one time, each measurement period extended over a total of nine months: the first study participants began with the measurements in July 2012. The last participants completed their measurements in May 2013. The second measurement phase followed twelve months later in each case, i.e. beginning in July 2013 and ending in May 2014.

For two three-week periods, the participants took their blood pressure every morning and evening.

## BLOOD PRESSURE MONITORING IN PICTURES

On two occasions during the three-week measurement period, the study participants were visited by a project worker – at the beginning and at the end. In the time between, the measurement devices remained in the participants' homes.

On his first visit, the project worker shows the study participant how to fit the sleeve of the measurement device correctly.



Doebbeling



Doebbeling

Alongside the blood pressure measurement device, all of the study participants receive for the duration of the measurements a mobile phone equipped with special transmission software. It uses a Bluetooth connection to automatically receive the values of all the blood pressure measurements, and sends them in encoded form to the database of the NORAH team.

Double back-up: The measurement values are sent telemedically (📖 [Glossary “Telemedicine”](#)) by mobile phone via an encoded Internet connection to the NORAH team. In addition to this, the study participants enter their blood pressure measurement manually in a table every morning and evening.



Doebbeling

## THE ACOUSTICS OF THE BLOOD PRESSURE STUDY

It took nine months – from July 2012 to May 2013 – until all of the participants in the Blood Pressure Study had completed their three-week, first measurement phase. Exactly twelve months after the first series of measurements, the second one began for each participant: whoever had measured his blood pressure ([📖 Glossary](#)) for the first time in July 2012, started with measurement phase two in July 2013. As the measurements extended over several months, the scientists were not able to include the noise exposure of a fixed time period in their calculations. Instead they calculated for each participant the individual noise exposure – specifically for the respective measurement time and the address. The NORAH acoustics team thus succeeded in calculating the noise exposures more precisely than in any previous noise impact study.

*(Read more about this in “NORAH Knowledge” 2: sound and noise – The basic acoustic principles).*

### One year of individual noise exposure

---

The aviation noise which could be heard in the twelve months before the respective blood pressure measurement at the addresses of the study participants was used by the NORAH scientists in their calculations. For persons who, for example, had measured their blood pressure for three weeks in September 2012, the acoustics team calculated the aviation noise exposure from September 2011 to August 2012. The basis for the calculations was provided by flight and radar data for flight movements in the Rhine-Main Region (see also “NORAH Knowledge” 2: sound and noise). For each month the acoustics experts calculated an average value. The NORAH scientists also took into account the rail and road noise – here they used the respective annual average as the basis.

**The basis for the calculations was provided by flight and radar data for flight movements in the Rhine-Main Region.**

### Address-specific calculation

---

The actual traffic noise at a particular address depends not only on how many cars, trains and planes pass by at which distance. The terrain also plays a role – in built-up residential areas or a hilly landscape, sound is propagated differently than in a flat, open area. The NORAH acoustics experts also took this into account: with the aid of a three-dimensional terrain model they calculated the individual noise levels at the addresses of all study participants.

## WELL PROTECTED DATA

Every individual has the right to careful protection of his personal data. This is upheld by the Federal Data Protection Act and by various state laws. Sensitive medical information such as that collected in a study like NORAH requires especially solid protection. This is why the scientists only began their surveys and measurements after the data protection officer of the State of Hessen had rigorously examined the data protection measures of the Blood Pressure Study. In addition to this, the ethics committee at the Faculty of Medicine of the Justus Liebig University of Gießen also assessed the planned procedures and study materials. In July 2012 they gave their approval for the execution of the study.

## Consent and confidentiality obligation

It is a basic principle for all scientific studies: participation must be voluntary and the participants must verify their consent in writing. Making contact with participants by telephone and with the aid of address data from the residents' register is common in the case of population-specific research projects such as NORAH. This is in line with the stipulations of the Federal Data Protection and Registration Act. Only those who, after the first contact, signalled a willingness to participate in the Blood Pressure Study received a visit from the project workers by telephone appointment. In the first conversation the scientists explained the project in detail. Then the persons concerned could sign the written declaration of consent – or decide not to. Even while the study was running, the participants had the option at all times of ending their participation. All project workers also signed a confidentiality declaration which prohibits them from passing on the personal data of persons contacted within the framework of the study. This obligation is similar to the medical oath of confidentiality in terms of content and significance.

## Anonymous evaluations

In order that as few people as possible have access to the personal data of the study participants, the Blood Pressure Study uses various databases. These separately administrate:

- ▶ the blood pressure measurement values and the responses to the questionnaire,
- ▶ the individual noise exposure at the addresses of the participants,
- ▶ names and addresses of the participants.

All data are linked with the aid of identification numbers ("numerical pseudonyms"), in short IDs. This makes it possible to link the individual noise exposures with the health and blood pressure data of the participants, without their name ever appearing. The NORAH acoustics experts, for example, calculated the noise exposure at certain addresses, but did not know who lived there. No names or addresses appear in the evaluations, only the IDs. The data protection regulations oblige scientists not to investigate individual cases but only groups – for example all participants exposed to a certain level of noise.

**All data are linked with the aid of identification numbers ("numerical pseudonyms"), in short IDs. This makes it possible to link the individual noise exposures with the health and blood pressure data of the participants, without their name ever appearing.**

# Glossary

---

You will find further explanations in the glossary at [www.laermstudie.de](http://www.laermstudie.de).

## Blood pressure

As it travels through the body, the blood exerts pressure on the walls of the blood vessels. This pressure can be measured. Blood pressure measurements always give two values, for example 120 over 80. The higher (“systolic”) value stands for the highest pressure occurring when the heart contracts to pump blood through the vessels. The lower (“diastolic”) value states how high the pressure is on the vessel walls when the heart muscle is at rest between two beats. The measurement unit for blood pressure is “millimetres of mercury” (mmHg). In daily usage, however, this is normally omitted.

---

## High blood pressure

If the blood pressure is too high, this places a major burden on the whole cardiovascular system. The World Health Organization (WHO) has established an upper limit value for blood pressure of 140 over 90. If, after multiple measurements after five-minutes sitting at rest, one of the two values is this high or higher, a medical blood pressure check is recommended. The medical term for high blood pressure is hypertension.

---

## Continuous sound level

The equivalent continuous sound level (in short:  $L_{pAeq}$ ) is a measure for the average noise exposure over a certain period in which frequency, duration and level of the individual sound events are taken into account. The  $L_{pAeq}$  is the basis for the determination of noise protection zones pursuant to the aviation noise act – separated according to day (6 – 22 hrs) and night (22 – 6 hrs). The  $L_{pAeq}$  is stated in decibels (dB).

---

## Telemedicine

Telemedicine allows diagnoses and therapies even when doctor and patient are spatially separated. In everyday clinical work it can be used, among other things, for the registration and transmission of vital data such as pulse, blood sugar or lung function. The information is transmitted by the Internet, telephone networks or satellites. In the Blood Pressure Study the scientists used tele-medical sets consisting of an upper arm blood pressure measurement device with Bluetooth function and a mobile phone. The measurement devices transmitted the blood pressure values to the mobile phone, which then sent them in encoded form via a protected data line directly from the house of the study participants to the database of the NORAH scientists.

---

## 10-year heart attack risk

(“PROCAM quick check”)

Various factors influence the risk of suffering a heart attack. The NORAH Study used the “PROCAM quick check”, which is medically established in Germany, for their calculations. On the basis of nine factors (age, gender, diabetes, smoking, blood pressure, weight, height, intake of medication against high blood pressure, heart attacks in the family) it measures how probable it is that someone will suffer a heart attack in the next ten years.

---



**Legal Notice**

Gemeinnützige Umwelthaus GmbH  
Rüsselsheimer Str. 100  
65451 Kelsterbach

<b>Tel</b>	06107 98868-0
------------	---------------

<b>Fax</b>	06107 98868-19
------------	----------------

<b>E-mail</b>	<a href="mailto:norah@umwelthaus.org">norah@umwelthaus.org</a>
---------------	--

**Concept, text and design**

Mann beißt Hund – Agentur für Kommunikation GmbH  
[www.mann-beisst-hund.de](http://www.mann-beisst-hund.de)

**Status**

October 2015