Quality of Life
Health
Development

NORAH
Knowledge No. 11

NORAH Noise Impact Study
Blood Pressure Study: Effects of aviation noise on blood pressure
Results

forum flughafen & region
umwelt- und nachbarschaftshaus

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Results

"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 investigated the effects of aviation, road and rail noise on humans.

von Aichberger

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 was 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 government of Hessen, communities, Fraport AG and Lufthansa were also involved in the financing.

Contents

The NORAH Study examined 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 was 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 addressed some of the most topical issues currently being dealt with by international noise impact research. It also covered 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 addition to this, highly complex and innovative techniques were used to calculate the acoustic exposure. In this edition of "NORAH Knowledge" we present the results of the Blood Pressure Study, one of the five sub-studies.

Further information on the NORAH Study is available on the Internet at **www.laermstudie.de**. There you can also subscribe to the newsletter "NORAH Brief".

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OVERVIEW OF THE BLOOD PRESSURE STUDY

Noise can generate stress, stress increases the blood pressure in the short term – this is the basic thesis of the study. But how does the blood pressure respond to chronic traffic noise? Can effects be measured in the residents around Frankfurt Airport which cannot be explained by the typical risk factors such as age, smoking or obesity alone, but are linked with the noise level?

High number of participants, precise acoustic calculations

In contrast to other studies, the 844 randomly selected participants in the NORAH Blood Pressure Study measured their own blood pressure every morning and evening over a period of three weeks. They repeated these measurements one year later. This allowed the scientists to examine whether changes in the noise exposure had any effect on the blood pressure. All of the participants lived in the environs of Frankfurt Airport. The participants were not selected, however, solely on the basis of the distance of their address from the airport, but on the basis of the actual noise exposure: only people at whose addresses the average air traffic noise during the day was at least 40 decibels (Glossary) were allowed to take part in the study. They measured not only their blood pressure, but also completed a questionnaire. This allowed the NORAH team to take account of possible confounding factors in their investigations. The blood pressure team took detailed information on the respective, address-specific noise exposure from the NORAH acoustics database.

For a more detailed account of the methods of the Blood Pressure Study, please refer to "NORAH Wissen" No. 8, which you can order from us or download from www.laermstudie.de.

Central results

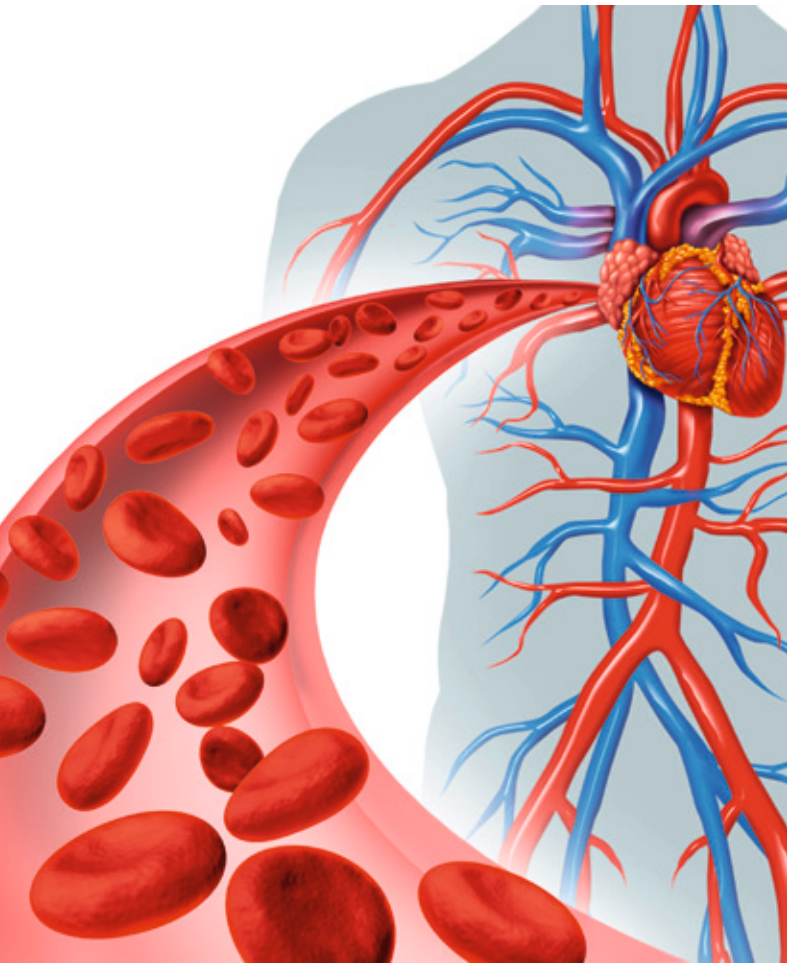
Connection between air traffic noise and blood pressure

The NORAH Blood Pressure Study was not able to verify a statistically significant (Glossary) connection between air traffic noise and the parameters blood pressure, heart rate (Glossary) and pulse pressure (Glossary) which are relevant for cardiovascular disease. The same applies for road and rail noise. Here also, it was not possible to verify such a connection for any of the investigated parameters.

Indications of especially sensitive sub-groups

The study provided indications that not all people respond to the same extent to traffic noise. There are, rather, more sensitive sub-groups. Differences in noise sensitivity, age, gender, residential duration and high blood pressure also play a role, although this is not equal for all three types of noise.

Participants measured their own blood pressure every morning and evening over a period of three weeks. They repeated these measurements one year later.



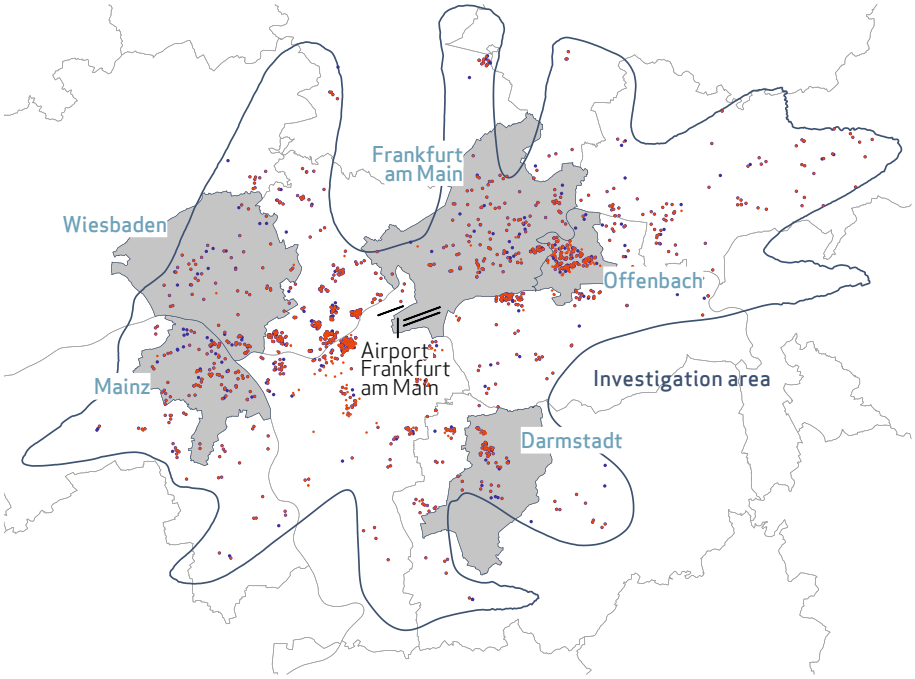
The heartbeat pumps the blood ceaselessly through the body – if it is constantly pulsing through the blood vessels at excessive pressure, this can lead to cardiovascular diseases.

The state of research up to now

Of all types of traffic noise, air traffic noise is what is mentioned first when study participants are asked what they perceive as the greatest noise-related annoyance and as the cause of sleep disturbances. This is followed at place two by road traffic noise and rail traffic noise at place three.

- If a human being is acutely exposed to very high noise levels, this increases blood pressure and heart rate due to the release of stress hormones. This does not tell us anything, however, about the effects of chronic noise.
- Even low levels of noise can trigger an acute stress response in the body while sleeping or in a relaxed state. Noise at night has a greater impact on the body than noise during the day.
- People can get used to noise to a certain extent. For example, study subjects in the sleep lab have been found to respond more strongly to noise in the first nights than in the last nights of the experiment.
- Up to now there have been just a few long-term studies and epidemiological studies with a large number of participants on the effect of air traffic noise on blood pressure and the risk of heart attack. The largest study so far is the HYENA Study (Hypertension to Noise near Airports). This study, which surveyed residents around five European airports, comes to the conclusion that severe air traffic noise increases the risk of hypertension. Another large epidemiological study which was carried out on male residents around Stockholm Airport suggests that, particularly in older persons, the risk of developing hypertension increases if they are exposed to high noise levels.

SELECTION OF THE STUDY PARTICIPANTS



Möhler + Partner AG

The map shows the distribution of the participants of the two observation periods (OP) within an area in which the daytime or night-time continuous sound level (Glossary) is over 40 decibels.

What was the composition of the participant group?

The aim of the NORAH scientists was to recruit a sample of adults in the environs of Frankfurt Airport who are exposed to an air traffic noise level of more than 40 decibels (Glossary) at their residential address. The contact data of the possible participants were established with the aid of the resident registration authorities. The participants for the Blood Pressure Study were then contacted in close collaboration with the scientific team of the NORAH Quality of Life Study. Persons who had taken part in the Quality of Life Study were able to give their consent there that they could also be contacted by the scientists working on the Blood Pressure Study. People who, according to their own information, had been diagnosed by a doctor with hypertension before the start of the study were excluded from participation. The study concept provided for the investigation solely of persons who were healthy in terms of their blood pressure. Any long-standing hypertension due to other causes was not to be included in the study. In addition to this, hypertension sufferers usually take drugs to lower their blood pressure, so that their measurement values cannot be readily compared with those of other persons. Nonetheless, some people with hypertension were ultimately also investigated, i.e. those person who were unaware of it at the start of the study.
A special correction procedure was developed for persons who were taking medication to reduce blood pressure (see page 5).

How large was the sample?

Persons who took part in the Quality of Life Study were able to give their consent there to being contacted by the scientists of the Blood Pressure Study. This amounted to 1,824 persons and thus just few more than was originally planned for final participation in the study design.

As it could not be expected that all of the persons contacted would participate, the NORAH scientists decided to recruit further participants with two different procedures. Due to the different procedures in the recruitment, the two new participant groups differed too widely in terms of decisive parameters, however, from the first group. This is why a joint evaluation for this research question would not have been methodologically appropriate. In agreement with the Scientific Advisory Board for Quality Assurance (WBQ), the scientists thus decided to restrict the evaluation to answer the study questions to the originally provided sample. A total 844 persons aged from 19 to 86 were included in the evaluations, including 493 women (58.4 %) and 351 men (41.6 %).

A statistical analysis showed that, with this size of sample, noise-related blood pressure changes of 1 mmHg per 10 dB (Glossary) increase in noise can be verified. Over the whole range of the level values in the investigation area – around 45 dB – changes of 4.5 mmHg could thus be statistically verified with sufficient test strength. This is entirely sufficient for the NORAH research question.

How was it ensured that the data were correctly registered?

Before the measurements started, the members of the NORAH team visited the study participants at home to show them how to operate the blood pressure measurement devices. The devices were connected via Bluetooth with a mobile phone which transferred the data automatically and in encoded form to a server of the NORAH team. The data included the time at which the measurement was taken, the blood pressure values (systolic and diastolic, Glossary) and the heart rate (Glossary). In addition to this, the participants also wrote down their values in a table. In order to ensure that the values were correctly registered, the NORAH scientists then compared the automatically transferred data with the values recorded by the participants.

What happened to the data of people who were already suffering from hypertension?

People with constantly elevated blood pressure were actually excluded from the study in the course of the participant recruitment. Nonetheless, after looking at the data, it was found that some of the participants were, in fact, suffering from hypertension. This amounted to around 5 percent of all participants. Their data were nonetheless evaluated. Most of them were not aware of their disorder at the start of the study. If they were taking medication when the measurements were being carried out, this was taken into consideration accordingly *(see following paragraph)*.

Which other factors that influence blood pressure were considered?

Within the framework of the survey at the start of the study, the participants were asked about underlying health issues, lifestyle and personal factors such as age or gender which are relevant for cardiovascular diseases.

The main ones were:

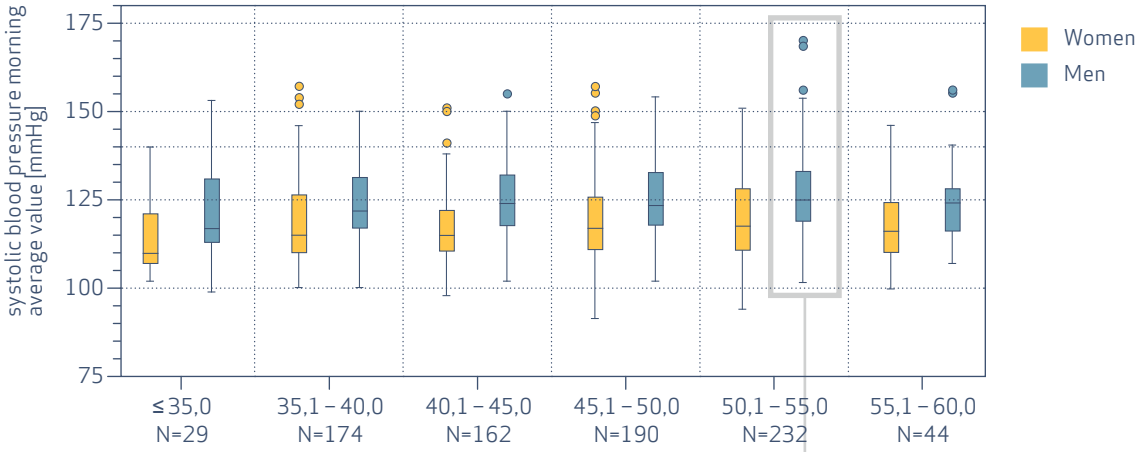
- social status
- waist and hip circumference
- tobacco and alcohol consumption
- sporting activity

These factors were always used for the statistic model if they played a role in the analysis of the influence of traffic noise on blood pressure.

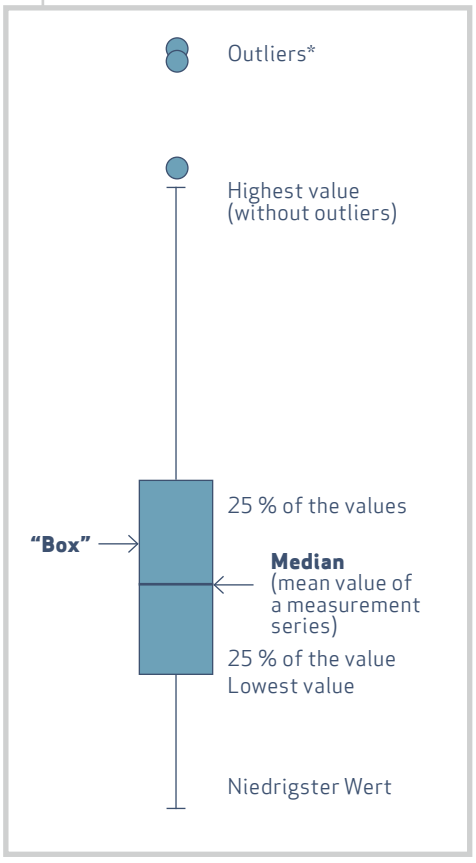
Various types of drugs can have an effect on blood pressure - not only those which are specifically prescribed by a doctor for hypertension. Whenever participants stated they were taking medication with the primary or secondary effect of reducing blood pressure, the measured blood pressure values were corrected upwards by 10 mmHg.

RESULTS AND DISCUSSION

Blood pressure in the morning for men and women



The graphic shows the distribution of the mean values from the three-week measurement series (mornings) of the upper blood pressure value ("systolic") in relation to air traffic noise, separately for women (orange) and men (blue). Even with increasing noise, the values remain in the same range. At all times at least 75% of the mean values are below the limit value for the normal systolic blood pressure of 140 mmHg (Glossary), which is only exceeded in a few cases. The air traffic noise data refer to the continuous sound level between 18:00 and 06:00 hrs over a period of 12 months before the respective measurements of the individual participants. The data are from the observation period 1 (July 2012 to June 2013).



(*) Outliers:
Outliers are exactly defined: if the distance of a measurement value from the box exceeds a certain value (1.5 times the box length), it is regarded as an outlier.

Air traffic noise and blood pressure

At the start of their work, the scientists formulated their research question in the form of a so-called zero hypothesis, i.e. the assumption: "There is no connection between air traffic noise and blood pressure." With the aid of the measurement data, they then examined whether this assumption can be rejected. But all of the relationships found between chronic air traffic noise and the mean blood pressure values were weak and not statistically significant (Glossary). This is why the main analysis of the study could not verify a connection between the two. From a scientific point of view, however, this does not mean that there is no such connection. In sensitivity analyses (Glossary), the scientists found indications that the increase in blood pressure in certain groups of persons is more pronounced in connection with air traffic noise. These are people with medium noise sensitivity, older people, men, and people who already suffered from hypertension. These results were also not statistically significant.

Rail traffic noise and blood pressure

The study was unable to establish a connection between rail noise and the parameters heart rate (Glossary) and pulse pressure (Glossary). But the scientists did find indications that younger people tend to react more strongly to rail traffic noise.

Road traffic noise and blood pressure

The scientists were unable to establish a connection between road traffic noise and the parameters heart rate and pulse pressure. In some of the sub-groups they identified a somewhat stronger connection between noise exposure and blood pressure. This includes men, older persons, especially noise-sensitive persons and persons who already suffered from hypertension. These effects are, however, even lower than those for air traffic noise, and also not statistically significant.

Residential duration

Does it make any difference how long a person has been living at his/her current address? To find this out, the participants were divided into three groups of equal size:

- up to 13 years inclusively living at the same address
- 14 to 26 years living at the same address
- 27 years and more living at the same address

The result: people living for up to 13 years at the same address tended to react more strongly to the noise exposure due to air or rail traffic. Both blood pressure and heart rate were on average higher than in people who have been living longer at the same address. The difference, however, is not statistically significant.

Differences after a year

The study participants repeated the blood pressure measurements after a year. The NORAH team wanted to find out how the blood pressure developed in the study period in relation to the air traffic noise in the respective previous 12-month periods. But even when the air traffic noise in the residential environment of a participant increased or decreased in the course of a year, this had no verifiable influence on blood pressure.

Doebbeling

The project worker from the Justus Liebig University of Gießen takes the health status of the participant and explains the blood pressure self-measurement and the necessary technology during a visit to the home. He also documents the measurement.

Doebbeling

First data analysis of the measurement values taken under instruction

Doebbeling

First self-measurement

The measurement devices used are designed for self-measurement. They show correct values even for measurements through thin clothing. As soon as clothing or incorrect handling obstructs a measurement to the extent that no correct value can determined, the device gives a fault alarm and terminates the measurement. The devices were tested for these functions before being used in the field.

Strengths of the study

Several investigations carried out before the NORAH Study provided indications that people who are regularly exposed to severe noise are more likely to suffer from hypertension. The results of these studies were, however, very different in the detail. Often they were only able to verify the described connection for certain sub-groups of the population concerned. There was no clear overall picture. Many studies only took into consideration the number of hypertension patients instead of including the measured blood pressure in the evaluation. The NORAH Blood Pressure Study thus wanted to investigate this connection in detail, while avoiding the methodological weaknesses of previous studies.

The NORAH Blood Pressure Study has the following strengths:

Large number of measurements

844 persons took part in the study. They measured their own blood pressure every morning and evening over a period of three weeks and repeated these measurements after one year. This meant that the NORAH scientists were able to use more than 130,000 blood pressure measurements for their analyses. This is a very high number for this type of study. Self-measurements on this scale have never been carried out before.

Blood pressure measurement at home

The participants took their own blood pressure measurements at home. This is because blood pressure is often higher when measured by the doctor – presumably due the patient being nervous in this situation. Doctors call this "white coat syndrome". All of the participants were trained to carry out the measurements correctly. The mean values from three-week measurement series were used for the evaluation.

Correlation of the results with the three traffic noise types

It was possible to correlate the measures blood pressure with very precise acoustic data for the three traffic noise types. Former studies usually only investigated one type of noise. NORAH also measured the air traffic noise exposure in a complex procedure for exactly twelve months before the blood pressure measurements began. Here it was taken into consideration, for example, that air traffic noise affects all of the facades of a building, while road and rail traffic noise only affects individual walls.

INTERVIEW WITH THE STUDY DIRECTOR

Doebbeling

Prof. Dr. Thomas Eikmann is the overall director of the Blood Pressure Study.

Doebbeling

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

The overall director of the Blood Pressure Study was Prof. Dr. Thomas Eikmann; the health scientist Dipl.-Ing. Anja zur Nieden, MPH, from the Institute for Hygiene and Environmental Medicine of the Faculty of Medicine at the Justus Liebig University of Gießen was responsible for the execution.

There are several quite serious studies that conclude that traffic noise has negative consequences on blood pressure. The NORAH Blood Pressure Study cannot verify this connection. Did the result surprise you?

Thomas Eikmann: Such studies exist. But there are also equally serious studies that come to similar conclusions as NORAH. Also, not all studies are readily comparable because they did not all use the same methods. The NORAH Blood Pressure Study has many strengths compared with other studies: the participants measured their own blood pressure every day for three weeks. These measurements were then used to form a mean value. This is a much better data basis than when only individual measurements are taken, and that possibly in a stress situation. We also have address-specific noise data for the NORAH Study. This means that we know exactly the noise exposure for each individual. We can thus say with a clear conscience that this study has been well done.

All in all you were unable to identify any statistically verifiable connection between the blood pressure values and the traffic noise. Your study does show, however, that there are certain groups who react especially sensitively to air traffic noise. What health-related consequences does this have for the persons affected?

Thomas Eikmann: We established that there are differences in the connection between noise exposure and blood pressure values between certain sensitive groups and the other study participants. These sensitive groups included, for example, persons who suffer from hypertension, or who have not been living so long at the specific address. The group differences, however, were very small and not statistically significant.

You recruited additional study participants during the course of the study. But these were not used in the evaluation. Why not?

Anja zur Nieden: There were methodological reasons for this. In the originally planned recruitment method, fewer participants agreed to take part than the study concept required. This can happen with epidemiological field studies of this kind, especially when there is so much input required of the participants, and is not necessarily calculable. This is why we decided to recruit additional participants. This can, however, lead to distortions in the composition. We examined this and found, unfortunately, that the composition of the three samples differed in many aspects. Therefore, in order to answer our study question we had to apply clean methodology and restrict ourselves to the first sub-group, which was by the way, sufficiently large to produce valid results.

Has the NORAH Blood Pressure Study definitively answered the question as to whether air traffic noise has an effect on blood pressure values?

Anja zur Nieden: For a scientist there is no such thing as a definitively answered question. With the blood pressure values taken over several weeks of self-measurements, we have a medical parameter that is relatively robust. I am confident, therefore, that the results are also robust. But even though the results of the study are quite clear, it may be a good idea to take another, closer look at this group of noise-sensitive persons. The data could also be looked at taking into consideration the subjective noise annoyance, well-being and the quality of life from the other NORAH Study investigations. Then it would be possible to show to what extent there is a connection between these parameters and blood pressure.

OUTLOOK

The NORAH Blood Pressure Study was unable to verify a connection between air traffic noise and blood pressure. But the study does provide indications that there are groups that react more sensitively to traffic noise than others with a rise in blood pressure values. However, even the results for sensitive groups do not reach statistical significance (Glossary). In order to identify the health consequences of high air traffic noise exposure, further studies would have to be carried out on selected groups of persons. Because, as the NORAH scientists point out: we must not forget that the reactions to chronic stress vary greatly from person to person.

These sensitive groups included, for example, persons who suffer from hypertension or persons who have not lived so long at the specific address.

Glossary

You will find further explanations in the glossary at **www.laermstudie.de**.

Heart rate
The heart rate describes how often the heart muscle contracts and relaxes within a minute. The blood pressure measurement devices used in the study indicate the blood pressure and the pulse. In healthy persons pulse and heart rate are identical.

Pulse pressure
The pulse pressure is the difference between the upper (systolic) and the lower (diastolic) blood pressure value.

Decibel
Decibel – "dB(A)" – is a measure of the loudness. The decibel scale from 0 to 120 dB(A) reflects the range from the absolute threshold of hearing to the pain threshold. The scale is not linear. We perceive an increase of ten decibels as roughly a doubling of the loudness – in the lower and at the upper ends of the range.

mmHg
Blood pressure is stated in mmHg. 1 mmHg is the pressure that a one-millimetre column of mercury exerts. "Hg" is the abbreviation for the chemical element mercury.

Sensitivity analyses
In the sensitivity analyses the scientists carried out calculations separately for various sub-groups and then compared whether the estimate values found for the context differ substantially. If, for example, the connection is stronger for men than for women, this suggests that their blood pressure reacts more sensitively to noise.

Systolic and diastolic
Blood pressure is usually recorded with two values. The higher value is the so-called systolic blood pressure. This measures the pressure in the arteries when the heart muscle contracts and presses the blood out of the heart chambers. The systolic blood pressure is, therefore, the pumping performance of the heart. The diastolic blood pressure is the phase in which the heart muscle relaxes and the heart chambers fill up with blood.

Significance , significant
In statistics we speak of a significant result if there is only a very low probability (usually less than 5 %) of it being a random effect. The significance can be checked using statistical methods.

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