Quality of Life
Health
Development

NORAH Knowledge No. 12

NORAH Noise Impact Study

Study on Health Risks

Results

forum flughafen & region
umwelt- und nachbarschaftshaus

NORAH

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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 aircraft, road and rail traffic noise on humans.

von Aichberger

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 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 important 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 more than 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 built on the current international state of research. In addition to this, extremely complex and innovative techniques were used to calculate acoustic exposure. In this edition of "NORAH Knowledge" we present the results of the Study on Health Risks, one of the five sub-studies.

Contents

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".

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

Tel 06107 98868-0
Fax 06107 98868-19
Email norah@umwelthaus.org
Internet www.laermstudie.de

OVERVIEW OF THE STUDY ON HEALTH RISKS

The Study on Health Risks focuses on five diseases: heart attack, stroke, heart failure (also called cardiac insufficiency) including hypertensive heart disease without heart failure, depression and breast cancer. All five diseases are wide-spread in Germany. They have one more thing in common: past studies suggest that all of these diseases occur with above-average frequency in persons who are exposed to a lot of traffic noise in their everyday lives.

The Study on Health Risks dealt with this suspicion. The scientists evaluated the health insurance data of about one million persons in the Rhine-Main Area. For this, the NORAH team cooperated with three large health insurances in the Rhine-Main Area. In parallel, the NORAH acousticians calculated the aircraft, road and rail traffic noise at all addresses in the Rhine-Main Area, partially even back to 1996. A special data privacy procedure ensured anonymity of the study participants. In the end, the NORAH team knew how many insured persons suffered from one of the five diseases, when and how much noise the place of residence of this person was subject to, but not where these persons lived or what their names were. Several thousand persons additionally participated in a more detailed survey. This enabled the scientists to collect further insights on the effects of noise among persons suffering from cardiac insufficiency.

The cardiovascular risk is increased by exposure to traffic noise

The NORAH study proves that traffic noise can increase the risk of developing heart attack, stroke or cardiac insufficiency. Only taking into consideration the long-term energy equivalent sound level (glossary), the risk of cardiac insufficiency was most strongly associated with railway noise, followed by road and aircraft noise. There were indications that the duration of the noise exposure was also relevant to cardiovascular risk. The scientists were also able to find a statistically significant (glossary) connection between strokes and all three examined traffic noise types - i.e. aircraft, road and railway noise. However, for aviation noise, the stroke risk tended to decrease as the long-term energy equivalent sound level increased. A statistically significant increase in stroke risk due to aircraft noise was only shown when considering the maximum aircraft sound level at night. For those who had a heart attack, there was a connection to road and railway sound. For those insured who died during the period of examination, there was a connection to aircraft sound. Depending on disease, noise type and group examined, the risk increases by up to 3.9 percent per ten dB (glossary) of increase in traffic noise.

Depression: traffic noise increases the risk of disease

All three types of traffic noise can contribute to developing depression. The scientists were able to calculate that the risk for a depressive episode increases on average by 8.9 percent when the aircraft noise stress increases by ten dB. For road noise, the risk rose by 4.1 percent per ten dB increase, for railway noise by 3.9 percent. However, these averages only partially reflect the study results. For aircraft and railway noise, the NORAH team found that the risk seems to drop again at very high sound levels. One possible explanation for this would be that people who tend to develop depression often move to calmer areas.

Breast cancer: further research required

A possible influence of traffic noise on the development of breast cancer was only suggested by three studies before NORAH. There was less evidence from the beginning for this association than for cardiovascular diseases, for example. The NORAH Study was unable to confirm that road or railway noise may contribute to the development of breast cancer. For aircraft noise, however, the scientists found a small connection: in the group of women where the long-term energy equivalent sound level between 11 p.m. and 5 a.m. was above 55 dB, there were more cases of breast cancer than expected. Further research on this subject is needed. Indisputable conclusions are not possible yet.

The Study on Health Risks focuses on five diseases: heart attack, stroke, heart failure, depression and breast cancer.

THE QUESTIONS AND METHODS OF THE STUDY ON HEALTH RISKS

The Study on Health Risks wanted to find out whether traffic noise increased the likelihood of developing heart attack, stroke, heart failure or hypertensive heart disease, depression or breast cancer. To answer this question, epidemiologist (glossary) and specialist for occupational medicine Prof. Dr med. Andreas Seidler and his team of scientists from the TU Dresden decided to use a case-control study. This form of study compares people suffering from a specific disease ("cases") to those that do not ("control persons"). It examines whether specific factors – in the case of NORAH, traffic noise – occur more frequently in the group of patients. To come to an indicative result, case-control studies sometimes need to include several thousand persons.

Health data from three statutory health insurers

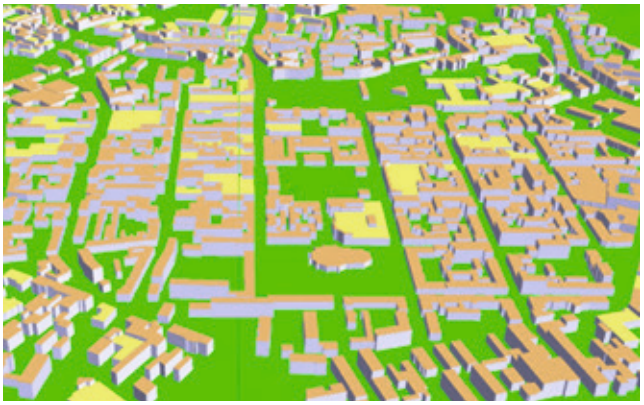
For the Study on Health Risks, three large health insurers from the Rhine-Main Area provided the scientists with the "pseudonymised" (glossary) data of approx. one million insured persons. Using complex search queries, the NORAH team was able to filter out those persons who suffered from one of the five diseases between 2005 and 2010. Persons were to be included as "cases" when doctors in the hospital or a practice diagnosed the disease for the first time. Since most of the examined diseases only occur more frequently in the second half of life, the scientists included only insured persons older than 40.

Individual noise calculations

To answer the research questions, the NORAH team also needed to know how much road, aircraft and railway noise each of the insured persons were exposed to at home. Therefore, the study acousticians calculated the noise load for approx. 900,000 addresses within the examination area – not only for the present, but retroactively to 1996. This way, the noise exposure over several years could be reconstructed for insured persons who lived in the area under examination during this time period and whose past addresses were known to the health insurance.

The NORAH acousticians based their aircraft noise calculations on radar recordings of all aircraft movements in the Rhine-Main Area – this data was provided by the German Air Traffic Services. States and municipalities provided the scientists with information on the road traffic in the examined area. The Deutsche Bahn and Germany's Federal Railway Office (EBA) provided data on rail movements in the Rhine-Main Area. The acousticians also used a three-dimensional terrain model for their calculations to determine how noise from cars and trains spreads. This information could finally be used to calculate when and how much noise was audible at each address in the area under examination.

Terrain models show where there are hills, valleys and buildings. The acoustic team used them to calculate how the railway and road traffic noise spread in the examined area.



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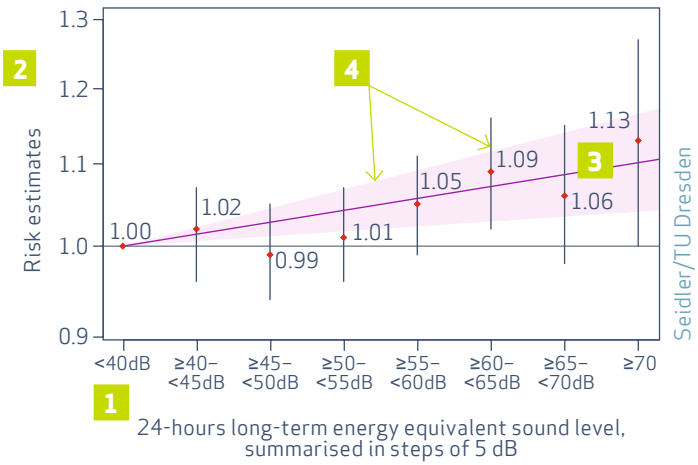
More precise results from an in-depth survey

The health insurance data provided the NORAH team with lots of information on the diseases of the insured persons. Since cardiovascular diseases, in particular, are known to have several other risk factors – e.g. smoking or being overweight – the scientists asked some insured persons to participate in an in-depth survey. They thus received additional information on the lifestyle and living situation of several thousand persons. With this information, the NORAH team was able to examine whether consideration of further risk factors changed the traffic noise results among persons suffering from cardiac insufficiency.

A reading aid for this issue of NORAH Wissen

The Study on Health Risks examines whether the risk of developing one of the five examined diseases increases when exposed to more traffic noise. The scientists present the results of their research in exposure-effect curves (glossary). Since you will find many of these curves on the following pages, we provide a reading aid here:

Heart attack and road noise



1

Long-term energy equivalent sound level

This axis shows the long-term energy equivalent sound level (glossary). The noise increases from the left to the right. For some calculations, the scientists also used "Sound level classes". If, for example, the long-term energy equivalent sound level at the address of an insured person was at 63.7 dB (glossary), their health data was included in the calculation for the sound level class "→ 60 dB – < 65 dB".

2

Risk estimates

Risk estimates indicate how high the "relative illness risk" is. 1 corresponds to the "basic risk" of a person not subject to traffic noise. If the value is higher, this suggests that noise at this degree may contribute to the disease. Additional calculations must show whether an increased or reduced relative risk is statistically significant (glossary) and thus with a high probability not due to chance.

3

Exposure-effect-curve

The exposure-effect-curve shows how the health risk changes with increasing noise. In this example, the risk increases by 2.8 percent per ten dB. Additional calculations show whether this increase is statistically significant.

4

Confidence intervals

The confidence interval is a statistically calculated trust range above or below the risk estimates. The smaller the confidence interval, the more reliable and indicative the risk estimates. It is usual to apply a 95 percent confidence interval. Simplified, this means that the "actual" risk is within this range with a probability of 95%. The figures show the 95 percent confidence intervals of the individual risk estimates (black vertical lines) as well as the 95 percent confidence interval above and below the exposure-effect curve (pink area).

TRAFFIC NOISE INCREASES HEART ATTACK RISK

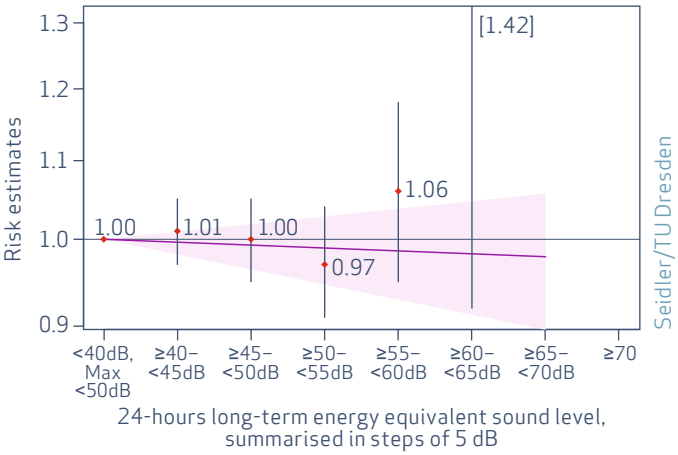
Acute heart attack is the second-most frequent cause of death in Germany. More than 50,000 persons die here every year from circulation problems of the heart muscle. Many factors that increase the risk of heart attack have been known for years, including high blood pressure, severe obesity, and lack of exercise. Different studies in the past have suggested that permanent traffic noise exposure may also increase the probability of suffering a heart attack. The Study on Health Risks dealt with this question with a higher degree of precision than many earlier examinations did – among other things, with more precise noise calculations.

Heart attack risk in figures

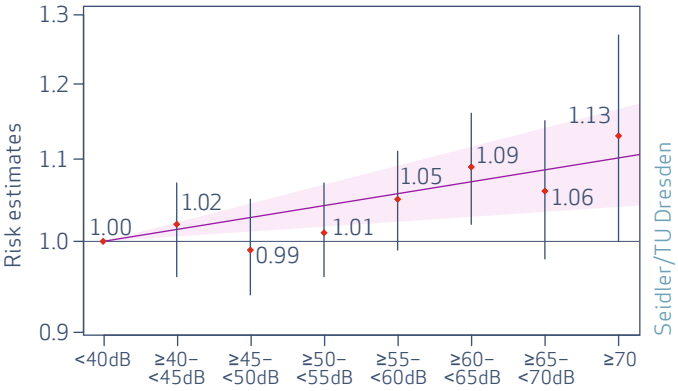
The scientists were able to confirm with NORAH that traffic noise is a heart attack risk factor:

- When the 24-hours long-term energy equivalent sound level (glossary) of road noise increases by ten dB (glossary) the risk of heart attack increases by 2.8 percent.
- The heart attack risk increases by 2.3 percent per ten dB of railway traffic noise.
- Aircraft noise shows no statistically significant (glossary) connection between the evenly increasing noise and heart attack. However, fewer people in the examination area were exposed to loud aircraft noise: only about two percent of the persons had long-term energy equivalent aircraft sound level above 55 dB, and it never exceeded 65 dB. In comparison: the road sound level for26 percent and the railway sound level for seven percent of the insured persons exceeded 55 dB. Therefore, it is more difficult to depict the risk relationship for aircraft noise.

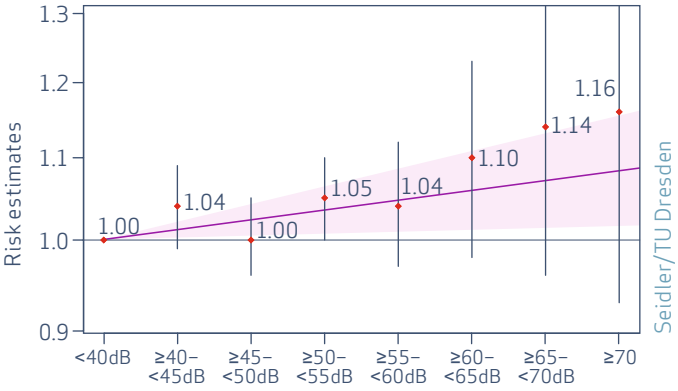
Heart attack and aircraft noise



Heart attack and road noise



Heart attack and railway noise



Deceased heart attack patients: connection to aircraft noise found

Heart attacks often have a fatal result. 53 percent of the insured persons who had a heart attack according to health insurance data from 2005 to 2010 had already died by 2014/15. However, the NORAH team did not know what they died of. For this partial group, the scientists performed separate analyses. They were able to document a statistically significant connection in the persons affected between aircraft noise exposure and heart attack risk – among other things if the 24-hour-long-term energy equivalent sound level at their addresses was 60 dB or above. An aircraft noise increase of ten dB increased the risk of fatal heart attack by 3.2 percent. For road and railway noise, similarly high risks were found. The results suggest that traffic noise is not only a risk for the occurrence, but also for the severe progression of a heart attack.

AIRCRAFT NOISE
The figure shows no statistically significant risk change, since the "basic risk" of 1.0 is within the light-violet shaded 95%-confidence interval.

ROAD TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 2.8% per 10 dB (statistically significant).

RAIL TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 2.3% per 10 dB (statistically significant).

STROKE: CLEAR DIFFERENCES BETWEEN NOISE TYPES

In the last years, the number of deaths from stroke has dropped considerably. Nevertheless, the sudden circulation disorder of the brain or bleeding in the brain is still among the most frequent causes of death in Germany. More than 18,000 persons died of a stroke in 2013. The known risk factors include, among other things, being overweight, smoking and hypertension. The NORAH study was able to prove that all three examined traffic noise types also influenced the stroke risk.

Road and railway noise: long-term energy equivalent risk increases with increasing long-term energy equivalent sound levels

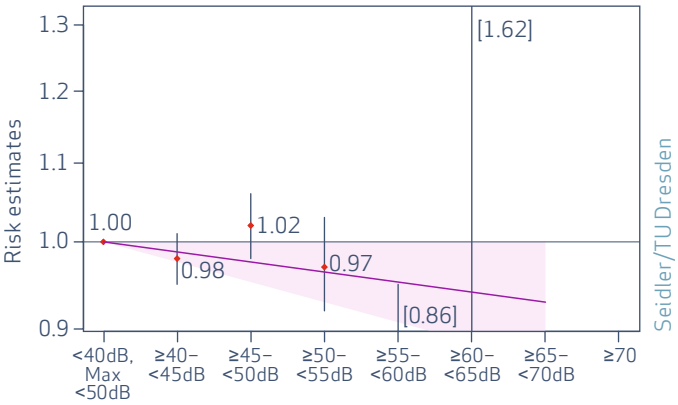
The NORAH team was able to find a statistically significant (glossary) connection to strokes, both for noise caused by trains and for car noise:

- When the 24-hours long-term energy equivalent road sound level (glossary) increases by ten dB (glossary), the risk of stroke increases by 1.7 percent.
- For railway noise, the stroke risk increases by 1.8 percent per ten dB.
- There was no increase in stroke risk with regards to aircraft noise, but as the long-term energy equivalent sound level increased, there was a decrease in risk.

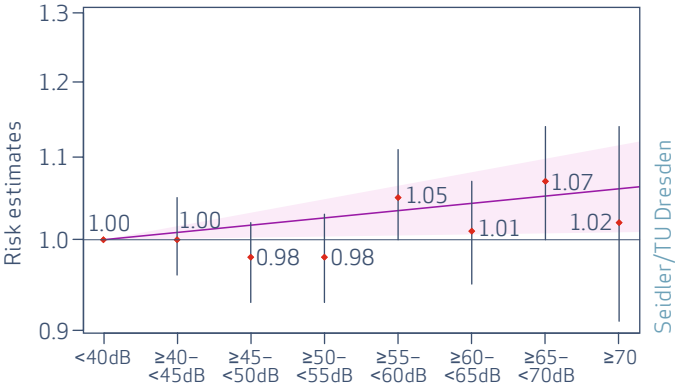
Aircraft noise: does maximum noise play a role?

Most calculations of the NORAH team were based on long-term energy equivalent sound levels. This physical value averages the number and sound level of the individual sounds within a specific period – e.g. 24 hours. Additionally, the scientists also considered the maximum sound level (glossary): the maximum sound level that reaches an address when a car, train or aircraft passes nearby. For aircraft noise, the NORAH team found a statistically significantly increased stroke risk in persons with a long-term energy equivalent sound level below 40 dB if the maximum sound level at night exceeded 50 dB.

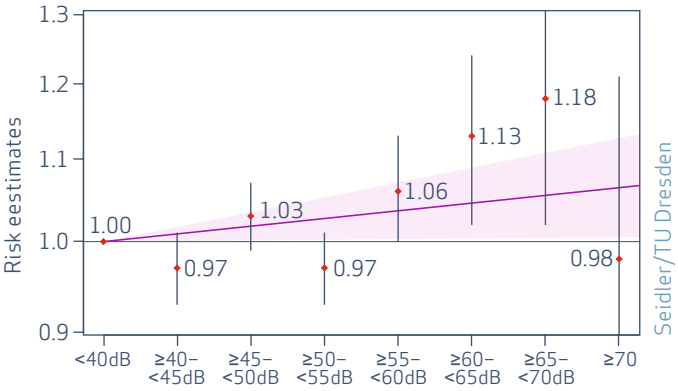
Stroke and aircraft noise



Stroke and road noise



Stroke and railway noise



AIRCRAFT NOISE
The figure shows a linear risk decrease (violet line) of 2.4% per 10 dB (statistically borderline significant).

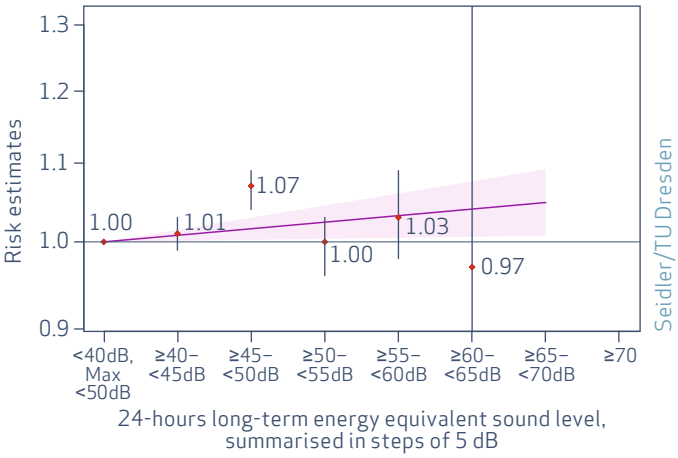
ROAD TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 1.7% per 10 dB (statistically significant).

RAIL TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 1.8% per 10 dB (statistically significant).

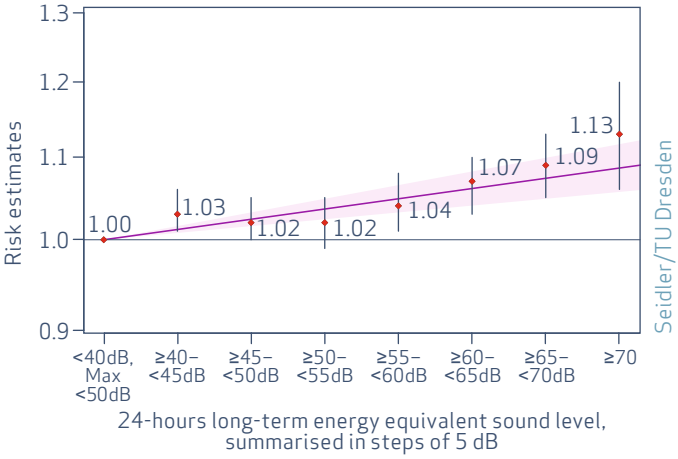
CLEAR RESULTS FOR CARDIAC INSUFFICIENCY

Doctors speak of cardiac insufficiency when the heart is no longer able to sufficiently supply the body with blood. This disease, commonly called heart failure, may have many causes. In many patients, the coronary vessels and, as a consequence, the heart muscle, are damaged. High blood pressure also facilitates cardiac insufficiency. Even though the patients have a better survival chance than stroke or heart attack patients, cardiac insufficiency is the third-most frequent cause of death in Germany. 45,815 persons died of it in 2013.

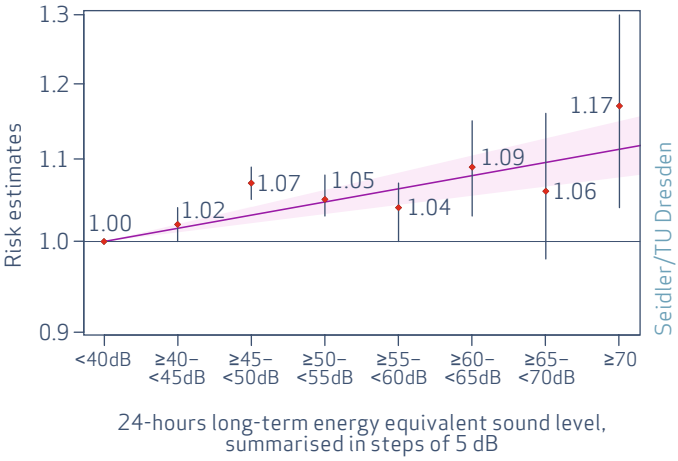
Cardiac insufficiency and aircraft noise



Cardiac insufficiency and road noise



Cardiac insufficiency and railway noise



AIRCRAFT NOISE
The figure shows a linear risk increase (violet line) of 1.6% per 10 dB (statistically significant).

ROAD TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 2.4% per 10 dB (statistically significant).

RAIL TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 3.1% per 10 dB (statistically significant).

Connections with all three traffic noise types found

Aircraft noise, as well as railway and road noise, statistically significantly (glossary) increase the risk of developing cardiac insufficiency.

- The connection is the clearest with railway noise: per ten dB (glossary), the risk of cardiac insufficiency increases by 3.1 percent.
- Road noise increases the risk of cardiac insufficiency by 2.4 percent when noise increases by ten dB.
- At 1.6 percent per ten dB, the risk increase under the influence of aircraft noise is a little lower – but even this result is statistically significant.

Additionally, the aircraft noise results tend to be less certain than the road and railway noise results, since aircraft sound levels above 65 dBs did not exist in the area under examination. Additionally, the data suggests that the time of residence plays a role: according to this, the risk of cardiac insufficiency may increase in persons who lived in noisy areas for several years. This assumption needs to be tested by further studies.

Survey to supplement health insurance data

The scientists took things a step further for cardiac insufficiency: they not only analysed the health insurance data, but also used an additional survey to collect and analyse information regarding risk factors for cardiac insufficiency or hypertensive heart disease. For this, the health insurers wrote to some of the insured persons. About 3,000 persons suffering from cardiac insufficiency or hypertensive heart disease and a high number of "control persons" not suffering from cardiac insufficiency or hypertensive heart disease reported to the survey collection office in Gießen and subsequently participated in the in-depth survey.

The NORAH team could use data collected based on the in-depth survey to ensure that the traffic noise risks found for cardiac insufficiency or hypertensive heart disease could not be explained by other factors. This suggests that the increased disease risks are actually caused by traffic noise.

Noise within the apartment considered

Additionally, thanks to the additional information, the scientists could gain insight on how loud the apartments of the respondents actually were. For this, the participants reported, among other things, the orientation of their bedrooms at home and whether the bedroom window was preferably tilted open or closed at night. From this information, the NORAH team initially estimated the sound level inside the apartment and then the cardiac insufficiency risk depending on the interior sound level.

The result: generally, the risk estimates increase when the interior sound level is considered instead of the exterior levels. This is true for aircraft noise, road noise and railway noise. This result generally suggests that traffic noise can cause cardiac insufficiency.

MORE DEPRESSION FOR TRAFFIC NOISE

The scientists found statistically clear connections for depression. The noise from aircraft, cars and trains increases the risk of suffering from a depressive episode. The disease, which usually happens in episodes, is one of the most frequent mental illnesses in Germany. Every fifth person experiences at least one depressive episode in his or her life. The causes of depression are diverse, and usually several factors come together. One possible factor is stress, which in turn may be caused by chronic traffic noise.

Clear connection with all three noise types

In fact, the scientists were able to find a connection between traffic noise and the medical diagnosis of a depressive episode with NORAH. Increases of the long-term energy equivalent sound level (glossary) by ten dB (glossary) increases the depression risk

- by 8.9 percent for aircraft noise.
- by 4.1 percent for road noise.
- by 3.9 percent for railway noise.

The data also suggests the time spent living in the noisy area may also influence the risk of depression. Future studies should follow-up on this result of the NORAH study.

Both the noise from aircraft and that of cars and trains increases the risk of suffering from a depressive episode.

The risk drops in very loud regions

Included among the rather unexpected results of the study were the results for depression with aircraft and railway noise: the curve is an inverted U. This means: the risk for depressive disease first increases with rising noise levels. In areas with very high aircraft or railway noise exposure, however, the estimated risk drops again. The cause of this, compared to the other results, unusual distribution cannot be determined by the NORAH study.

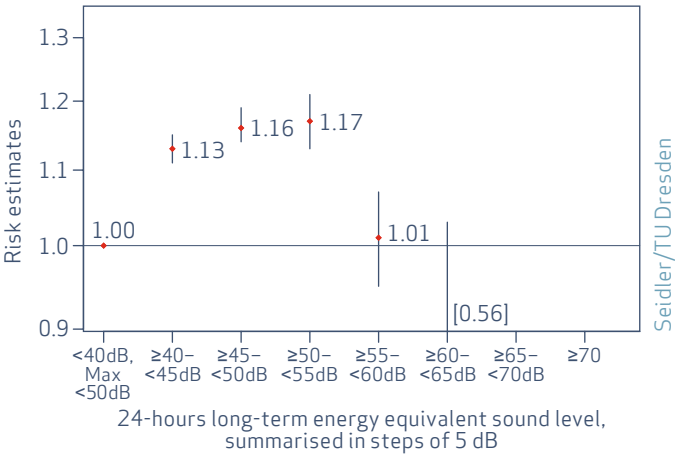
One explanation may be that persons who suffer more from noise and are more prone to developing depression, move less often to areas with high aircraft or railway noise exposure or may move away from these areas more often. Whether this is accurate, and why this is different for road noise compared to aircraft and railway noise must be determined in future studies.

AIRCRAFT NOISE
The depression risk increases first with rising noise, but drops again at high noise exposures. This figure shows no linear risk increase, but the risk estimates for each 5-dB-steps. The vertical dashes above and below the risk estimates indicate the "confidence interval" in which the actual value will be found with a likelihood of 95% (also see reading aid on page 5). From this data, an increase of the depression risk of 8.9% per ten dB can be calculated (statistically significant).

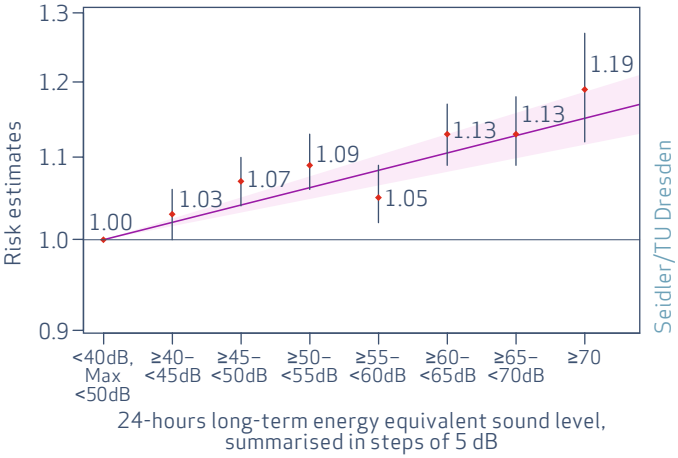
ROAD TRAFFIC NOISE
The figure shows a linear risk increase (violet line) of 4.1% per 10 dB (statistically significant).

RAIL TRAFFIC NOISE
The depression risk increases first with rising noise, but drops again at high noise exposures. This figure shows no linear risk increase, but the average risk estimates for each 5-dB-steps. The vertical dashes above and below the risk estimates indicate the "confidence interval" in which the actual value will be found with a likelihood of 95% (also see reading aid on page 5). From this data, an increase of the depression risk of 3.9% per 10 dB can be calculated (statistically significant).

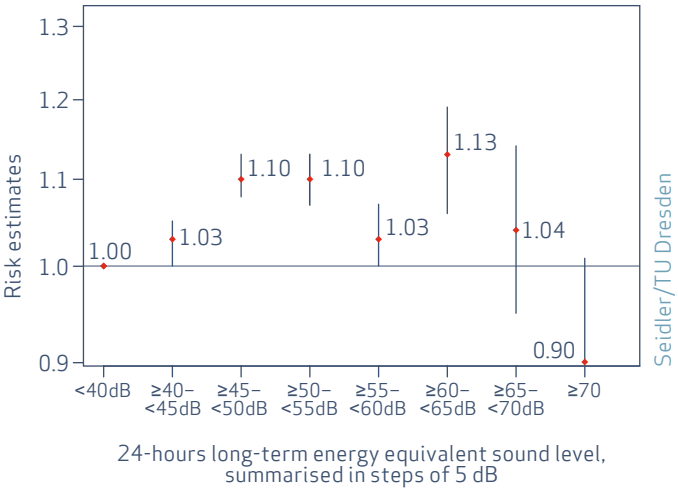
Depression and aircraft noise



Depression and road noise



Depression and railway noise



HARDLY ANY CONNECTIONS DISCOVERED FOR BREAST CANCER

Three studies in past had suggested that traffic noise also promotes the development of breast cancer. However, there were much fewer indications for this assumption than for other diseases examined by NORAH. Breast cancer is one of the most frequent cancers in Germany: the tumour disease is diagnosed in approx. 70,000 women in the Federal Republic every year.

There are hardly any indications of a connection between the breast cancer risk and traffic noise

The scientists were unable to find any connection between the 24-hour long-term energy equivalent sound level (glossary) and the breast cancer risk. The type of traffic causing the noise – aircraft, cars or trains – plays barely any role for the development of the disease.

The only exception is loud aircraft noise at night

The NORAH team was able to find a statistically significant (glossary) connection between noise and breast cancer only for a very small part of the insured persons: women, at whose places of residence the long-term energy equivalent sound level between 11 p.m. and 5 a.m. was between 55 and 60 dB (glossary), were nearly three times as likely to develop breast cancer than other women. However, the authors note that the insured persons only included 145 women from places of residence where the aircraft noise exposure was so high. Six of them had been diagnosed with breast cancer. Since 2011, Frankfurt has had a prohibition of planned flights between 11 p.m. and 5 a.m.; therefore, the long-term energy equivalent sound level during this time is now clearly reduced.

The scientists were unable to find any connection between the 24-hour long-term energy equivalent sound level and the breast cancer risk.

INTERVIEW WITH STUDY MANAGER PROF. DR ANDREAS SEIDLER: “NOISE MAY ALSO INFLUENCE THE PROGRESSION OF DISEASES”

Prof. Dr med. Andreas Seidler, institute director at the Technical University of Dresden, manages the Study on Health Risks. In the interview, the epidemiologist (glossary) and occupational physician tells how he interprets the results and which he found the most surprising.

Stephan Wiegand

Prof. Dr med. Andreas Seidler from the Technical University of Dresden (Institute of Occupational and Social Medicine) manages the Study on Health Risks.

NORAH Knowledge: Which results were surprising for you?

Andreas Seidler: Several! I had not expected, for example, that for heart attacks, we would find clear differences between the overall group and the partial group of deceased patients: the risk of fatal heart attack was higher in all three noise types than the risk for a new heart attack in general. This makes us wonder if traffic noise may not only be relevant for the occurrence of the disease, but also for the progression. I also find it interesting that we found similar, statistically significant exposure-risk relationships for the disease with the most cases: cardiac insufficiency.

Thirdly, the continually high health risks for the indoor levels surprised me. The noise inside the apartments – for the sleeper – can only be estimated very generally. These uncertainties of noise determination could blur the risks. The fact that we found increased risks suggests a causative effect of the traffic noise.

In addition to the analysis of the health insurance data, you conducted a in-depth survey with some insured persons. How do the answers contribute to your results?

With the in-depth survey we sought to determine using the example of cardiac insufficiency, whether the results from the health insurance data would be confirmed, or whether known risk factors such as social status, smoking or sports had distorted the results. When we consider these confounding factors, our results remain nearly unchanged. This suggests that the results derived from the health insurance data are highly indicative.

For strokes, it seems as if the health risk sinks with increasing aircraft sound levels. How do you explain this?

We should remember two things: one, we see particularly clearly in the case of strokes that the maximum level (glossary) is relevant as well. We examined the group of persons separately where the long-term energy equivalent sound level (glossary) was less than 40 dB (glossary), but the maximum sound level above 50 dB. In this group, we find statistically significant increased risks. Apparently, the long-term energy equivalent sound level of aircraft noise is not enough to describe the aircraft noise effect – we also must look at the maximum sound level.

Another reason may be that none of the insured persons were exposed to an aircraft sound level above 65 dB – in contrast to road and railway noise. And when looking at the long-term energy equivalent sound level range above 55 dB, only about two percent of the included population had an long-term energy equivalent aircraft sound levels exceeding 55 dB. For railway noise, however, seven percent were above it; and 26 percent for road traffic. If higher level values barely occur in aircraft noise, or are missing entirely, the entire curve progression becomes less certain.

For depression, the risk due to aircraft and railway noise seems to increase first and then drops again in the louder regions. What might be the reason?

Relatively few persons were exposed to higher sound levels of aircraft and also railway noise – much fewer than in the case of road noise. This makes the results less certain. However, this is not a sufficient explanation. Future studies should examine whether moving plays a role. We have looked at the depression risks for those persons we knew did not move in the last five years. In this group, we found statistically significant increased depression risks for the highest aircraft noise exposures.

Professor Seidler, thank you for the interview!

FUTURE RESEARCH NEEDS

As with every scientific examination, the Study on Health Risks not only answered questions, but also brought up new ones. In particular, the authors of the study see further need for research in five areas.

1 What is the role of the maximum sound level?

Noise effect studies use mostly the long-term energy equivalent sound level (glossary) – an average of the number and volume of "noise events". The Study on Health Risks suggests that the maximum sound level (glossary) – i.e. the maximum volume of individual noise – may also influence the health risks, especially for aircraft, but also for railway noise. Future traffic noise studies should deal with the question of how to use both measures to better describe the effect of traffic noise.

2 More research required on traffic noise and depression

The clear connection between traffic noise and depression, as well as the reduced risk at higher aircraft or railway sound levels, give reason for further research. Future studies should deal, for example, with whether persons bothered by noise move more often to calmer areas and whether depressive diseases influence moving.

3 Does traffic noise influence the progression of diseases?

Future studies should deal with the question of what influence traffic noise has, not only on the occurrence of the disease, but also its progression.

4 After what time will traffic noise increase the health risk?

The Study on Health Risks has also included past noise exposure where possible. Considering the duration of noise exposure, the health risks increase in part. However, it is not definitively clear after how many years what effect occurs.

5 Connection between aircraft noise and breast cancer?

The results suggest only a possible influence of high nocturnal aircraft noise exposure on the breast cancer risk. Whether there actually is a connection should be determined by future studies.

Glossary

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

Long-term energy equivalent sound level

The long-term energy equivalent 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 aircraft noise act – separated according to day (6 a.m. – 10 p.m.) and night (10 p.m. – 6 a.m.). The L_{pAeq} is stated in dB.

Decibel

The decibel – "dB" or "dB(A)" – is a measure of sound pressure level and thus of 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.

Epidemiology

Epidemiology is the study of the distribution of risk factors and diseases in populations. It contributes towards a better understanding of the cause of disease. Epidemiology develops measures to prevent disease or to prevent the spread of disease. It also helps to develop strategies for the treatment of diseases.

Exposure-effect relationship

The results of noise impact studies such as NORAH can often be expressed in exposure-effect relationships. This means that the scientists quantify as accurately as possible at which traffic noise exposure the risk of a certain disease increases by how much.

Maximum sound level

The physical value which best describes how strongly nocturnal aircraft noise impacts sleep is the maximum sound level. It shows to what extent aircraft noise stands out from the existing background noises. The overall annoyance effect depends on the level and the frequency of occurring maximum sound levels.

Pseudonym

In everyday usage a "pseudonym" is a false name, artist's name or code name. The pseudonym makes it impossible to trace statements back to the author personally. The Federal Data Protection Act defines pseudonymisation as "substituting a person's name and other identifying characteristics with a label, in order to preclude identification of the data subject or to render such identification substantially difficult." In other words: features that can identify the individual person – for example the name – are substituted with a code, for example a randomly selected number. All of the personal details have to be substituted so that it is not possible to identify a person.

Statistical significance

In simplied terms, statistics speak of a significant effect when it is very unlikely (usually less than five percent) to be a random effect. Statistical significance is determined by calculations.

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Gemeinnützige Umwelthaus GmbH
Rüsselsheimer Str. 100
65451 Kelsterbach
Tel 06107 98868-0
Fax 06107 98868-19
Email norah@umwelthaus.org

Concept, text and design
Mann beißt Hund – Agentur für Kommunikation GmbH
www.mann-beisst-hund.de

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