



#### Key messages

- ▶ Almost every second adult in Germany feels bothered by noise at home.
- ▶ Throughout Germany, 6.6% of women and 5.7% of men report being very or extremely annoyed by noise in their living environment.
- ▶ At a national level, road traffic and neighbours are the main sources of noise annoyance.
- ▶ In independent metropolitan cities, the proportion of the population feeling very or extremely annoyed by noise is higher than in urban and rural districts.
- ▶ Low socioeconomic status is associated with more severe noise annoyance from traffic and neighbours.
- ▶ Being very or extremely annoyed by noise is associated with impaired physical and mental health.

### Noise annoyance – Results of the GEDA study 2012

The increase in motorised traffic and, in particular, private transport are the main factors causing noise to be considered a ubiquitous environmental problem with high public health relevance today (Clark, Stansfeld 2007; World Health Organisation 2011). The World Health Organisation estimates that at least one million disability-adjusted life years (DALY) are lost in Western Europe due to illnesses caused by traffic noise (World Health Organisation 2011).

Noise is defined as sound which is disruptive or unwanted. It can lead to a variety of negative effects. These can be observed not only at high sound levels, but also at lower intensity levels, when sound impacts on the human organism over a long period of time (for example, during activities requiring high concentration or during rest and recuperation) (Ising et al. 1996; World Health Organisation 2000; Clark, Stansfeld 2007).

With respect to the effects of noise, we distinguish between auditory effects on the hearing organs and extra-auditory effects. With auditory effects, i. e. hearing damage, the strength of the effect depends on the duration and intensity of the sound (Ising et al. 1996). Unlike auditory effects of noise, extra-auditory effects do not depend on the respective sound level. Rather, extra-auditory effects occur in the sense of a stress factor even at sound levels which are well below the effect threshold for hearing damage. This effect of noise as a physical stressor is not different here to that of other stressors, such as chronic underload, chronic overload or performance pressure (Ising et al. 1996; Clark, Stansfeld 2007). The direct effect of noise on the central nervous system triggers physiological reactions which, depending on the intensity, frequency and mental processing of the noise, can become stress reactions (Ising et al. 1996).

However, the noise-related disturbance and impairment of activities, mental processes, communication and recuperation can also lead to stress reactions (Ising et al. 1996; Clark, Stansfeld 2007). Stress effects have both mental (annoyance, anger, tension) and physiological (endocrinological, vegetative) components that have an effect on certain functional systems of the human organism, such as the cardiovascular system or the metabolism (Ising et al. 1996; Babisch 2002). The two elements of stress reactions form a unity, are interdependent, and can reinforce one another's effects (Ising et al. 1996). In this context, we speak of a psycho-physiological reaction complex.

Feeling bothered or annoyed by noise sources is one of the most significant effects in the general population caused by environmental noise (Babisch 2011; Schreckenberg, Meis 2006). Surveys generally inquire about the noise pollution perceived by respondents within the past 12 months (cf. Fields et al. 2001). The information on the degree to which respondents feel bothered or annoyed by noise (not at all, slightly, moderately, very or extremely) therefore does not describe the current noise anno-

## German Health Update (GEDA)

<b>Data owner:</b>	Robert Koch Institute
<b>Goals:</b>	Provision of updated data on health-related topics and the analysis of current developments and trends
<b>Survey method:</b>	Computer-assisted telephone interviews (CATI)
<b>Population:</b>	People resident in Germany aged 18 years and over
<b>Sample:</b>	19,294 women and men
<b>Cooperation rate:</b>	76.7%
<b>Response:</b>	22.1%
<b>Survey period:</b>	February 2012 to March 2013

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yance, but the more long-term experience of noise during various situations and activities such as sleep, concentration and communication, with consideration of individual expectations, acclimatisation, sensitisation and conditioning.

Until now, no clear answer could be given to the question of which role noise-related annoyance plays in the development of health problems in everyday life. Results from reviews and a meta-analysis suggest a positive and significant association between noise annoyance caused by traffic and the risk of high blood pressure, as well as a positive association between noise annoyance and the risk of ischemic heart disease (Kohlhuber, Bolte 2011; Ndrepepa, Twardella 2011).

This article presents results on noise annoyance in the living environment of the general population in Germany from various noise sources. The results are taken from the »German Health Update« study (GEDA) of the Robert Koch Institute (RKI) from 2012. The analysis focuses on examining the relationship between noise annoyance and selected demographic and socioeconomic factors, as well as self-reported physical and mental health problems.

### Experience of noise annoyance is widespread among adults

According to the data from the GEDA study 2012, almost every second adult in Germany feels bothered by environmental noise. 44.7% of adults report being bothered or annoyed by noise in their living environment. At 46.1%, the proportion of men reporting this is higher than the proportion of women, at about 43.4%.

However, in the majority of cases, the severity of noise annoyance is not considered high: overall, 23.0% of women and 26.5% of men report being »slightly« bothered or annoyed. 13.8% of women and also 13.8% of men report being »moderately« bothered by noise. The proportion feeling »very« or »extremely« bothered by noise is

6.2%, and is only slightly higher in women than in men, with 6.6% as compared to 5.7%. The higher overall prevalence of noise annoyance among men than among women results from the fact that a higher percentage of men than women report feeling »slightly« bothered by noise.

### Young adults are bothered by noise more than older people

The proportion of men and women bothered by noise in their living environment is higher in younger age groups than in older age groups (Figure 1). Approximately every second person aged between 18 and 39 years reports feeling bothered or annoyed by noise at home, whereas this drops to about every third person from the age of 60 years. Significant differences between women and men can be observed in the higher age groups from 60 years old. While 38.9% of men aged 60 years or older report being bothered by noise in their living environment, this is only the case with 31.2% of women in this age group.

The relatively high prevalence of being bothered by noise in younger age groups results primarily from the fact that young adults feel »slightly« or »moderately« bothered by noise more frequently than older people. However, if we consider the proportions »very« or »extremely« bothe-

### Measuring noise annoyance in GEDA

Information on environmental noise annoyance was collected by means of five questions in the GEDA study 2012. The wording and response scales were based on the recommendations of the International Commission on Biological Effects of Noise (ICBEN) (Fields et al. 2001). An introductory question asked about noise pollution overall in the respondent's living environment:

»Thinking about the last 12 months, when you are at home, how much does noise - all in all - bother, disturb, or annoy you?«

The other questions referred to noise annoyance from individual noise sources:

»Irrespective of your overall impression, what is the situation with the individual noise sources? Thinking about the last 12 months, when you are at home, how much does noise from road traffic bother, disturb, or annoy you?«

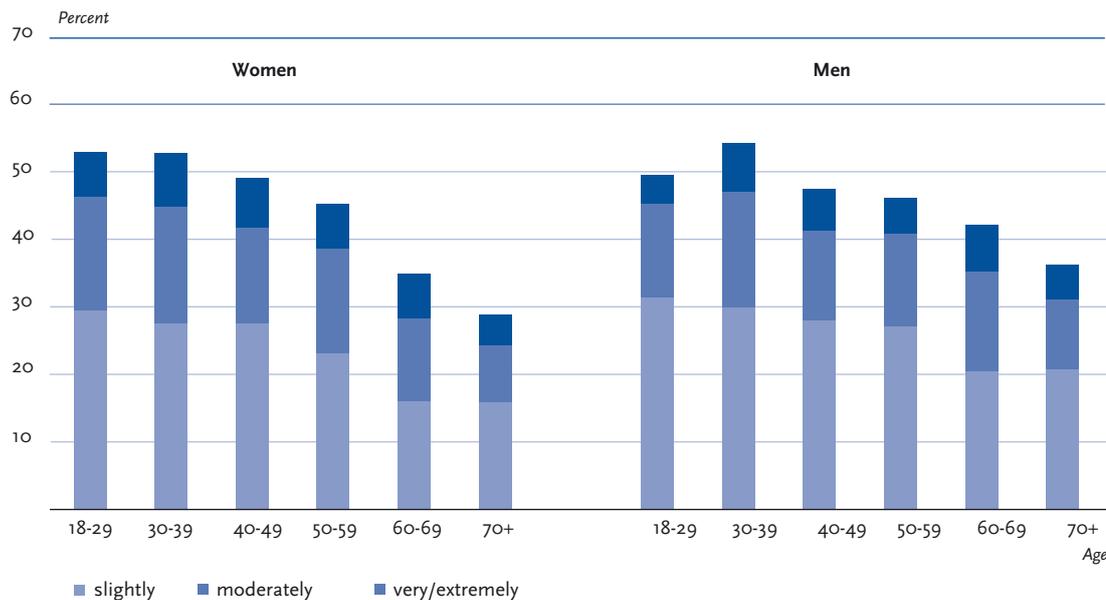
»Thinking about the last 12 months, when you are at home, how much does noise from air traffic bother, disturb, or annoy you?«

»Thinking about the last 12 months, when you are at home, how much does noise from rail traffic bother, disturb, or annoy you?«

»Thinking about the last 12 months, when you are at home, how much does noise from neighbours bother, disturb, or annoy you?«

The respondents could answer with »not at all«, »slightly«, »moderately«, »very« or »extremely«. According to the ICBEN recommendations, the categories »very« and »extremely« were combined in the statistical analysis of the data.

**Figure 1**  
**Noise annoyance in the living environment within the last 12 months, by age group**  
 Data source: GEDA 2012



red by noise, no significant differences can be recorded between the age groups in men. In women, by contrast, the proportion of those feeling at least »very« bothered by noise is highest in middle-aged adults between 30 and 49 years and is significantly different to the lowest proportion, which can be observed in the age group above 70 years.

### Road traffic noise and neighbours are the main sources of noise annoyance

In the GEDA study 2012, the study participants were not only asked about noise in their living environment overall, but also about noise annoyance from specific sources. The results show that, throughout Germany, road traffic and neighbours are the main sources of noise annoyance perceived by men and women (Figure 2). Overall, 37.2 % of women and 39.3 % of men specified road traffic in their living environment as a source of bothersome or annoying noise. Noisy neighbours represent the second most common source of noise experienced as bothersome or annoying by 32.0 % of women and 33.1 % of men. Nationwide, 19.1 % of women and 20.9 % of men feel bothered by noise from air traffic in their living environment. 10.5 % of women and 11.4 % of men perceive rail traffic noise as a disturbing factor in their homes.

Road traffic and neighbours can be identified as the main sources of environmental noise annoyance based on the severity of the annoyance. Road traffic accounts for the highest proportion of men and women »very« or »extremely« bothered by noise, while noise from neighbours accounts for the second highest proportion (Table 1). A higher proportion of women than men feel at least »very« bothered by noise from neighbours. Feeling »very« or »extremely« bothe-

red by noise from air and rail traffic is reported less often as compared to noise from road traffic and neighbours.

The GEDA data also indicates that, in the majority of cases, severe noise annoyance experienced by adults in Germany can be attributed to a single source of noise, rather than noise from a combination of sources. Throughout Germany, the proportion of people feeling »very« or »extremely« bothered or annoyed by noise at home from one of the four noise sources considered (road traffic, neighbours, air traffic, rail traffic) is 9.8 % in women and 9.3 % in men, while 1.6 % of women and 1.4 % of men in Germany feel at least very bothered by more than one of these sources of noise.

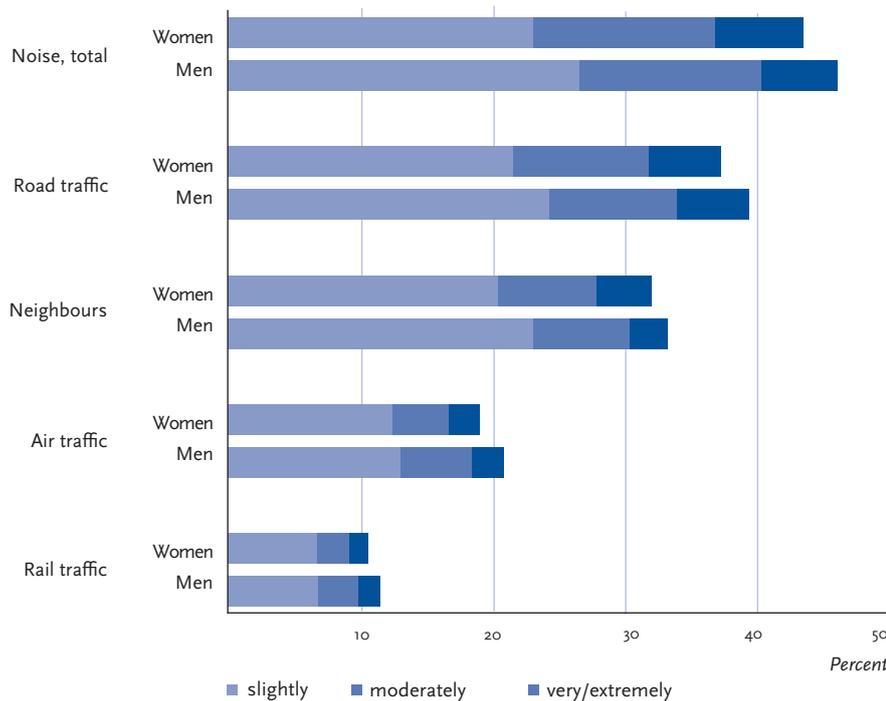
### Higher noise annoyance in metropolitan cities than in the country

The GEDA data also allows urban/rural differences in noise annoyance to be identified. Unlike other studies, this study did not use the type of municipality, but rather a district typology of the Federal Institute for Research on Building, Urban Affairs and Spatial Development (2014).

**Table 1**  
**Proportion of people very or extremely annoyed by noise in their living environment within the last 12 months, by source of noise**  
 Data source: GEDA 2012

Noise	Women	Men
Road traffic	5.4 %	5.4 %
Neighbours	4.2 %	2.9 %
Air traffic	2.3 %	2.4 %
Rail traffic	1.4 %	1.7 %

**Figure 2**  
**Noise annoyance in the living environment within the last 12 months, by source of noise**  
 Data source: GEDA 2012



The district types considered include: independent metropolitan cities (independent metropolitan cities with at least 100,000 residents), urban districts (districts with at least 50 % of the population residing in large or medium-sized cities and with a population density of at least 150 residents / km<sup>2</sup> as well as districts with a population density without large and medium-sized cities of at least 150 residents / km<sup>2</sup>) and rural districts (combined: rural districts with population concentrations and sparsely populated rural districts).

The results allow us to identify higher noise annoyance as perceived by the population in independent metropolitan cities than in urban or rural districts. 50.9 % of women and 51.5 % of men living in independent metropolitan cities report being bothered or annoyed by noise at home. In urban districts, these figures are significantly lower, at 41.2 % for women and 45.7 % for men. The same is true for rural districts, where 39.5 % of women and 42.4 % of men feel bothered by noise.

The regional differences in the severity of noise annoyance are also evident when deviations in the age structure between independent cities, urban districts and rural districts are statistically compensated for by means of age standardisation. The age-standardised proportions feeling »very« or »extremely« bothered or annoyed by noise from road and rail traffic or from neighbours is higher in each case in independent metropolitan cities than in urban and rural districts (Figure 3). The corresponding proportions of the population feeling bothered by noise from air traffic are higher in both independent metropolitan cities and

urban districts than in rural districts, when age is statistically adjusted.

### Noise annoyance is related to socioeconomic status

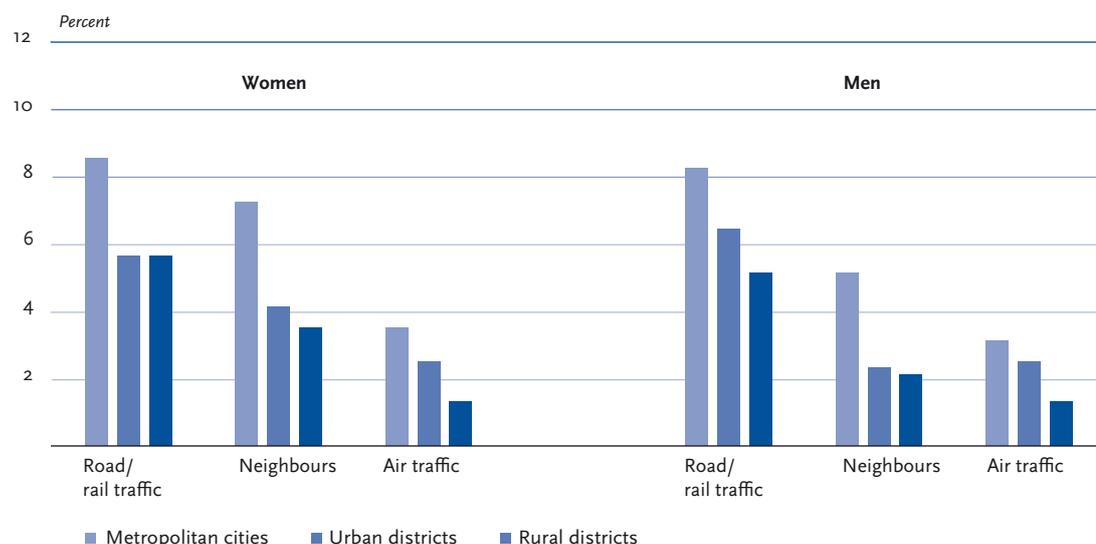
The GEDA data also shows that environmental noise annoyance is related to the socioeconomic status (SES) of women and men. These associations remain beyond the influence of age and district type (independent metropolitan city/urban district/rural district). In the GEDA study, the SES is determined based on information on the level of education, occupational status and income (Lampert et al. 2013). However, the type and extent of the associations between the SES and noise annoyance differ depending on the source of noise (Table 2).

According to the GEDA data, the odds of being at least very annoyed by noise from road traffic or rail traffic is 1.7 times higher in people with a low SES than in people with a high SES (Women: OR=1.58; 95 %-CI=1.17–2.12; men: OR=2.01; 95 %-CI=1.51–2.67). The influence of other variables, such as age, district type (independent metropolitan city/urban district/rural district) and self-assessed sensitivity to noise (Question: »To what extent does the following statement apply to you? I am sensitive to noise.« Possible answers: not at all / a little bit / fairly true / true / very true), were statistically controlled.

The odds of being at least very annoyed by noise from neighbours is 2.2 times higher in persons with a low SES than in those with a high SES (Women: OR=1.99; 95 %-CI=1.41–2.82; men: OR=2.60; 95 %-CI=1.70–3.98). In contrast, no correlations were found between SES and

**Figure 3**  
Age-standardised proportion of people very or extremely annoyed by noise in their living environment within the last 12 months, by district type and source of noise (age-standardised to the old European standard population)

Data source: GEDA 2012



being at least very annoyed by noise in the case of air traffic noise. Noise annoyance is associated with health problems. The GEDA study 2012 collected information on health problems partly by using an instrument for measuring health-related quality of life (Centers for Disease Control and Prevention 2000). For the analyses, it was assumed that physical or mental health problems were present when the respondents indicated that they had felt unwell on at least 14 of the past 30 days due to their physical health or mental state.

The results show that people who feel »very« or »extremely« annoyed by noise report physical and mental health problems more frequently than people who are »not at all« annoyed by noise (Table 3). This is evident in both women and men. Even after statistical adjustment for potentially confounding factors (age, district type, socioeconomic status, self-assessed sensitivity to noise, social support, alcohol consumption, smoking, obesity, hearing impairments, chronic illness), associations between environmental noise

annoyance and health problems are apparent. In particular, it is evident that being »very« or »extremely« annoyed by noise is associated with increased odds of physical and mental health problems as compared to the reference group (no noise annoyance at all) (Table 3). After multivariate adjustment, no increased odds of health problems can be observed in people who are »slightly« or »moderately« annoyed by noise as compared to those who are »not at all« annoyed by noise.

## Discussion

In the GEDA study, the level of noise annoyance perceived by older people is significantly lower than that experienced by 18 to 39 year olds. One possible cause of the dependence of noise annoyance on age could be that the mental workload and daily work stress are higher in working people than in older people or younger people under the age of 18 years (van Gerven et al. 2009). Evidence of this is given by a study by

**Table 2**

Correlations between socioeconomic status and being annoyed (very / extremely) by noise in the living environment within the last 12 months, by source of noise (results of binary logistic multi-level regressions)

Data source: GEDA 2012

	Road – / rail traffic noise				Noise from neighbours				Air traffic noise			
	Women		Men		Women		Men		Women	Men		
	OR <sup>1</sup>	(95% – CI)	OR <sup>1</sup>	(95% – CI)	OR <sup>1</sup>	(95% – CI)	OR <sup>1</sup>	(95% – CI)	OR <sup>1</sup>	(95% – CI)		
<b>Socioeconomic status</b>												
low	1.58	(1.17–2.12)	2.01	(1.51–2.67)	1.99	(1.41–2.82)	2.60	(1.70–3.98)	1.03	(0.63–1.71)	0.82	(0.48–1.41)
middle	1.59	(1.30–1.95)	1.38	(1.14–1.67)	1.42	(1.10–1.84)	1.90	(1.41–2.56)	1.27	(0.94–1.70)	1.00	(0.76–1.32)
high	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.	1.00	Ref.

OR = Odds ratio; CI = Confidence interval; Ref. = Reference category

<sup>1</sup> adjusted for age, district type (independent metropolitan city / urban district / rural district) and self-assessed sensitivity to noise

**Table 3**  
**Associations between noise annoyance in the living environment in the last 12 months and physical or mental health problems (results of binary logistic multi-level regressions)**

Data source: GEDA 2012

	Women			Men		
	%	OR <sup>1</sup>	(95%–CI)	%	OR <sup>1</sup>	(95%–CI)
<b>Physical health problems<sup>2</sup></b>						
Noise annoyance, total						
not at all	14.3	1.00	Ref.	10.3	1.00	Ref.
slightly / moderately	15.1	1.08	(0.94–1.24)	11.4	0.94	(0.80–1.11)
very / extremely	23.0	1.49	(1.19–1.88)	20.1	1.75	(1.34–2.29)
<b>Mental health problems<sup>2</sup></b>						
Noise annoyance, total						
not at all	10.8	1.00	Ref.	6.8	1.00	Ref.
slightly / moderately	14.2	1.05	(0.91–1.22)	7.7	0.86	(0.71–1.03)
very / extremely	25.2	1.41	(1.12–1.79)	18.0	1.77	(1.32–2.35)

OR = Odds ratio; CI = Confidence interval; Ref. = Reference category

<sup>1</sup> Adjusted for age, district type (independent metropolitan city / urban district / rural district) socioeconomic status, self-assessed sensitivity to noise, hearing difficulties, social support, alcohol consumption, smoking, obesity, chronic illness

<sup>2</sup> Data was collected using an instrument for measuring health-related quality of life (Centers for Disease Control and Prevention 2000). It was assumed that physical or mental health problems were present when the respondents indicated that they had felt unwell on at least 14 of the past 30 days due to their physical health or mental state.

Lundberg et al. (1994), which showed that the middle age groups in particular are placed under the most significant burden by work, family and household. Another factor which can be considered is the decreasing hearing ability or hearing acuity with age. This has the result that older people are less sensitive to noise due to the increasing prevalence of age-related hearing difficulties (van Gerven et al. 2009).

The results of the GEDA study 2012 are consistent with the results of earlier national population-based studies with respect to the ranking order of the individual sources of noise according to the severity and level of noise annoyance (Table 1 and Figure 2). Road traffic noise represents the main source of noise annoyance, followed by noisy neighbours, air traffic noise and rail traffic noise (Hoffmann et al. 2003; Rückert-John et al. 2013; Laußmann et al. 2013). This ranking order can be explained primarily by the different geographic prevalence of the individual sources of noise in Germany. While road traffic noise and noisy neighbours are widespread almost everywhere and therefore affect large sections of the population, air traffic and rail traffic have a more uneven distribution. This has the result that smaller sections of the population are bothered by noise from these sources. However, if we look at the degree of noise pollution, air traffic noise at the same noise level (continuous sound level) leads to the highest proportions of people feeling very or extremely annoyed by noise, followed by road traffic noise and rail traffic noise (Miedema, Voss 1999).

Due to infrastructural conditions such as a well-developed road and rail network, the urban location of airports, and the

high density of residential accommodation, groups of the population very or extremely annoyed by noise can mainly be found in large cities (Figure 3). The fact that the largest proportion of residents feeling very / extremely annoyed by noise can be found in urban regions was already established for the sources of noise (road and air traffic, neighbours) examined in the German Health Interview and Examination Survey for Adults (DEGS1) of the RKI (Laußmann et al. 2013). It must be noted here that the district typology used in GEDA results in a rougher regional classification than a typology on a municipal basis, which was used in the DEGS1 study.

In addition to the evident dependencies on age and area of residence, the results of the GEDA study 2012 indicate varying degrees of associations between socioeconomic status and being bothered by noise from specific sources. With respect to these associations, it should be noted that traffic noise is one of the environmental factors that can contribute to social segregation, i. e. geographical separation according to social groups (e. g. Schuemer et al. 2003). Thus, households with a lower income are more likely to be located along busy roads and are more exposed to noise (Hoffmann et al. 2003; Mielck 2004; Kohlhuber et al. 2006; Laußmann et al. 2013). This means that the much higher levels of sound (noise exposure) may be responsible for the higher noise annoyance perceived by people with a lower socioeconomic status. The segregation effects described above are not evident in the case of air traffic; this could explain the difference between the various sour-

ces of noise with respect to SES (Table 2).

GEDA collected data on noise annoyance perceived by respondents by means of a subjective assessment (feeling bothered or annoyed by noise) only. Studies which gathered data on objective noise pollution using local measurements in addition to subjective assessments indicate that members of higher status groups tend to feel more bothered or annoyed by certain sources of noise, such as road traffic, at the same objective noise pollution level (Heinrich 2001). Due to the different status-specific responses, the actual existing noise pollution may be underestimated for people in lower status groups.

Many publications describe a relationship between noise-induced annoyance with a chronic effect (between 10 and 15 years) and the presence of higher risks of disease (Niemann et al. 2005; Eriksson 2007; Eriksson et al. 2010). This relationship pertains to various diseases including high blood pressure, cardiovascular diseases and metabolic diseases. The nationwide DEGS1 study of the RKI also outlines this relationship between road traffic noise pollution and metabolic diseases (Heidemann et al. 2014). The relational pattern found in the GEDA data showing that those bothered more severely by noise report more physical and mental health problems was also found in two other studies examining this relationship with respect to road traffic noise using other indicators for physical and mental health (Dratva et al. 2010; Welch et al. 2013).

Because a majority of the population is exposed to constant environmental noise, and noise or thereby caused annoyance can have a variety of different health effects, noise pollution should be considered as a significant public health problem (Passchier-Vermeer, Passchier 2000). This is also confirmed by the results of the GEDA study 2012. The prevention of noise annoyance in the population is therefore an important issue for public health.

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