

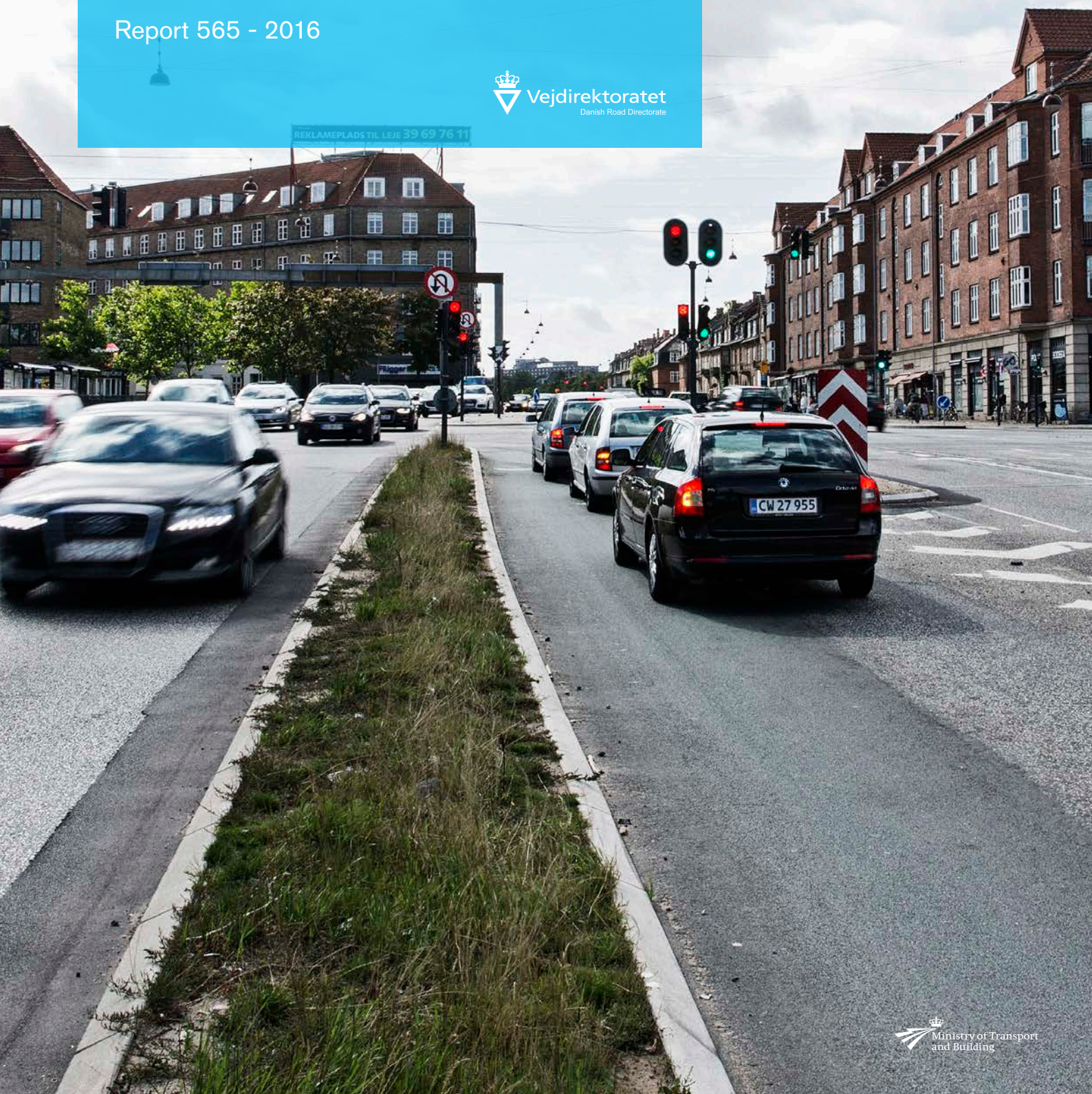
Noise annoyance from urban roads and motorways

Survey of the noise annoyance experienced
from road traffic for residents along motorways
and urban roads

Report 565 - 2016



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Contents

1. Summary	4
2. Introduction	6
3. Method	7
3.1 Calculated noise levels	7
3.2 Questionnaire - survey of the experienced annoyance	7
3.3 Conduct of interviews	8
3.4 Calculation of dose-response curves	9
4. Description of roads and geographic areas	10
4.1 Selection of roads and areas	10
4.2 Motorways	10
4.3 Urban roads	12
5. Respondents and noise impact	19
5.1 Distribution of respondents by road type	19
5.2 Distribution of noise levels	20
6. Relationship between noise impact and noise annoyance	21
6.1 Total dose-response for motorways and urban roads	22
6.2 Dose-response for motorways	22
6.3 Dose-response for urban roads	23
6.4 Drawing of dose-response curves	23
6.5 Comparison of motorways and urban roads	24
7. Factors which affect annoyance perception	26
7.1 Dwelling type	26
7.2 Overall annoyance perception, indoors and outdoors	28
7.3 Access to quiet side	30
7.4 Age	30
8. Comparison with other studies	34
8.1 General European dose-response curves (Miedema)	34
8.2 The Danish Environmental Protection Agency's survey of the difference between annoyance impact of motorway noise and noise from other roads	36
8.3 The Danish Road Directorate's previous survey of noise annoyance from urban roads and motorways	36
8.4 Swedish results about the relationship between quiet side and minor noise annoyance	38
9. Summary and conclusion	40
10. References	42
Appendix:	
Descriptive statistics - answers to questionnaire by road type	44

1. Summary

The Danish Road Directorate studied the noise annoyance from road traffic experienced by residents along motorways and urban roads in Denmark. This was done by studying the dose-response relationship, i.e. the noise impact to which a population is exposed (dose) compared to the share of the population which experiences some extent of annoyance (response).

The relationship between noise exposure and the experienced annoyance is relevant because annoyance from road traffic noise may have negative health effects. The dose-response relationship is also used as basis for determining indicative noise limits for the purpose of preventing and reducing noise annoyance from the road traffic.

The study was based on a questionnaire survey in the autumn of 2014, where about 7,000 respondents along motorways and urban roads answered questions about the extent to which they are annoyed by road traffic noise at their home. The answers were linked to information about the noise level to which the individual respondent is exposed at their home.

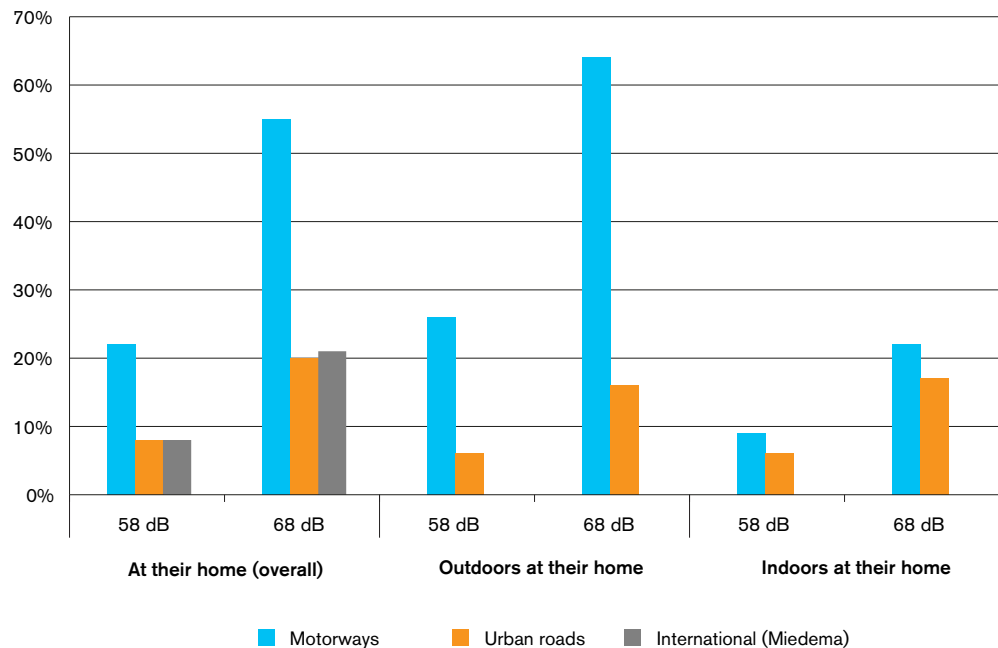
The study had three primary purposes:

- To study whether the noise annoyance experienced by residents along motorways is greater than the noise annoyance experienced by residents along urban roads, at the same noise levels.
- To compare the results for the dose-response relationship from this study with the general European noise annoyance curves (Miedema /3/).
- To make suggestions for the possible reasons why the noise annoyance from motorways is greater than from urban roads.

On the basis of the study, it can be concluded that:

- People who live along motorways are significantly more annoyed by road traffic noise compared to people who live along urban roads when they are exposed to the same noise level on the dwelling facade. 2-3 times as many people along motorways feel Highly annoyed compared to people along urban roads.

Figure 1.1
Proportion of people who feel Highly annoyed at noise levels of 58 dB and 68 dB (L_{den}) at their home (overall), outdoors at their home and indoors inside their home



Residents along motorways feel Annoyed at approx. 6- 13 dB lower noise levels compared to residents along urban roads.

- The annoyance experienced indoors in the home is almost the same for motorways and urban roads, while the annoyance outdoors at the home (in the garden, in the yard, etc.) is significantly greater along motorways than along urban roads.
- People who live along motorways are significantly more annoyed than shown by the European noise annoyance curves, whereas the annoyance for people who live along urban roads is in line with the general European noise curves.

The above points are summarised in figure 1, where the proportion of people who feel Highly annoyed at motorways, urban roads and in relation to the general European noise annoyance curve is compared at noise levels 58 dB and 68 dB (L_{den}). These are the levels of when a home in Denmark is regarded as noise exposed (58 dB) and severely noise exposed (68 dB).

A number of factors influence how annoyance is experienced, such as the noise characteristics (for example, a motorway may sound different than an urban road, and the characteristics of the traffic are different), the person who subjectively experiences the noise (the person's noise sensitivity, acceptance of noise, age, etc.), and the context in which the person experiences noise (e.g. the home, including whether the home is a single-family house/flat, indoors/outdoors, time, etc.).

Based on the available data, various contexts have been identified which influence the perception of noise annoyance. This has been described in more detail in the report. A number of contexts relate in particular to the dwelling conditions, each of which are factors which indicate that respondents along urban roads are less annoyed than those along the motorways, such as:

- People who live in flats are less annoyed than people who live in single-family houses – and significantly

more respondents live in flats along the urban roads.

- Access to a quiet facade in the home has a positive impact on the perception of annoyance – and significantly more homes in urban areas have a quiet facade.
- The overall perception of annoyance for people who live in single-family houses is mainly determined by the annoyance experienced outdoors in the garden, etc., while the overall annoyance experienced by people who live in flats is to a large degree determined by the annoyance experienced indoors in the home. It must be assumed that the outdoor recreational areas are generally less protected for single-family houses compared to flats. Many flats have yards where noise levels are typically low, while the outdoor areas at single-family houses are typically not shielded to the same extent.

In addition, it should be noted:

- That young people are less annoyed by traffic noise than elderly people - and relatively more young people live along the urban roads/in flats
- That the degree of acceptance of the noise level to which people are exposed has an influence on the experienced annoyance – the lower the acceptance, the greater the annoyance – and the respondents along the motorways generally have a lower degree of acceptance of noise levels compared to the respondents along urban roads.

As mentioned, a number of other factors than those stated above may contribute to the results of the study on relationship between noise levels and the noise annoyance experienced.

It is not the purpose of this report to specify actions or assess the consequences of the fact that the reported noise annoyance is significantly greater for motorways than for urban roads. However, the results give rise to considerations about how it can be taken into account in future that road traffic noise from motorways and urban roads is perceived very differently.

2. Introduction

Residents along roads in towns and cities and motorways experience noise annoyance from road traffic. A work report from the Danish Environmental Protection Agency from 2012 /1/ concluded that noise from motorways causes more annoyance than noise from urban roads at the same noise level. An additional survey carried out by the Danish Road Directorate in 2013 /2/ showed that noise from motorways causes more annoyance than noise from urban roads. The report concluded that noise from Motorring 3 in Copenhagen is perceived as a much greater annoyance than the noise from two urban roads in Copenhagen.

The Danish Road Directorate generally wants more knowledge of how road traffic noise affects people. This knowledge can be used in the future work to focus, improve and optimise efforts against road traffic noise. The Danish Road Directorate therefore carried out a major study of how citizens experience road traffic noise along motorways and urban roads in Denmark.

The primary purpose of this study was to find out whether the noise annoyance experienced by residents along motorways is greater than for residents along urban roads when the residents are exposed to the same average noise level from the road traffic and to make suggestions for the possible reasons for this difference.

In addition, the purpose was to compare the results of this study with the general European dose-response curves. The general European dose-response curves

/3/ were the result of collection of large volumes of data from many different annoyance studies in many different countries. The European dose-response curves are normally used to determine noise annoyance from roads and do not distinguish between noise from motorways and other roads.

This study was carried out on the basis of a large questionnaire survey with a total of approx. 7,000 respondents, evenly distributed by residents along motorways and along urban roads, and compared with data on the calculated noise level at the home of each individual respondent.

The project was carried out and managed by a project group consisting of:

Jakob Fryd, Danish Road Directorate (Project Manager)
 Lene Nøhr Michelsen, Danish Road Directorate
 Hans Bendtsen, Danish Road Directorate
 Lykke M. Iversen, Danish Road Directorate
 Torben Holm Petersen, ATS institute DELTA

In addition, Karen Forsting (Copenhagen Municipality) and Frank Pedersen (the Danish Environmental Protection Agency) participated in the analysis work. The market research firm Epinion A/S conducted the questionnaire survey and performed the subsequent data processing. In addition, the consultancy firm Ramboll assisted in the collection of noise data. The noise data for the study consist of extracts of noise mapping from the Danish Road Directorate and the municipalities of Copenhagen, Aarhus and Odense.

3. Method

The study was carried out on the basis of a large questionnaire survey with a total of approx. 7,000 respondents, evenly distributed by residents along motorways and along urban roads, and the results were compared with data on the calculated noise level at the home of each individual respondent. The following briefly describes the study method.

3.1 Calculated noise levels

Results from noise mapping of major roads and roads in larger cities have been used for the study. Common to all these noise mappings is that they have been carried out in accordance with the Environmental Noise Directive as implemented in Danish legislation /5/.

The Danish Road Directorate's noise mapping forms the basis of the study along the motorways, while noise mapping results from the municipalities of Copenhagen, Aarhus and Odense have been used for the study along the urban roads.

For all the mappings, noise levels have been calculated for the most noise-impacted dwelling facade. Noise is calculated as L_{den} (see fact box) using the Nord2000 propagation model /6/. The calculations were completed in 2012. The questionnaire survey was carried out in 2014. On the selected sections included in the study, the traffic conditions etc. are not considered to have changed so significantly during the period from 2012 to 2014 that it would have resulted in changes compared to the calculated noise levels in 2012.

The noise mappings are considered to be strategic noise mappings, unlike detailed noise calculations, and are assessed to be carried out with approximately the same systematics and level of detail. Given the large population studied, the results of the calculated noise levels are generally considered to form a solid and valid basis for estimating noise exposure of the respondents.

The calculated noise levels have been linked to each individual respondent by means of address details, and associated information about building and dwelling conditions from the Central Register of Buildings and Dwellings (BBR).

3.2 Questionnaire - survey of the experienced annoyance

The survey of the experienced annoyance was carried out on the basis of a questionnaire developed for the purpose. The survey contains many of the same questions as previous noise annoyance surveys carried out by the Danish Road Directorate, for instance along Motorring 3 /2/.

This report focuses on the relationship between road noise exposure at the home and the annoyance experienced by the respondent. The basis for the relationship between dose and response is the answer to the question: "Thinking about the last year or so, when you are at home, how much does noise from road traffic bother, disturb, or annoy you?". The respondents gave their answers on a numerical scale from 0 to 10 where 0 corresponds to "Not at all annoyed" and 10 corresponds to

What is L_{den} ?

The noise exposure from a road is expressed in decibels (dB) by the pan-European noise indicator, L_{den} . L_{den} is an overall weighting of the noise levels during the time periods day, evening and night. The calculation adds a 5 dB penalty to the noise level in the evening (19.00 - 22.00 hours) and a 10 dB penalty to the noise level at night (22.00 - 07.00 hours). The purpose is to take account of people's special noise sensitivity in the evening and at night. L_{den} is an English term for Level day-evening-night. L_{den} is calculated as an average level for a year.

The Danish Environmental Protection Agency has laid down an indicative threshold limit value for road traffic noise at dwellings of 58 dB, L_{den} . The threshold limit value expresses the maximum noise exposure deemed acceptable by the Danish Environmental Protection Agency seen from an environmental and health perspective.

3.4 Calculation of dose-response curves

The calculation of dose-response curves uses data about the calculated noise level, L_{den} , at the most exposed facade of each home and the respondent's related answers to questions about noise annoyance. Dose-response curves between the self-reported noise annoyance and the noise level (L_{den}) and 95% confidence intervals have been calculated by using logistic regression, where the answers concerning noise annoyance is divided into 1 dB noise classes which are weighted relative to the number of responses.

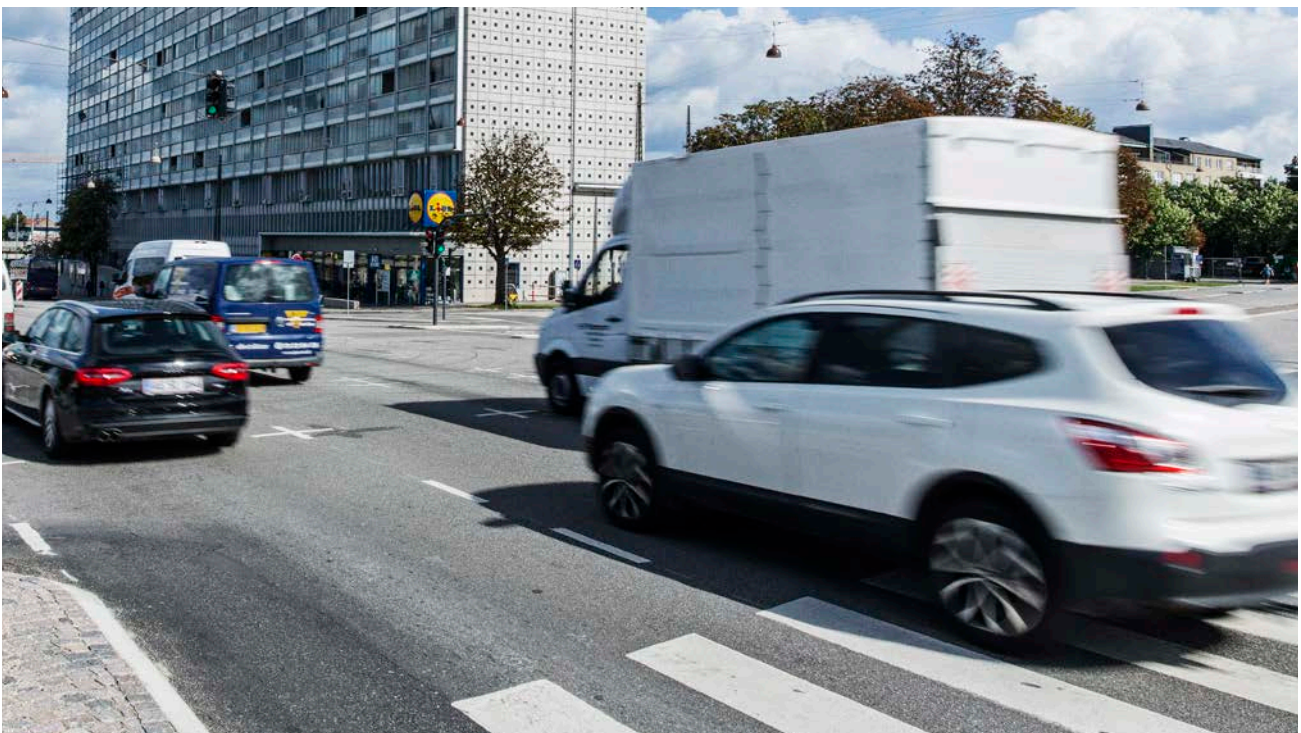
The dose-response relationship is described by a logistic function which is calculated by grouping the respondents into level classes of noise level (L_{den}) corresponding to 1 dB intervals. For each level class, the percentage of Highly annoyed, Annoyed and Slightly annoyed has been calculated on a scale for experienced noise annoyance ("... how much does noise from road traffic bother, disturb or annoy you ..."). The numerical scale (from 0: not at all annoyed; to 10: extremely annoyed) has also been used, unless otherwise indicated. Logistic transformation has been performed of these percentages. Linear regression has been performed where the transformed percentages are compared with the noise level (L_{den}). In the regressions, the level classes have been weighted according to the number of respondents in the relevant group. The method follows the similar method from previous surveys for the Danish Road Directorate, see references /2/ and /3/.

The curves shown are limited to the L_{den} -interval, where there is actually a meaningful grouping of observations, i.e. in the range 48 - 75 dB. A numerical response scale from 0 to 10 is used, allowing the respondent to grade answers about the degree of the experienced annoyance. The response scale is in accordance with the ISO 15 666 standard /7/, meaning that results about reported annoyance are comparable with similar surveys elsewhere and in other countries.

The following descriptors for noise annoyance have been used:

- Highly annoyed: All answers in the categories 8, 9 and 10
- Annoyed: All answers in the categories 5 to 10
- Slightly annoyed: All answers in the categories 3 to 10

Thus, the dose-response curves show a relationship between the respondents' experience of noise annoyance and the noise level (L_{den}), i.e. the average noise impact over a period of a year. The associated confidence intervals indicate the uncertainty of the calculated dose-response curve. If confidence intervals cross each other on the dose-response curves, the uncertainty is greater than the difference between the curves, and the difference cannot be regarded as significant.



4. Description of roads and geographic areas

4.1 Selection of roads and areas

The purpose of the noise annoyance survey was to study the differences in the noise annoyance experienced from motorways and urban roads, respectively. On this basis, it was important that the respondents in this study lived in areas where the primary source of road traffic noise was motorways and urban roads, respectively. Also, it was important that the respondents, and the environments in which they live, are roughly representative of people who live along motorways and urban roads in Denmark. For this reason, the criteria for selection of road sections for the survey were a reasonable distribution between road types, area types and geography.

The motorways include sections that affect residential areas in large cities (Aalborg, Odense and Copenhagen), and affect urban communities and residential areas in rural areas in Jutland and on Funen and Zealand. The urban roads include sections in the three largest cities in Denmark, Copenhagen, Aarhus and Odense. The road sections in agglomerations are both urban roads with little traffic, shopping streets and large, busy throughroads.

In the selection of road sections, it was also important that no conditions have changed the road noise significantly within the past year before the questionnaire survey was carried out. In this way, it was ensured that there were no noise conditions, which may have had an influence on the respondents' answers in relation to the calculated noise level. As an example, sections where noise barriers have recently been established were avoided. Sections with new asphalt, construction works and recent roadworks, traffic diversions, etc. were also excluded, since this may have resulted in changed noise levels which have not been included in the results of the noise mapping.

The general map in figure 4.1 shows the motorway sections, towns and cities which are included in the study.

4.2 Motorways

The selected motorways sections represent motorways through rural areas and through large cities such as Aalborg, Odense and Copenhagen. Furthermore, the motorway sections are located in different regions such as North and East Jutland, Funen and Zealand.

Altogether, the sections represent approx. 200 km motorway with speed limits from 110 km/h to 130 km/h. This corresponds to approx. 10% of the total Danish motorway system.

North Jutland Motorway (Aalborg - Støvring)

The section runs through Aalborg Øst, from the motorway intersection Vendsyssel just north of Limfjorden to a little south of Støvring to the south. The approx. 29 km long section passes close to residential areas in Aalborg Øst with single-family houses and a few multi-storey buildings. The southern half of the section passes close to Dall Villaby and Støvring, but otherwise it primarily runs in the open land with isolated properties. The annual average daily traffic is approx. 40,000 - 50,000 vehicles, and the signposted speed limit is 110 km/h or 130 km/h with variable speed at Limfjordtunnellen. The proportion of heavy vehicles is approx. 10 - 15%.

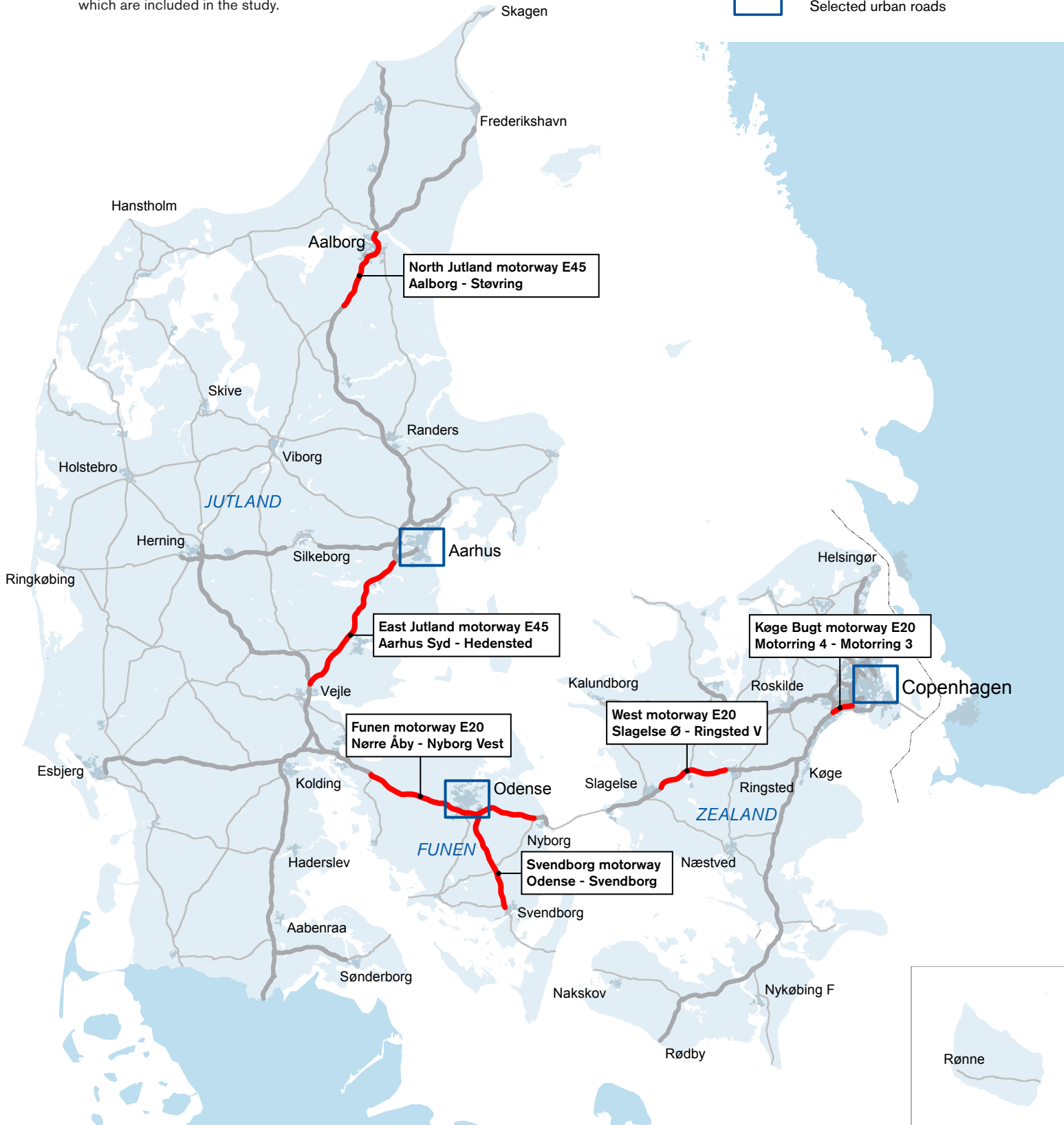
East Jutland Motorway (Aarhus Syd - Hedensted)

The section runs from the motorway intersection Aarhus Syd to Hedensted north of Vejle. The approx. 52 km long section primarily runs in the open land, but also in the vicinity of a number of residential areas at Skanderborg, Stilling, Hørning, Hatting etc. The dwellings along the section are single-family houses and isolated properties. The annual average daily traffic is approx. 40,000 - 60,000 vehicles. The speed limit on the section is 130 km/h. The proportion of heavy vehicles is approx. 10 - 15% on the southern half of the section, while the proportion of heavy vehicles is approx. 15 - 20% on the northern half.

Figure 4.1

General map showing the motorway sections and agglomerations which are included in the study.

- █ Selected motorways sections
- Selected urban roads



Funen motorway (Nørre Åby - Nyborg Vest)

The section runs from Nørre Åby in the west to Route 8 in the east. The approx. 58 km long section primarily runs in the open land, with passage of a few urban communities. The section passes large urban areas at Odense Syd. The dwellings along the section are mainly single-family houses and isolated properties. Around Odense, there are also terraced houses and a few multi-storey buildings. The annual average daily traffic is approx. 40,000-60,000 vehicles, and the speed limit is 130 km/h and 110 km/h at some sections around Odense. The proportion of heavy vehicles is approx. 15-20% on most of the section.

Svendborg Motorway

The section runs from Fynske Motorvej in the north to Svendborg in the south. The approx. 34 km long section primarily runs in the open land, with passage of a few towns such as Ringe and Kværndrup. The dwellings along the section are mainly single-family houses and isolated properties. The annual average daily traffic is 20,000 - 40,000 on the section north of Ringe and approx. 10,000 - 20,000 south of Ringe. The proportion of heavy vehicles is less than 10%. The speed limit on the section is 130 km/h.

West Motorway (Slagelse Øst - Ringsted Vest)

The section runs from Slagelse Øst to slightly west of Ringsted. The approx. 24 km long section primarily runs in the open land, however with passage of a large urban community at Pedersborg near Sorø. The dwellings along the section are mainly single-family houses and isolated properties. The annual average daily traffic is approx. 40,000-60,000, with a proportion of heavy vehicles of approx. 15-20% west of Sorø and 10-15% east of Sorø. The speed limit on the section is 130 km/h.

Køge Bugt Motorway (Motorring 4 - Motorring 3)

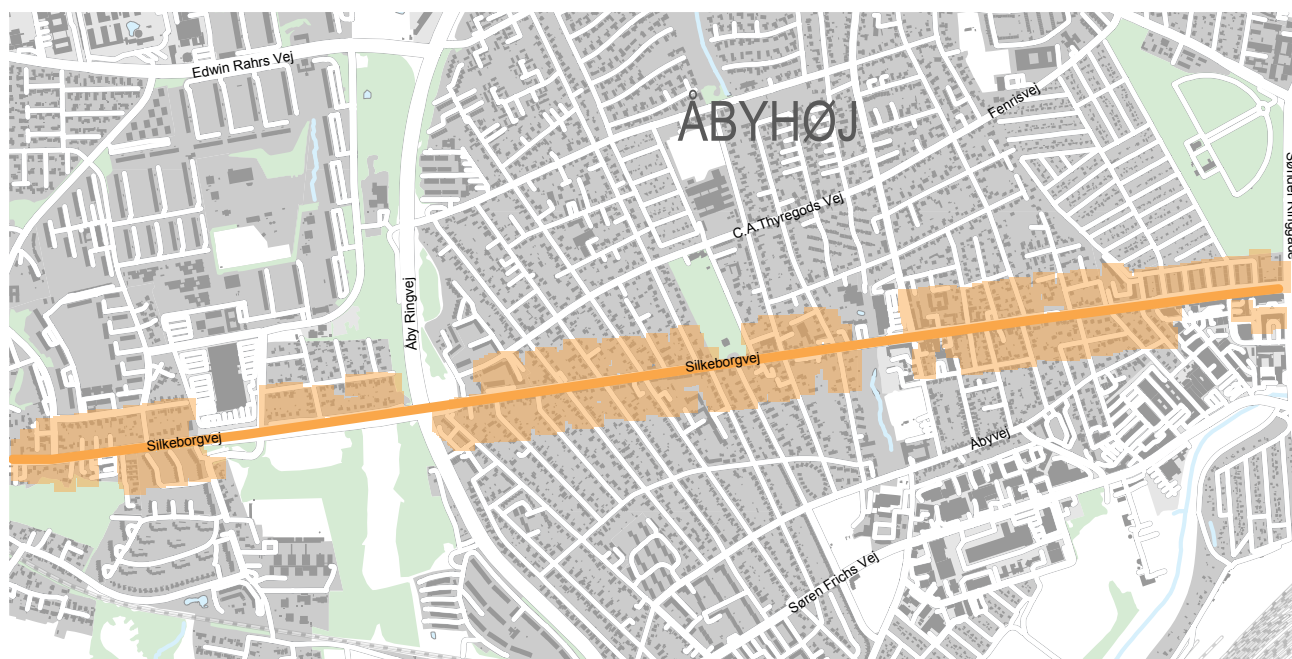
The section runs from Motorring 4 in the west to the merge with Motorring 3 in the east. The approx. 7 km long section runs through the municipalities of Ishøj, Valensbæk and Brøndby. The section is one of the large radial motorways to Copenhagen. The dwellings along the section are both single-family houses, terraced houses and multi-storey buildings. The annual average daily traffic is approx. 60,000-80,000, with a proportion of heavy vehicles of approx. 10-15%. The speed limit on the section is 110 km/h. Along this motorway section, it has been decided only to include respondents who live relatively close to the motorway (with noise levels above approx. 63 dB from the motorway), as it was assessed that dwellings with a noise level below 63 dB from the motorway may be affected by noise from local roads in the area. Noise from local roads is not included in the noise level at the respondent's address because this could affect the questionnaire response, including the relationship between the calculated noise level and the reported annoyance.

4.3 Urban roads

The choice of urban roads, including residential areas of different types and with different functions, is distributed between the cities Copenhagen, Aarhus and Odense. The choice of roads includes large throughroads, distributor roads, shopping streets and small local roads, each of which have different characteristics in relation to traffic intensity and type of area. In general, the urban roads have a significantly smaller proportion of heavy traffic compared to motorways, and of course a significantly lower speed limit.

On the following pages, general maps show the roads and residential areas which formed part of the study.

Aarhus - Silkeborgvej



Road name	Annual average daily traffic	Speed limit	Main features
Silkeborgvej	approx. 12.000 - 20.000	70 km/h	Major Throughroad / mixed housing

Aarhus - Frederiksbjerg



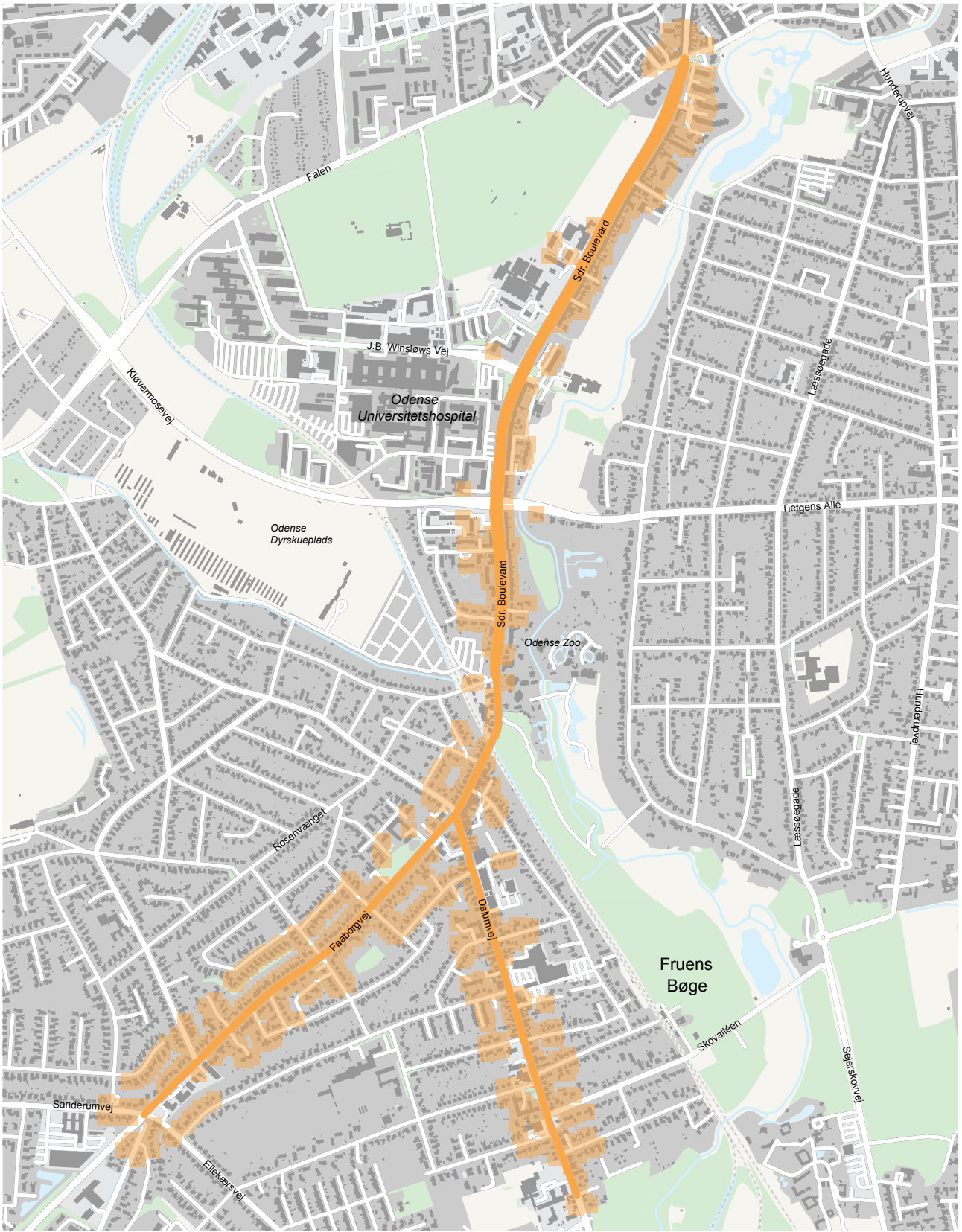
Road name	Annual average daily traffic	Speed limit	Main features
Marselisborg Alle	approx. 2.000	50 km/h	Small local road / multi-storey buildings
Odensevej	approx. 5.000	50 km/h	Small local road / multi-storey buildings
Ingerslevs Boulevard	approx. 5.000	50 km/h	Small local road / multi-storey buildings
Jægersgårdsgade	approx. 4.000	50 km/h	Shopping street / multi-storey buildings
Frederiks Alle	approx. 16.000	50 km/h	Shopping street / multi-storey buildings
De Mezas Vej	approx. 18.000	50 km/h	Throughroad / multi-storey buildings

Odense - Skibusvej



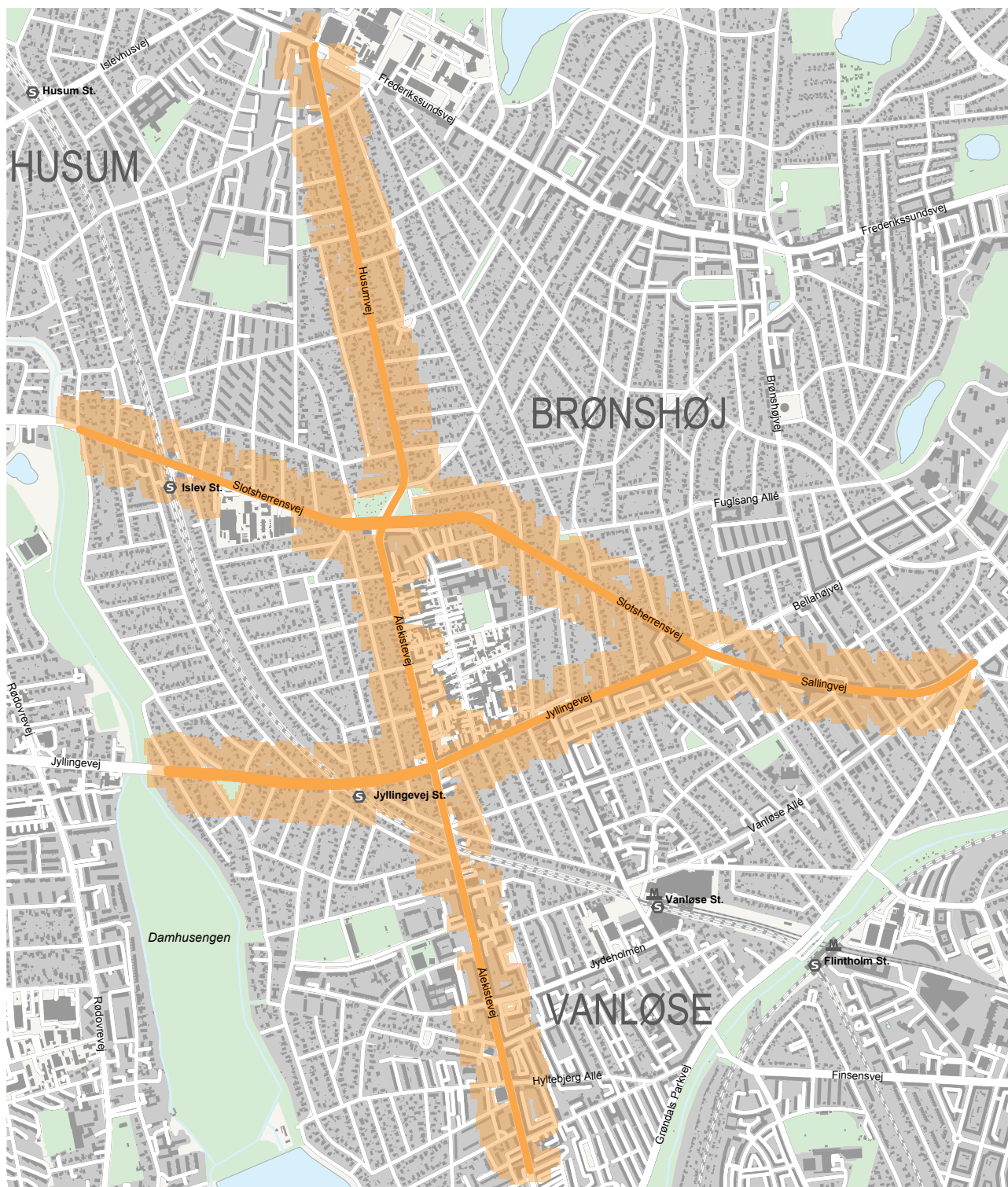
Road name	Annual average daily traffic	Speed limit	Main features
Skibusvej	approx. 6.000	50 km/h	Major Throughroad/shopping street/mixed housing

Odense - Sdr. Boulevard, Faaborgvej, Dalumvej



Road name	Annual average daily traffic	Speed limit	Main features
Faaborgvej	12.000 - 17.000	50 km/h	Throughroad/single-family houses
Søndre Boulevard	17.000 - 20.000	50 km/h	Throughroad/multi-storey buildings
Dalumvej	11.000 - 13.000	50 km/h	Throughroad/single-family houses

Copenhagen - Vanløse, Brønshøj, Husum



Road name	Annual average daily traffic – (heavy vehicles)	Speed limit	Main features
Husumvej	approx. 8.700 (2 %)	50 km/h	Small local road / single-family houses
Ålekistevej	approx. 13.900 (3 %)	50 km/h	Throughroad / mixed housing
Slotsherrensvej	approx. 15.900 (2 %)	50 km/h	Throughroad / single-family houses
Sallingvej	approx. 22.600 (3 %)	50 km/h	Throughroad / multi-storey buildings
Jyllingevej	approx. 24.000 (3 %)	60 km/h	Throughroad / mixed housing

Copenhagen - Amager



Road name	Annual average daily traffic – (heavy vehicles)	Speed limit	Main features
Øresundsvej	approx. 6.800 (6 %)	50 km/h	Throughroad / mixed housing
Englandsvej	approx. 8.800 (5 %)	50 km/h	Throughroad / mixed housing
Vejlands Allé	approx. 6.300 (6 %)	50 km/h	Small local road / single-family houses

Copenhagen - Østerbro



Road name	Annual average daily traffic – (heavy vehicles)	Speed limit	Main features
Classensgade	approx. 5.100 (5 %)	50 km/h	Small local road / multi-storey buildings
Østerbrogade	approx. 19.900 (4 %)	50 km/h	Shopping street / multi-storey buildings
Nordre Frihavnsgade	approx. 6.100 (7 %)	50 km/h	Shopping street / multi-storey buildings

5. Respondents and noise exposure

5.1 Distribution of respondents by road type

The following contains a presentation of how the respondents are distributed along motorways and urban roads. Figure 5.1 shows the overall proportion of respondents at motorways and urban roads. Almost the same number of responses has been received from residents at motorways as from residents at urban roads.

Figure 5.2 shows the percentage distribution of respondents along the individual urban road and motorway sections. The figure shows that the percentage distribution varies between approx. 4% and approx. 12% of the total population covered by the survey. It also shows that the study has a reasonably balanced distribution of respondents between Jutland (36%), Funen (34%) and Zealand (30%). The distribution of respondents along urban roads is 17% from Aarhus, 15% from Odense and 17% from Copenhagen.

Figure 5.1
Overall - distribution of respondents by road type

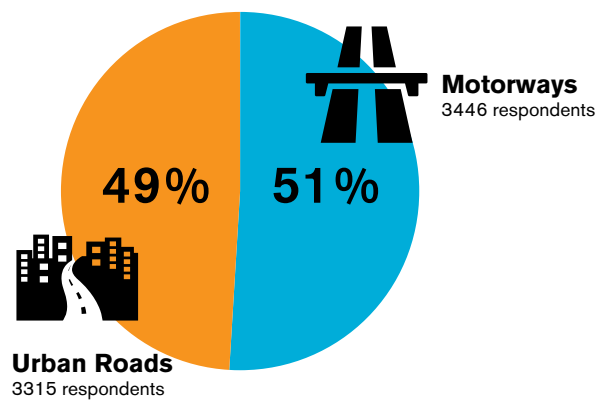


Figure 5.2
The percentage distribution of respondents along urban road and motorway sections relative to the total number of respondents

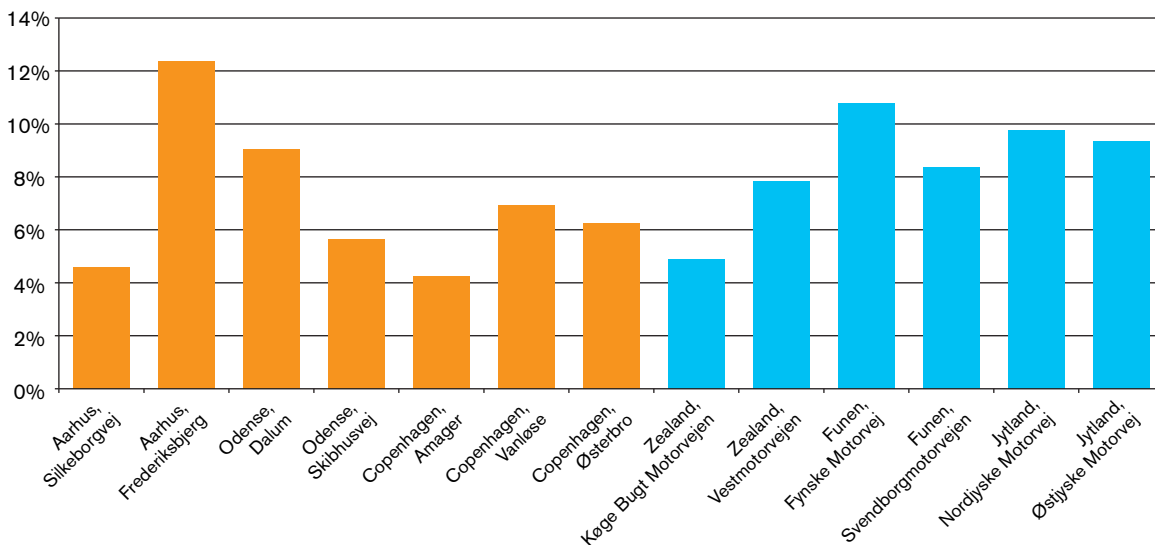
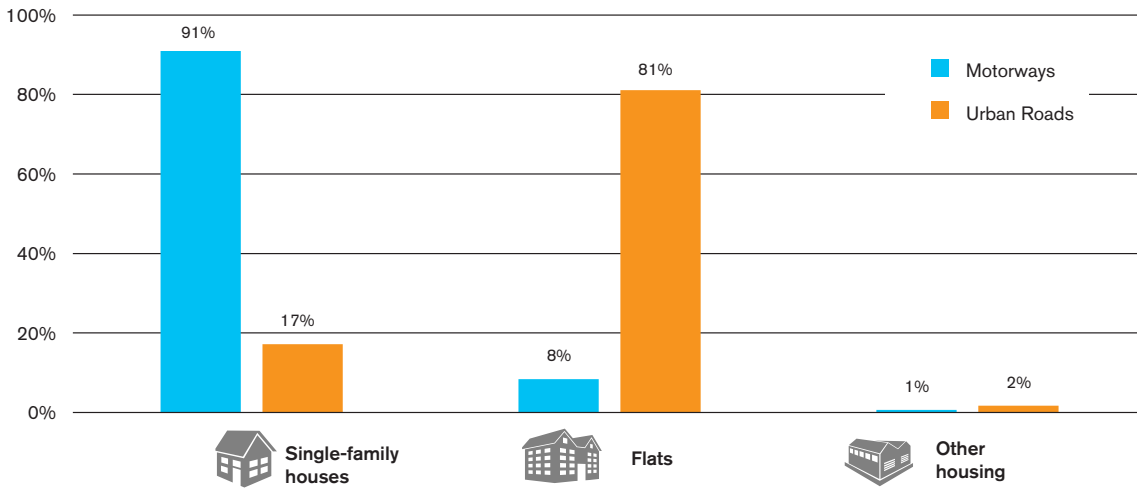


Figure 5.3

The percentage distribution of dwelling type by motorways and urban roads



The percentage distribution of the respondents' dwelling type, stated as single-family house or flat either along motorways or urban roads, can be seen in figure 5.3. The figure shows that the distribution between dwelling types is nearly inversely proportional. The majority of respondents at motorways lives in single-family houses, while the majority of respondents at urban roads lives in flats.

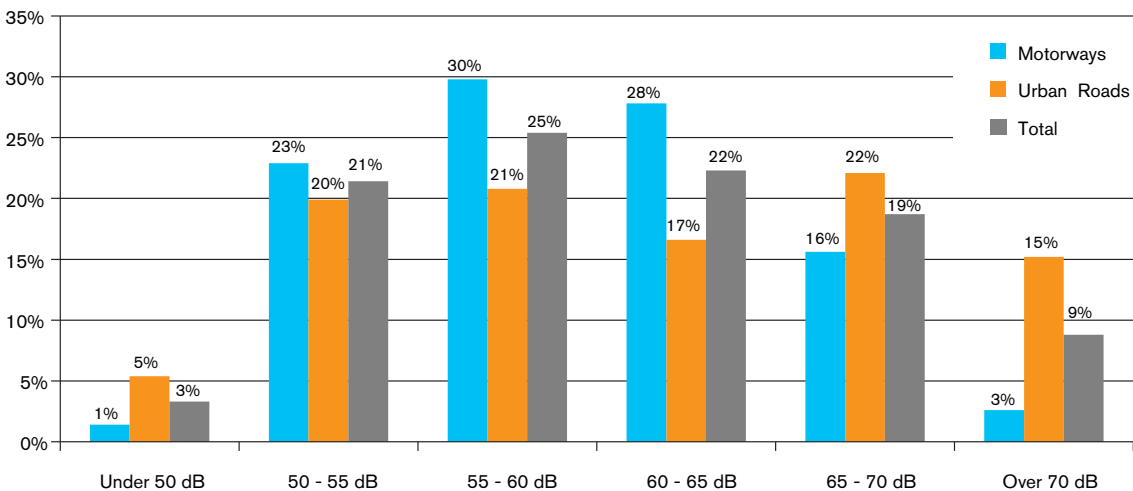
along road types differs. Along the urban roads, 37% of the homes have a noise impact of more than 65 dB, whereas "only" 19% of the homes along the motorways have a noise impact of more than 65 dB. Dwellings in towns and cities are generally exposed to noise levels in the high end compared to dwellings at motorways because many of the dwellings are located close to the noise source, while along motorways, the distance to the dwellings is generally greater. However, it should be noted that the areas and the road sections have been selected so as to ensure that the answers represent an impact from both high and low noise levels along motorways and urban roads, respectively.

5.2 Distribution of noise levels

The distribution of noise levels at the dwelling facade for all respondents, by motorways and urban roads, is shown in figure 5.4. The distribution of the noise levels

Figure 5.4

Percentage distribution of noise levels at the respondent's dwelling facade by motorways, urban roads and total



6. Relationship between noise impact and noise annoyance

This section describes the most important relationships between the noise level (L_{den}) at the dwelling and the experienced annoyance. The relationship is illustrated by means of dose-response curves and is limited to the noise range for which a sufficient number of answers has been received.

The dose-response relationship has been studied in three different situations:

1. **Overall annoyance** when people are at home, by asking:
"Thinking about the last year or so, **when you are at home**, how much does the noise from road traffic bother, disturb or annoy you?".
2. **Annoyance indoors** in the home, by asking:
"Thinking about the last year or so, **when you are inside your home**, how much does the noise from road traffic bother, disturb or annoy you?".
3. **Annoyance outdoors** at the home, by asking:
"Thinking about the last year or so, **when you are outside in the garden, yard or on the balcony at your home**, how much does the noise from road traffic bother, disturb or annoy you?".

For each question, the respondent can specify the degree of the annoyance (see section 3.2). Subsequently, answers from the individual respondents have been linked to the calculated noise level at the respondent's dwelling facade.

Usually, the dose-response relationship for the overall annoyance at the home (see item 1 above) is used as an indicator of how annoyed people are at different levels of road traffic noise. According to the Danish Environmental Protection Agency's guidelines on road traffic noise /8/, the guideline threshold limit value for noise at residential areas is 58 dB, which should correspond to 22% of the population feeling Annoyed (or more than Annoyed), of which 9% are Highly annoyed (or more than

Highly annoyed). This survey indicates that significantly more residents along motorways are annoyed by the noise than previously assumed.

The dose-response curves are described with the following terminology (see also section 3.4):

- **Highly annoyed** = Proportion of respondents stating that they are Highly annoyed or more than Highly annoyed.
- **Annoyed** = Proportion of respondents who feel Annoyed or more than Annoyed.
- **Slightly annoyed** = Proportion of respondents stating that they are Slightly annoyed or more than Slightly annoyed.

Relationship between noise impact and noise annoyance

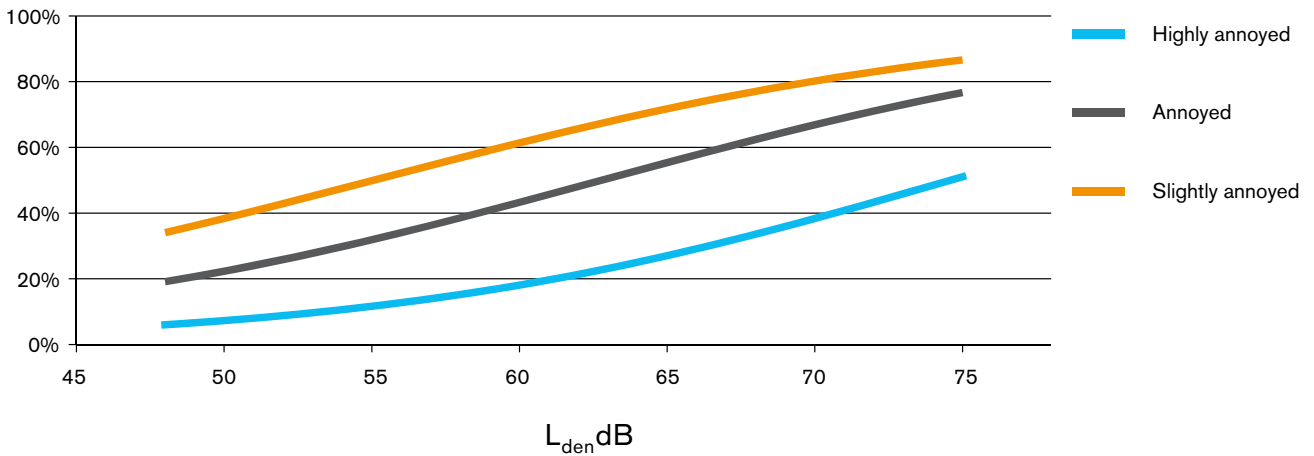


Figure 6.1
Dose-response - overall for the entire study including both motorways and urban roads

6.1 Total dose-response for motorways and urban roads

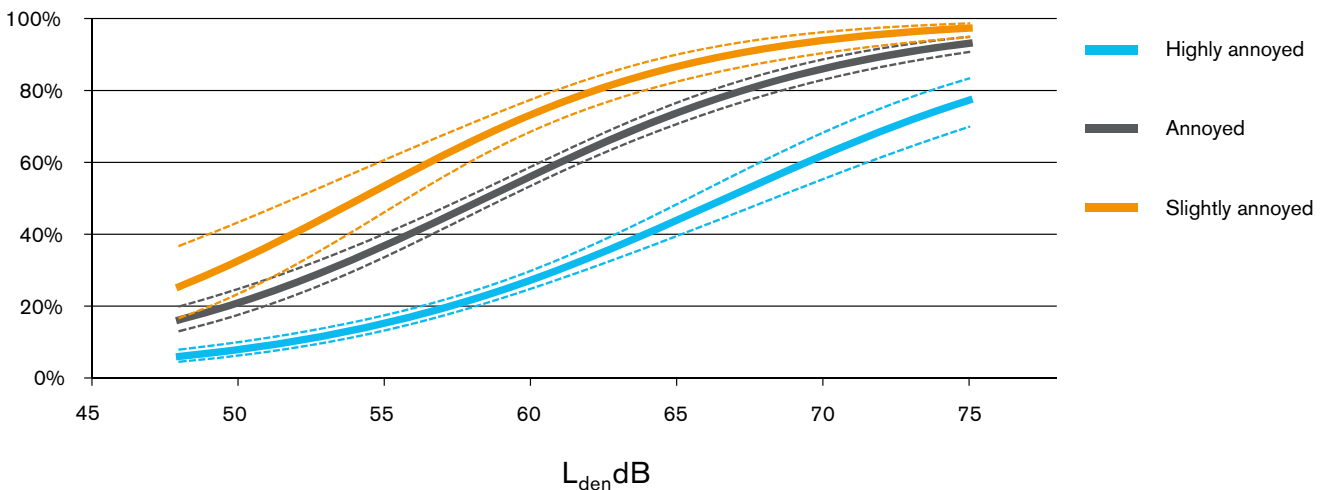
The dose-response curves in figure 6.1 show the overall results for all respondents in the survey (i.e. motorways and urban roads together), when they are asked about the noise annoyance in their home. As an example, approx. 39% state that they are Annoyed by the noise at a noise level of 58 dB, of which approx. 15% state that they are Highly annoyed.

It should be noted that the above dose-response curves are not representative of an overall dose-response curve for road traffic noise and annoyance in Denmark, since Denmark has more dwellings along urban roads than along motorways, which means that annoyance from motorway noise is over-represented in the above curves.

6.2 Dose-response for motorways

Figure 6.2 shows the dose-response relationship for respondents who are exposed to noise from motorways, Highly annoyed, Annoyed and Slightly annoyed, respectively. The figure shows that approx. 22% of the respondents feel Highly annoyed when the noise level at the dwelling facade is 58 dB, while 48% of the respondents feel Annoyed at 58 dB.

Figure 6.2
Dose-response for motorways (overall annoyance "when you are at home"). The dotted curves indicate 95% confidence intervals for the curves (see explanation in section 3.4).

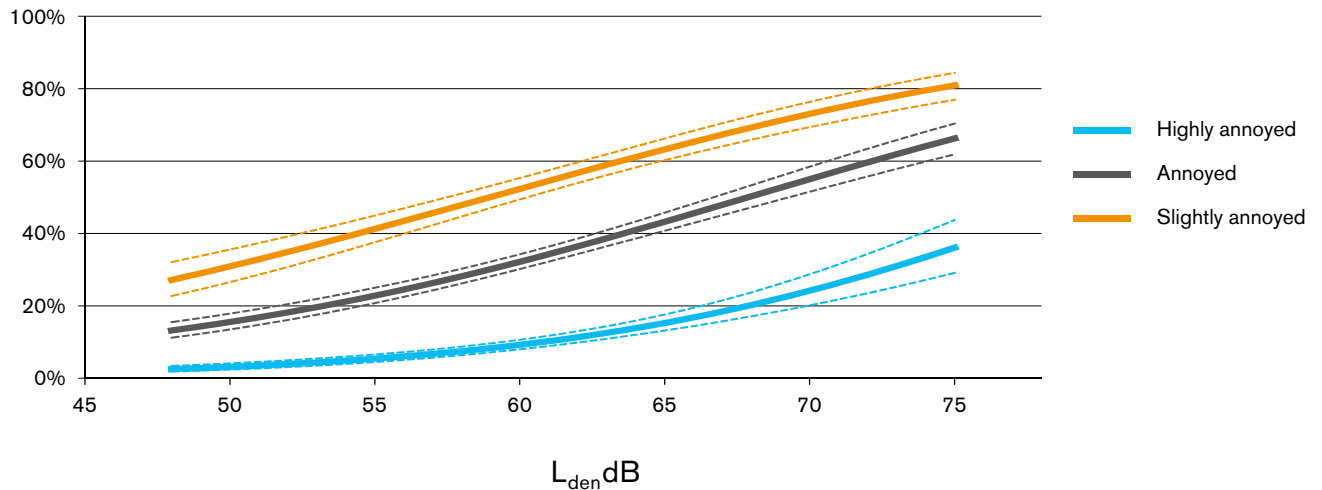


6.3 Dose-response for urban roads

Figure 6.3 shows the dose-response relationship between respondents who are exposed to noise from urban roads, Highly annoyed, Annoyed and Slightly annoyed, respectively. The figure shows that approx. 8% of the respondents feel Highly annoyed when the noise level at the most noisy dwelling facade is 58 dB, while 28% of the respondents feel Annoyed at 58 dB.

Figure 6.3

Dose-response for urban roads (overall annoyance "when you are at home"). The dotted curves indicate 95% confidence intervals for the curves



6.4 Drawing of dose-response curves

It may be relevant for users of the report to be able to draw the dose-response curves of this study for motorways and urban roads, respectively. The constants for the dose-response curves for motorways and urban roads from this study are shown in table 6.1.

The dose-response curves are expressed as /2/:

$$A = u / (1 + e^{-s(E-f)})$$

Where;

A is the percentage of annoyed (HA, A, LA) respondents

u is the upper limit of A (i.e. u = 100)

s is the slope

E is the noise Exposure, L_{den}

f is the value of E for a fifty percent annoyance response

Table 6.1

Constants for the dose-response curves in figure 6.3. L_{den} is the value for 50% annoyed (Highly annoyed, Annoyed and Slightly annoyed) and s expresses the steepness of the curves. The meaning of the constants is explained in more detail in the appendix to the Danish Road Directorate's report 44, 2013 /2/

Constants for the dose-response curves	Motorways		Urban Roads	
	f, dB	s	f, dB	s
Highly annoyed	66,7	0,147	80,0	0,114
Annoyed	58,4	0,157	67,9	0,095
Slightly annoyed	54,2	0,173	58,9	0,090

6.5 Comparison of motorways and urban roads

The difference between the dose-response curves for motorways and urban roads is significant when comparing the curves for the overall noise annoyance in the home (see figure 6.4). The overall noise annoyance is significantly higher along motorways than along urban roads. As an example, the proportion of respondents who are Highly annoyed at 65 dB at the dwelling facade is 44% along the motorway against 15% along the urban road.

If we compare the noise annoyance curves for Annoyed in figure 6.4, we see that at a noise level of 53 dB from motorways, 30% state that they are Annoyed whereas it is not until approx. 59 dB along urban roads that a similar proportion feels Annoyed. The difference in annoy-

ance from motorways and urban roads increases with the noise impact. At a noise level of 63 dB from motorways, approx. 67% state that they are Annoyed whereas the same proportion of Annoyed occurs at approx. 75 dB along urban roads.

If we compare the dose-response curves for motorways and urban roads with the experienced annoyance inside the home (see figure 6.5), the difference in experienced noise across road type is considerably smaller and not significant. However, if we look at the annoyance experienced outside the home (see figure 6.6), the difference is very pronounced. For motorway respondents the noise annoyance is significantly higher than for people who live near urban roads. Reasons for this difference are discussed in the following section.

Figure 6.4
Comparison of motorways and urban roads.
Dose-response curves for overall noise annoyance in the home.

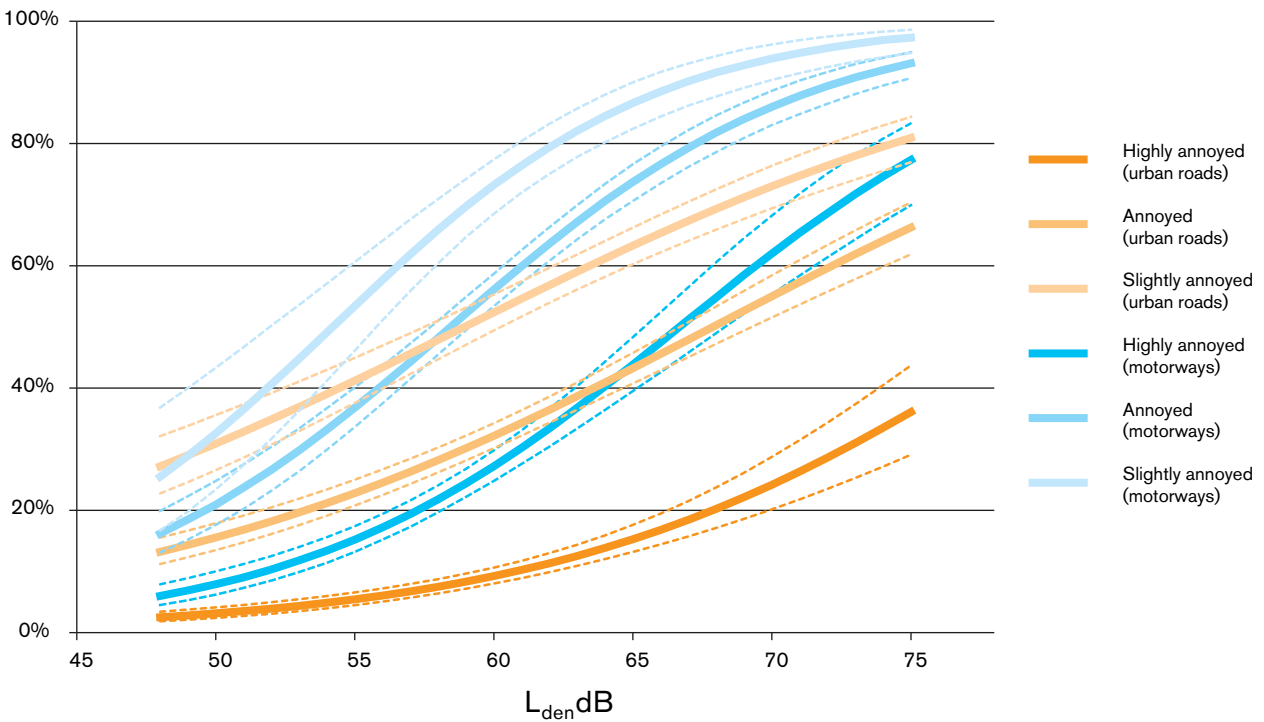


Figure 6.5
Comparison of motorways and urban roads (indoors).
Dose-response curves for noise annoyance experienced inside the home.

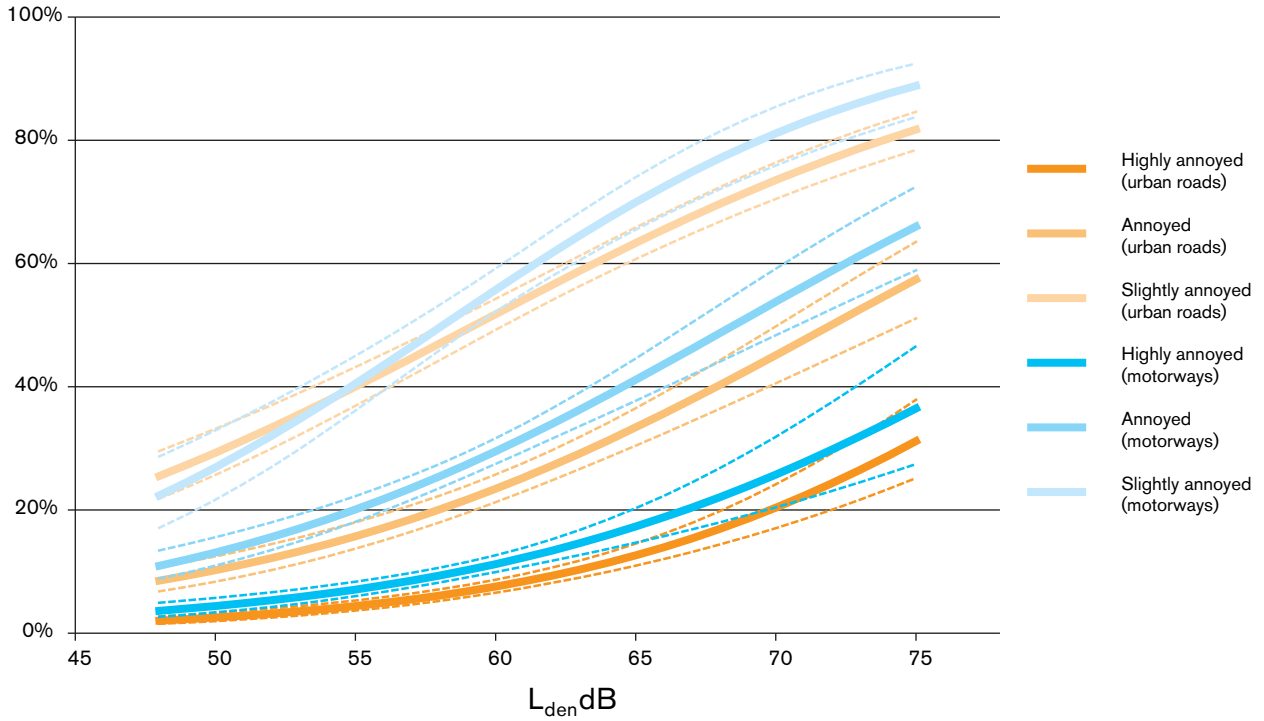
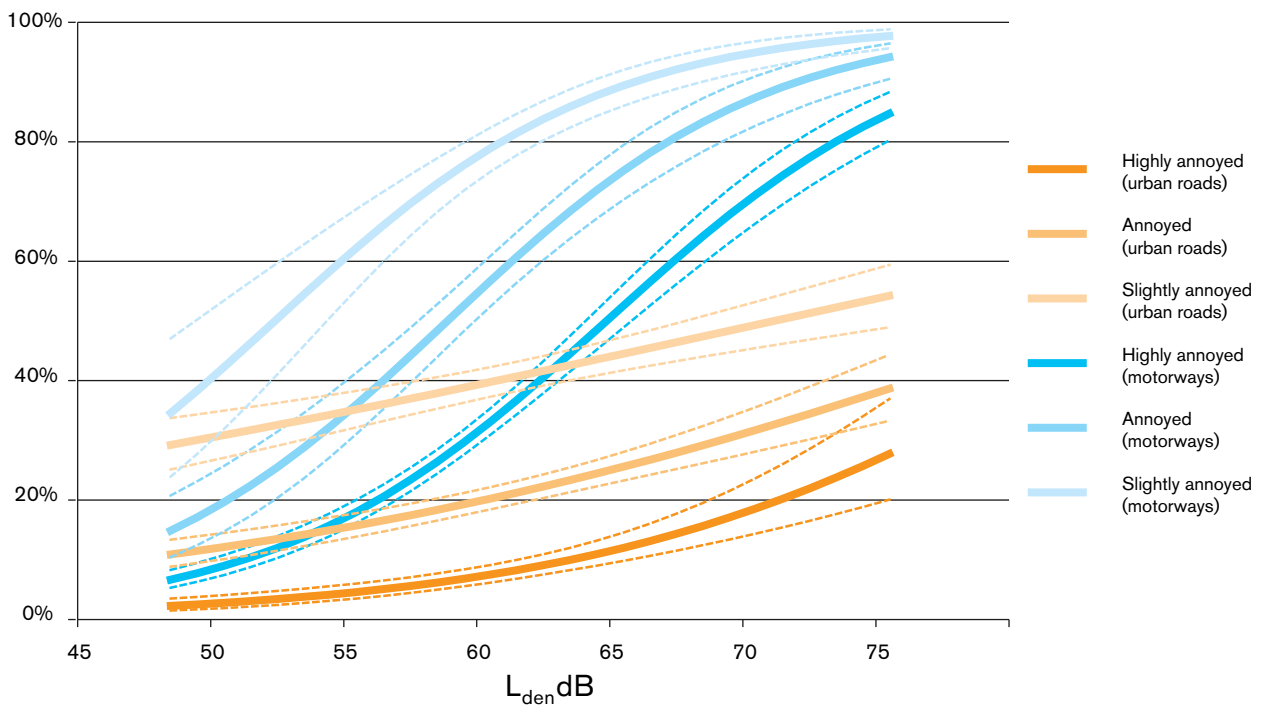


Figure 6.6
Comparison of motorways and urban roads (outdoors).
Dose-response curves for noise annoyance experienced outdoors at the home.



7. Factors which affect annoyance perception

Basically, it is important to take note of the fact that people are annoyed to the extent that they state. That said, it is of course relevant to study the reasons why the same noise exposure does not cause the same noise annoyance in different situations. The project team has tried to identify the factors that might affect the dose-response curves and to clarify why motorway neighbours are more annoyed by the same noise level compared to urban road neighbours.

Factors of relevance for the experienced noise annoyance might be the noise characteristics (a motorway sounds differently than an urban road and the traffic composition, diurnal distribution and speed differ), the person who subjectively experience the noise (noise sensitivity, acceptance of noise, age, etc.), and the context in which the person experiences the noise (e.g. in the home, indoors/outdoors, time of day, etc.) and not least the dwelling type (single-family house/flat).

Based on the available data, various contexts have been identified which influence the perception of noise annoyance. This is discussed in more detail in the following sections. A number of contexts relate to the dwelling conditions, each of which is a factor which indicates that respondents along urban roads are less annoyed than those along the motorways, such as:

- The dwelling type is relevant for the noise annoyance. People who live in flats are less annoyed than people who live in single-family houses – and significantly more respondents live in flats along the urban roads.
- Access to a quiet facade in the home has a positive impact on the perception of annoyance – and significantly more flats have a quiet facade.
- The overall perception of annoyance for people who live in single-family houses is mainly determined by the annoyance experienced outdoors in the garden, etc., while the overall annoyance experienced by people who live in flats is to a large degree determined by the annoyance experienced indoors in the home. It must be assumed that the outdoor recreational areas

are generally less protected for single-family houses compared to flats. Many flats have yards where noise levels are typically low, while the outdoor areas at single-family houses are typically not shielded to the same extent.

In addition, it should be noted:

- That young people are less annoyed by traffic noise than elderly people - and relatively more young people live along the urban roads/in flats
- That the degree of acceptance of the noise level to which you are exposed, has an influence on the experienced annoyance. Respondents along motorways generally have a lower degree of acceptance of the noise levels compared to respondents along urban roads
- The background for the above conclusions has been described in more detail in the following sections.

7.1 Dwelling type

The following figures 7.1, 7.2 and 7.3 show the proportion of respondents who are Highly annoyed by dwelling type; flat and single-family house.

Figure 7.1 shows the total proportion of respondents (motorways and urban roads) who are Highly annoyed by flats and single-family houses. The figure shows that people who live in single-family houses are significantly more annoyed than people who live in apartments. At a given noise level, more than twice as many people in single-family houses state that they are Highly annoyed than people who live in flats. In the interpretation of the curve, it must be borne in mind that most of the single-family houses are located along the motorways, and most of the flats are located along the urban roads.

Figure 7.2 shows the proportion of respondents in single-family houses who feel Highly annoyed by noise from motorways and from urban roads. It should be noted that in the case of single-family houses at a noise level of

Factors which affect annoyance perception

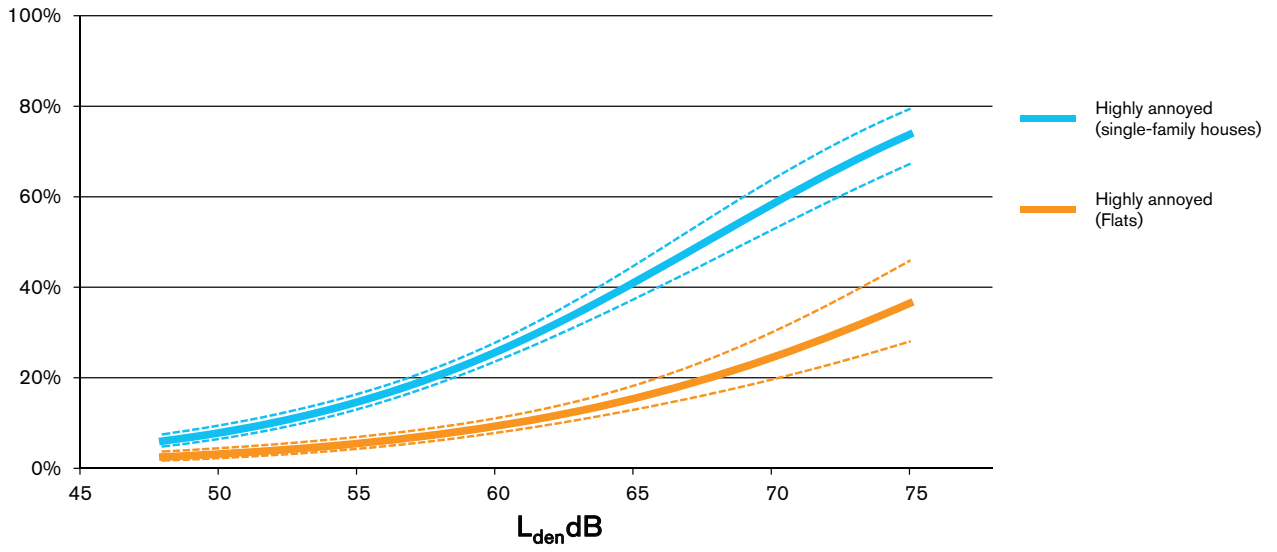


Figure 7.1
Dwelling type and the proportion of Highly annoyed respondents of the total number of respondents

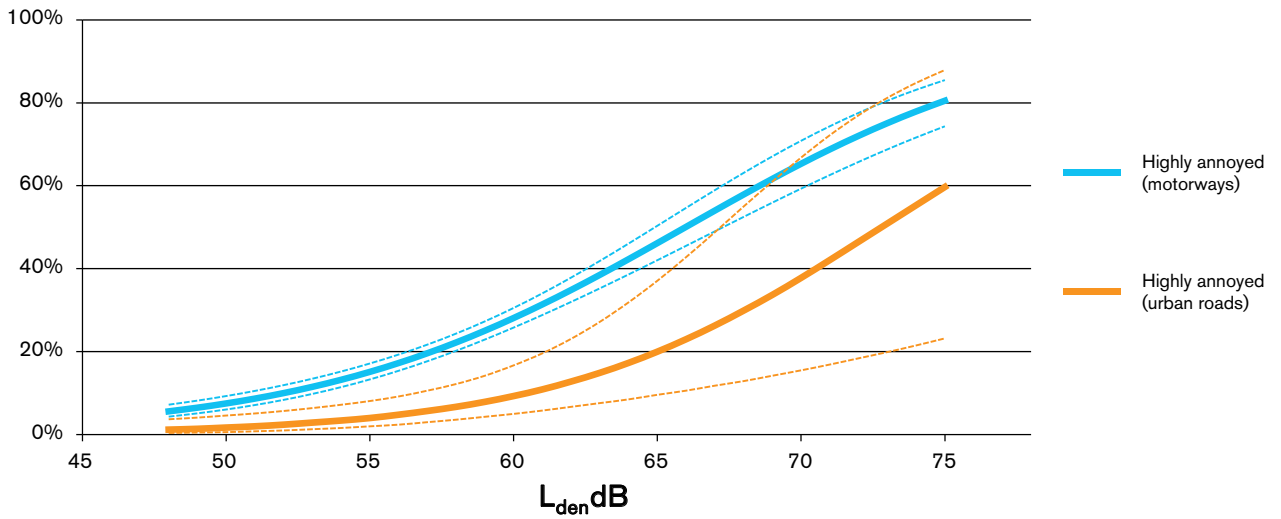


Figure 7.2
Single-family houses and proportion of Highly annoyed respondents by road types

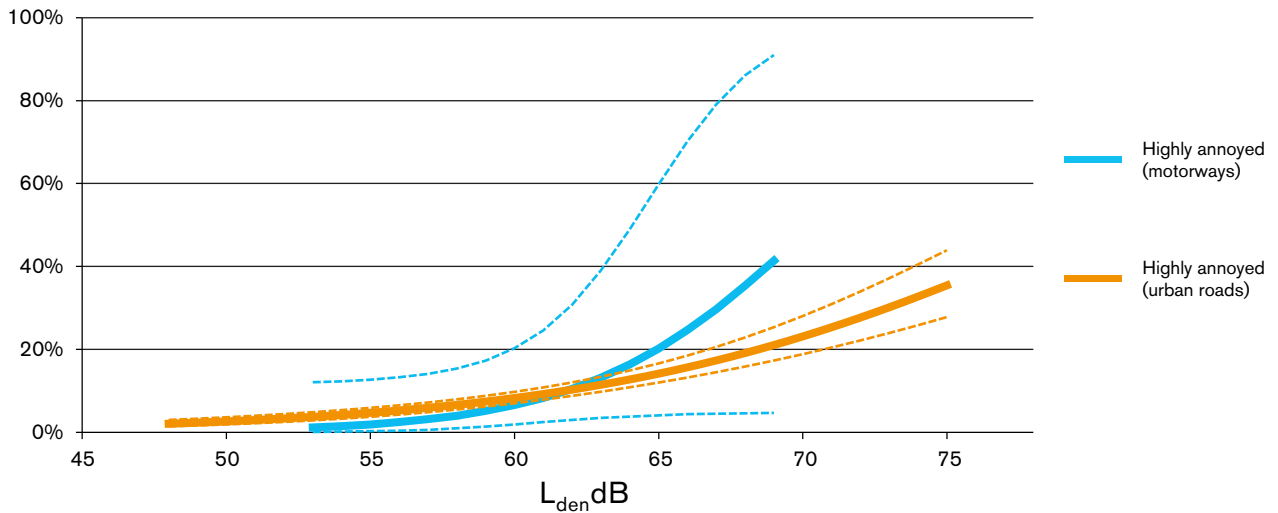


Figure 7.3
Flats and proportion of Highly annoyed respondents by road types

60 dB, approx. 3 times as many people are annoyed by noise from motorways as people annoyed by noise from urban roads. This indicates that it is far from only the dwelling type that determines the degree of annoyance.

Figure 7.3 shows the proportion of respondents in flats who feel Highly annoyed by noise from motorways and from urban roads. The study only includes a very limited number of flats along motorways – this explains the great uncertainty on the curve for flats along motorways. The uncertainty is so significant that no conclusions can be drawn about any differences in annoyance between motorway and urban roads. However, reference can be made to section 7.2 which verifies that the annoyance indoors in flats has a major influence on the overall annoyance experienced at the home and that the perception of the annoyance indoors in the home is almost the same for dwellings along motorways and along urban roads.

7.2 Overall annoyance perception, indoors and outdoors

The reported noise annoyance has been studied for both the overall annoyance "when you are at home", the indoor annoyance "inside your home", and the outdoor annoyance

"at your home". Figures 7.4 and 7.5 show the associated dose-response curves for respondents stating that they are Annoyed by the noise from motorways and urban roads, respectively.

For motorways, the dose-response for the overall annoyance and the dose-response for the outdoor annoyance are virtually identical, whereas the dose-response for the indoor annoyance is significantly lower. For urban roads, it is the other way around. The dose-response curve for outdoor annoyance is significantly lower than the overall annoyance, whereas the indoor annoyance is somewhere between the two.

If we compare the two figures, we can see that the difference in dose-response for indoor annoyance at urban roads and motorways, respectively, is small, whereas we see major deviations between urban roads and motorways when it comes to the outdoor annoyance where the respondents at motorways are much more annoyed.

Usually, the overall annoyance "when you are at home" is used to refer to the overall noise annoyance from road traffic. The overall annoyance will to some extent depend on how the noise is experienced indoors and outdoors

Factors which affect annoyance perception

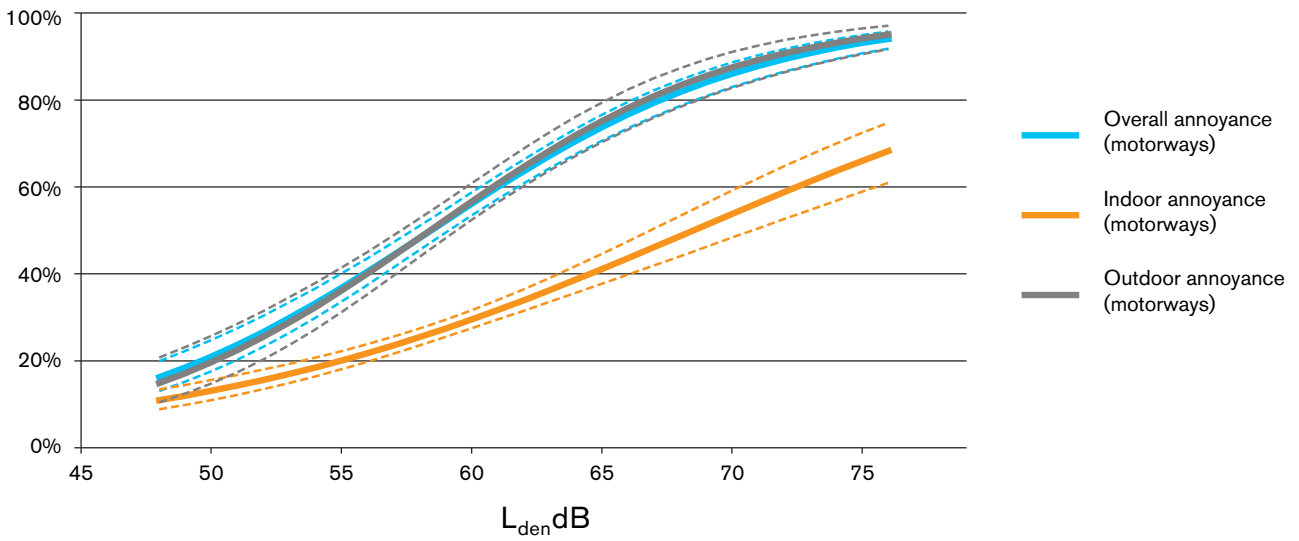


Figure 7.4
The proportion of Annoyed respondents along motorways by "overall annoyance", "indoor annoyance" and "outdoor annoyance"

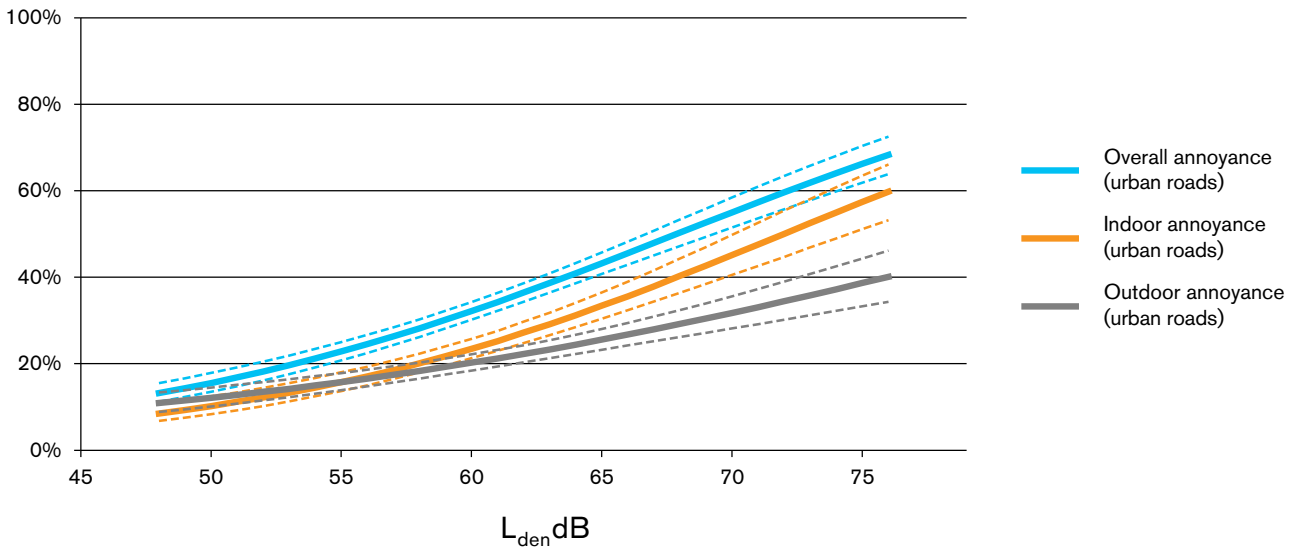


Figure 7.5
The proportion of Annoyed respondents along urban roads by "overall annoyance", "indoor annoyance" and "outdoor annoyance"

at the home. An analysis has therefore been made of the factors which influence the overall annoyance perception based on a comparison of the respondent's answers to the degree of overall annoyance, indoor annoyance and outdoor annoyance.

The analysis shows that both the indoor and outdoor annoyance have a very large influence on the overall annoyance. For residents at motorways, the outdoor annoyance (t-value = -19.88) is relatively more important than the indoor annoyance (t-value = -12.78), when it is analysed what drives the overall experience of annoyance. For residents at urban roads, the result is the opposite. Here the indoor annoyance is a much more important factor (t-value = -22.39) than the outdoor annoyance (t-value = -5.10). This means that for residents along urban roads, it is predominantly the indoor annoyance which determines the overall annoyance.

The same applies – not surprisingly – to the dwelling type, i.e. for people who live in single-family houses, the outdoor noise impact is of great importance for the overall noise annoyance at the home, whereas for people who live in flats, the indoor noise impact in the home is of importance to the overall noise annoyance at the home.

Generally, the results seem to confirm that it is important to be careful when you want to overcome the noise annoyance from motorways and urban roads, respectively, because it is very different what drives the overall experience of noise at home.

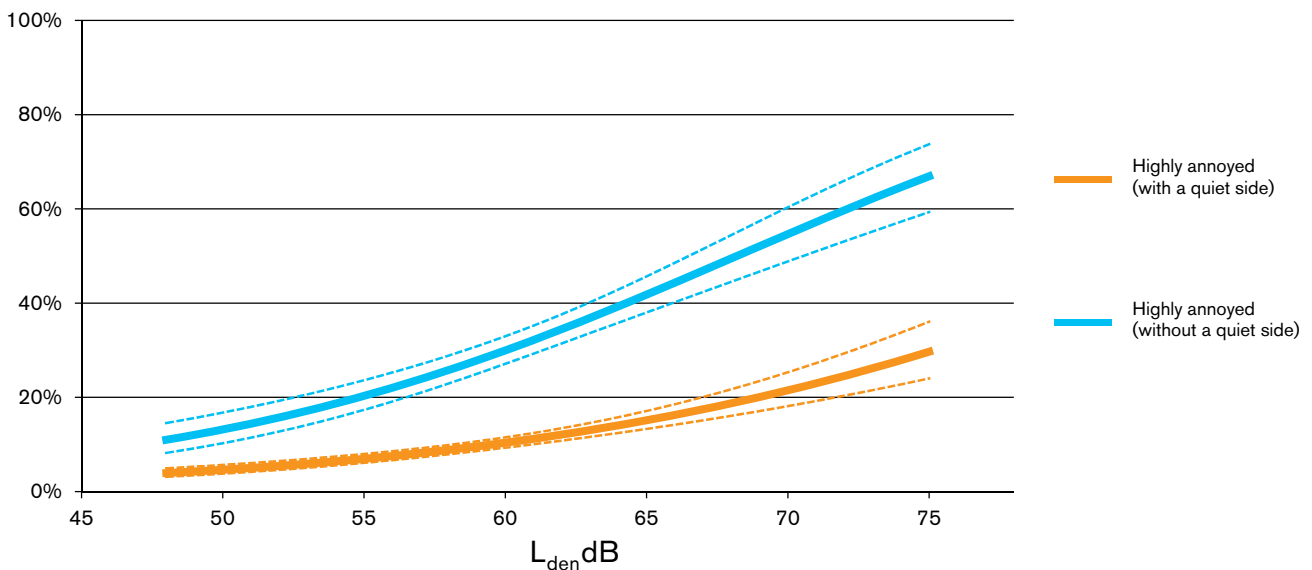
7.3 Access to quiet side

Previous research results (see section 8.4) indicate that if the dwelling has a quiet facade, which is not exposed to notable noise, it has a positive impact on the overall annoyance effects of noise at the home. Figure 7.6 shows the proportion of Highly annoyed respondents by respondents who have a quiet dwelling facade and respondents whose dwelling does not have a quiet side. At all noise impacts, the proportion of respondents who are Highly annoyed almost doubles when the dwelling does not have a quiet side.

7.4 Age

The age distribution of respondents who are Highly annoyed is shown in figure 7.7. The respondents are divided into three age groups, 18-34 years, 35-55 years and over 56 years.

Figure 7.6
The proportion of Highly annoyed respondents in dwellings with or without a quiet side



Factors which affect annoyance perception

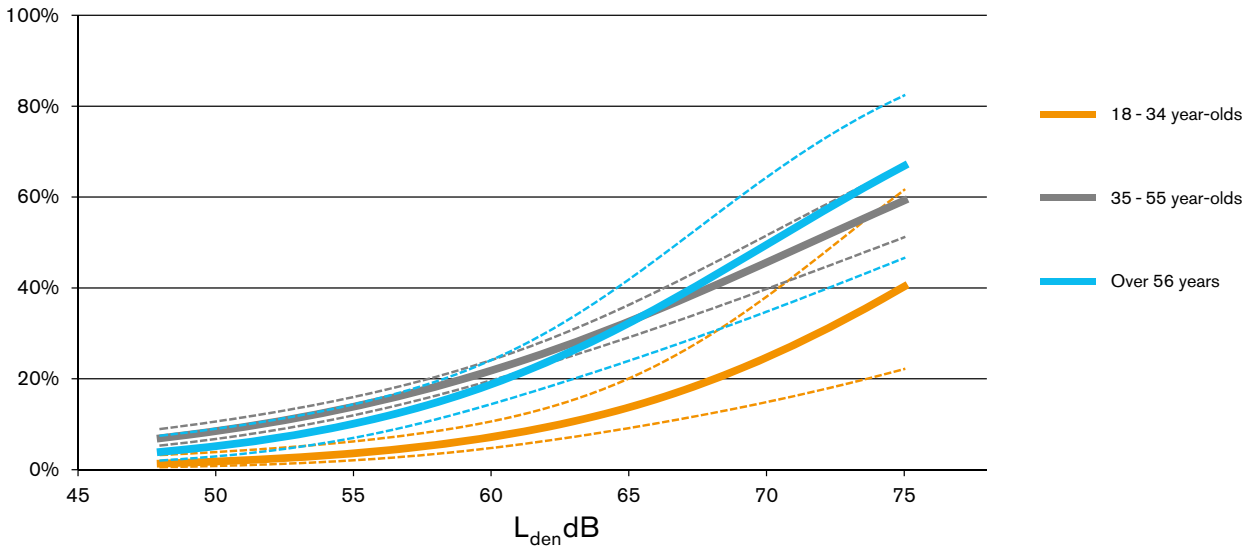
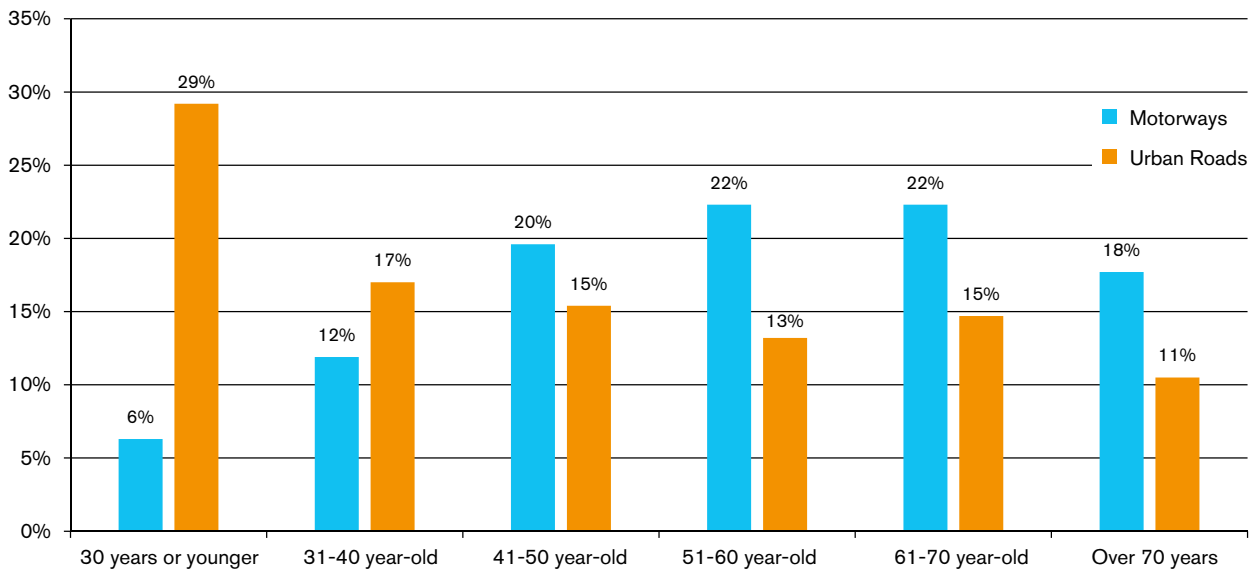


Figure 7.7
The total number of respondents by age who are Highly annoyed

Particularly in the youngest group with the 18-34-year-olds, the proportion of Highly annoyed is smaller than for the other age groups. This group is also strongly represented in the dwelling type: Flat.

Figure 7.8 also shows that nearly 29% of the respondents at urban roads are young people under 31 years of age. 46% of all respondents along urban roads are under 41 years of age. Conversely, only 6% of the respondents along motorways under 31 years of age. 18% of all respondents along motorways are under 41 years of age.

Figure 7.8
Age distribution of respondents who are exposed to noise from urban roads and motorways, respectively.



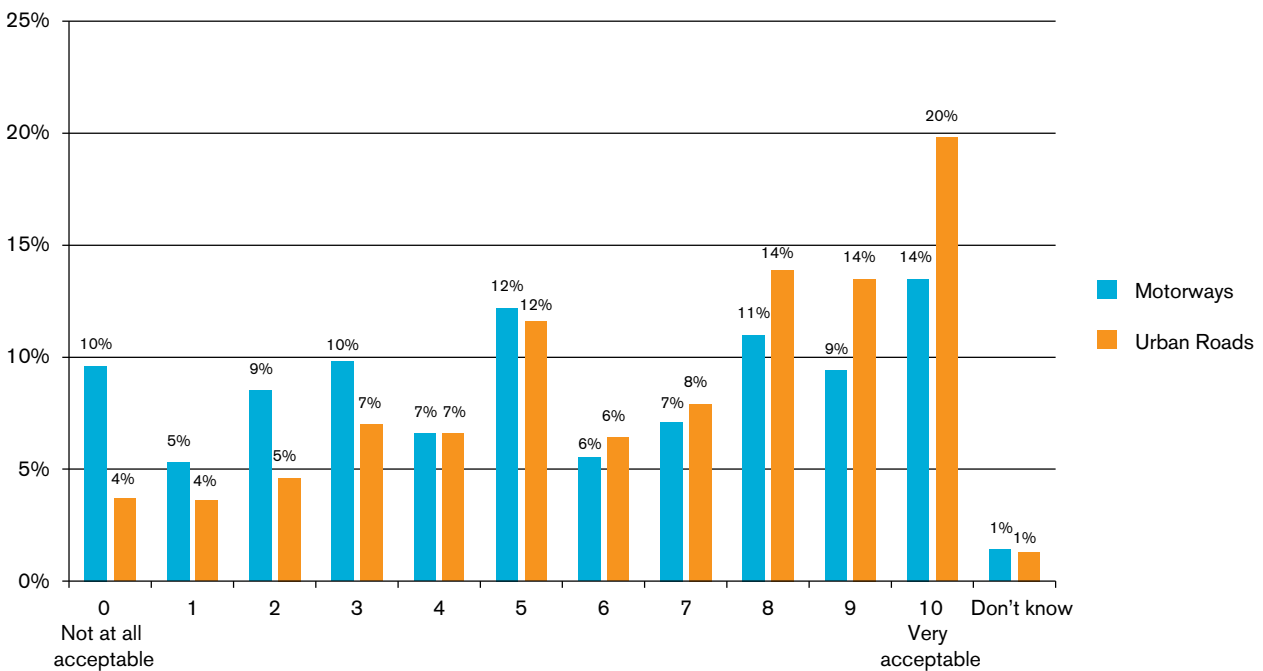
When the respondents are to answer whether they generally think that "the noise levels from road traffic in your home is acceptable", it seems that respondents along motorways have a lower degree of acceptance of the noise level at the home than respondents who live along urban roads.

Figure 7.9 shows the distribution of answers for motorways and urban roads from the score 0 (not at all acceptable) to the score 10 (very acceptable). Along the motorways, 24% of the respondents give a score of 0-2 (i.e. in the category not very acceptable), whereas 13% give this score along urban roads. Moreover, 48% of the respondents along urban roads give a score of 8-10 (i.e. in the category rather to very acceptable), whereas 34%

of the motorway respondents give this score. Furthermore, it should be noted that the respondents along urban roads are generally exposed to higher noise levels than the respondents along motorways (see previous figure 5.3).

Figure 7.10 shows the dose-response curves for respondents who state that they are Highly annoyed compared to the degree of acceptance of the noise impact on the home. No wonder, the respondents who state that they have a very low degree of acceptance (scores 0 - 2) of the noise impact are more annoyed than respondents who state that they have a high degree of acceptance (scores 8-10) of the noise impact.

Figure 7.9
Proportion of respondents' answer to: "Do you generally think that the noise level from road traffic in your home is acceptable?".



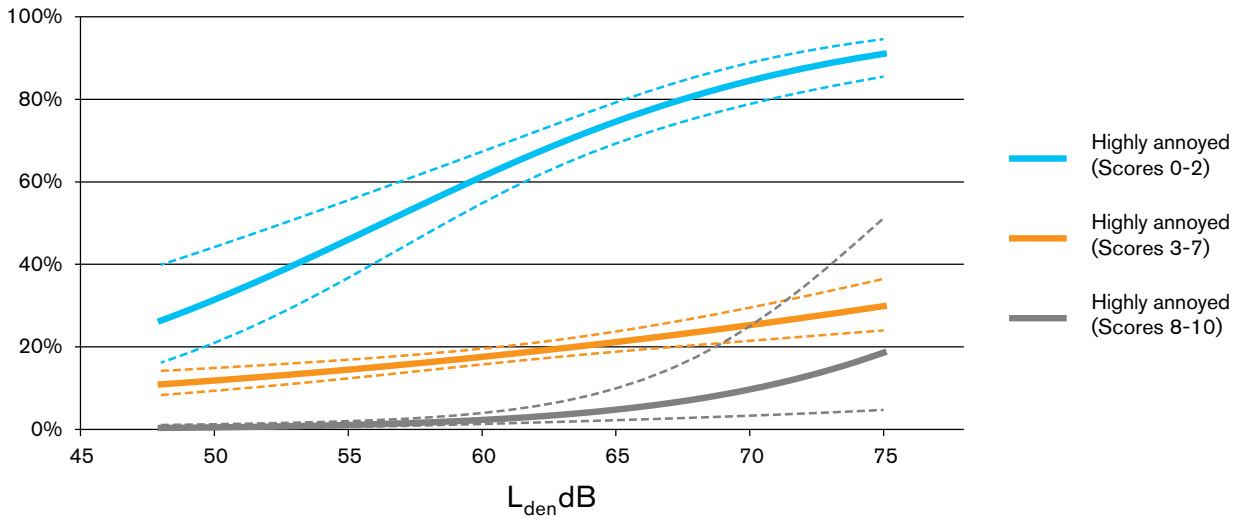


Figure 7.10
Dose-response for the proportion of highly annoyed respondents relative to acceptance of noise level (answer to: "Do you generally think that the noise level from road traffic in your home is acceptable?").



8. Comparison with other studies

Danish and other international studies have previously been made of the dose-response relationship for road traffic noise, and in the following, the results of this study is compared with a range of previous studies. The comparison with the general European noise annoyance curves is particularly interesting because these are normally the reference for calculations of noise annoyance from road traffic in Europe.

8.1 General European dose-response curves (Miedema)

The general European dose-response curves /4/, also known as the Miedema curves, indicate the relationship between noise level and the experienced annoyance and are often used to assess noise annoyance from roads, railways and airfields. These dose-response curves are based on data collected from many different annoyance studies. For road traffic noise, the dose-response curve is based on nearly 20,000 individual interviews from 26 different studies in different countries. On one hand, this provides a very well-substantiated relationship between noise level and annoyance. On the other hand, the Miedema dose-response curve is an average, which covers very different situations, and is therefore best suited to describe a general "noise annoyance in society" from road traffic.

Figures 8.1 - 8.3 compare the results from this study with the general European dose-response curves (Miedema). The distribution between motorways, regional roads and urban roads in the underlying data is unknown.

Figure 8.1 shows that the overall reported annoyance from motorways and urban roads put together from this study is significantly higher than the international average. Figure 8.2 shows that the annoyance effects around motorways in this study are significantly higher than the average annoyance in the general European dose-response curves (Miedema) which reflects effects found in a large number of studies. Figure 8.3 compares the dose-response results of this study for residents along urban roads with the international average. These results are in good accordance with those of Miedema.

If Miedema curves particularly represent noise in towns and cities, this survey may be in good accordance with the international dose-response curve.

If, for example, we look at the reported annoyance at a noise level of 65 dB, the international dose-response curve shows that 16% of the population is Highly annoyed. This is in good accordance with the result of this study for urban roads alone, which is also approx. 16%, while for motorways alone, the proportion of Highly annoyed respondents is 44% whereas the proportion for motorways and urban roads together is 30%.

Comparison with other studies

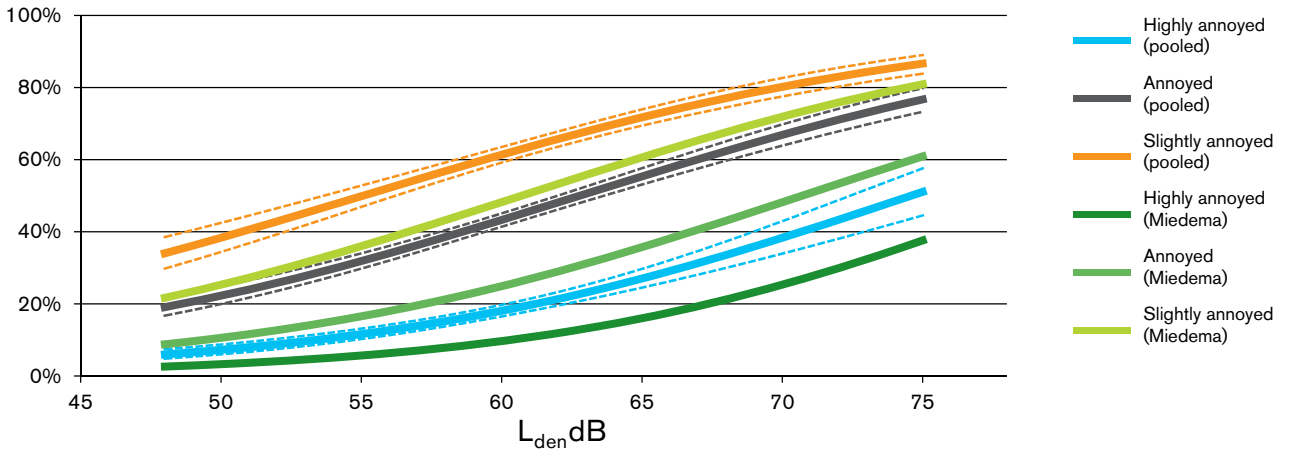


Figure 8.1
Motorways and urban roads put together (this survey)
compared with the international dose-response (Miedema)

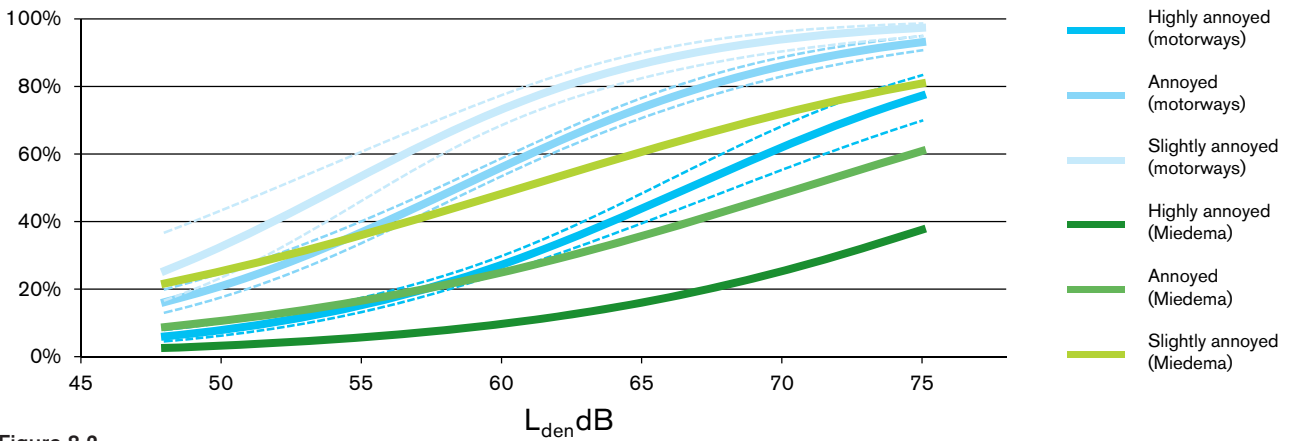


Figure 8.2
Motorways (this survey) compared with the
international dose-response (Miedema)

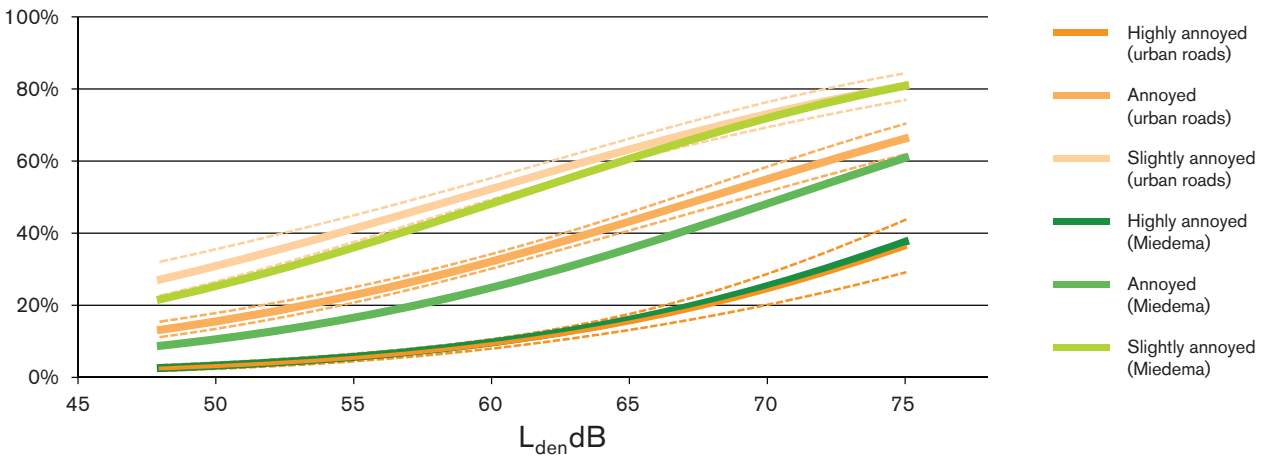


Figure 8.3
Urban roads (this survey) compared with the
international dose-response (Miedema)

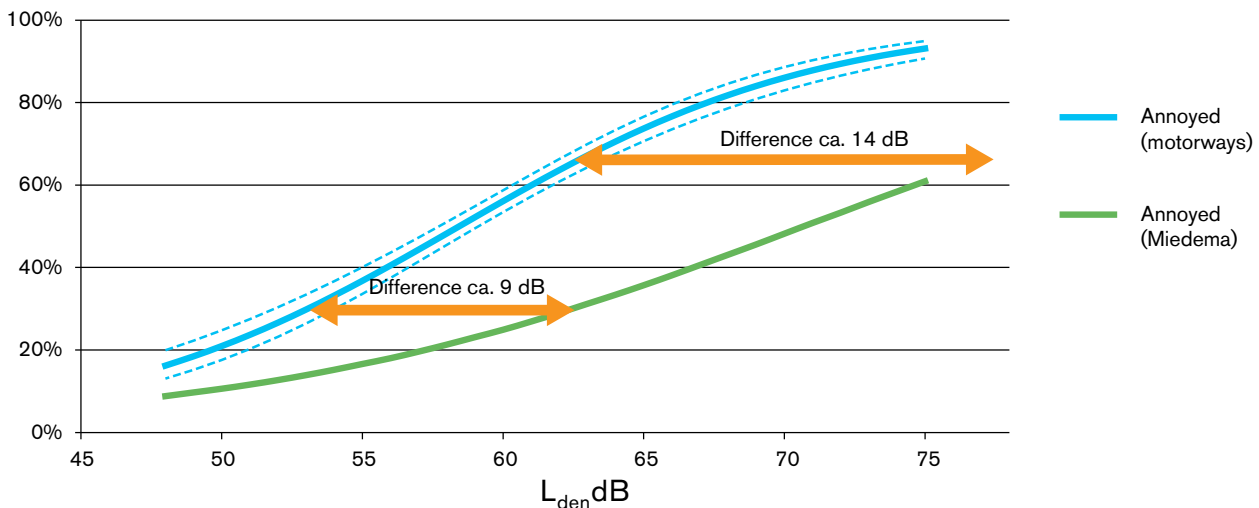


Figure 8.4
Motorways (this survey) compared with the international dose-response (Miedema) which illustrates the difference in noise level for the curves Annoyed

Figure 8.4 shows the difference between the reported noise annoyance for the annoyance score Annoyed from this survey and the general European dose-response curve (Miedema). If we compare the noise annoyance curves for Annoyed, the annoyance at the home is seen at a noise level at motorways which is approx. 9-14 dB lower than the European noise annoyance curve (when the starting point is in the range 53 dB to 63 dB along motorways in Denmark).

8.2 The Danish Environmental Protection Agency's survey of the difference between annoyance impact of motorway noise and noise from other roads

In the Danish Environmental Protection Agency's work report no. 1, 2013 on "Forskell mellem genevirkning af motorvejsstøj og støj fra andre veje" / 1/ (Difference between annoyance effect of motorway noise and noise from other roads) a literature study was carried out studies which could demonstrate any difference in noise annoyance from motorways and other roads, and, if possible, quantify this difference.

Only two major studies were found which could be directly used to quantify the difference. Based on the two studies, it was concluded that the difference in annoyance from motorways and other roads corresponds to at least 5 dB, but may be greater (up to about 10 dB), and that the difference in relation to less busy roads in towns and cities can even be even greater.

Similarly, one of the two studies shows that the noise annoyance from other roads than motorways is virtually pre-

dicted by the general European noise annoyance curve (Miedema). The other study shows nearly the same annoyance for roads in towns and cities as predicted by the Miedema curve at high noise levels (L_{den} greater than 70 dB), but at lower noise levels, a lower degree of annoyance than predicted by the EU curve.

8.3 The Danish Road Directorate's previous survey of noise annoyance from urban roads and motorways

The Danish Road Directorate's report no. 447, 2013, on "Støjgener fra byveje og motorvej M3" /2/ (Noise annoyance from urban roads and motorway M3) reviews the results from various questionnaire surveys along the Motorring 3 in Copenhagen – before and after the extension of Motorring 3 – and along three different urban roads in Copenhagen. The urban road data come from a study before and after the replacement of asphalt surfacing, where less noisy "thin-layer asphalt" was laid.

The average of the before and after situation does not show any significant difference in the annoyance perception at noise impacts below approx. 55 dB. At noise impacts above 55-58 dB, the noise from Motorring 3 is more annoying than the noise from the urban roads. At the higher noise impacts, the size of this difference corresponds to a difference in noise impact of about 5 dB.

Figures 8.5 and 8.6 make comparisons between this study and Danish Road Directorate's previous study. Again, people along the motorway seem to be significantly more annoyed than residents along the urban roads. While the noise annoyance curves for the urban

Comparison with other studies

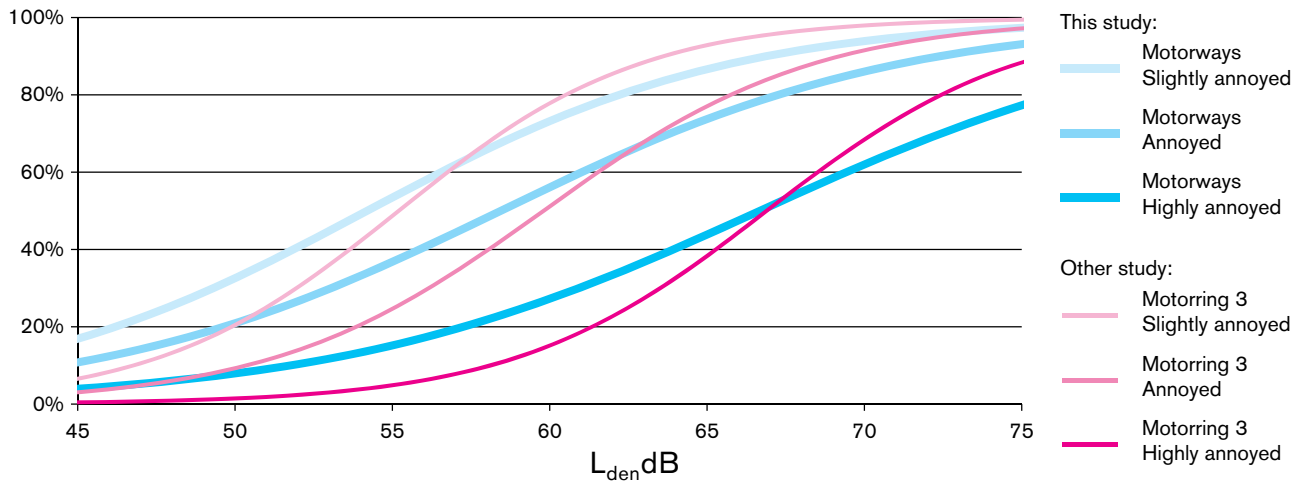


Figure 8.5
Dose-response curves at motorways from this annoyance study and for the Motrorring 3 questionnaire surveys

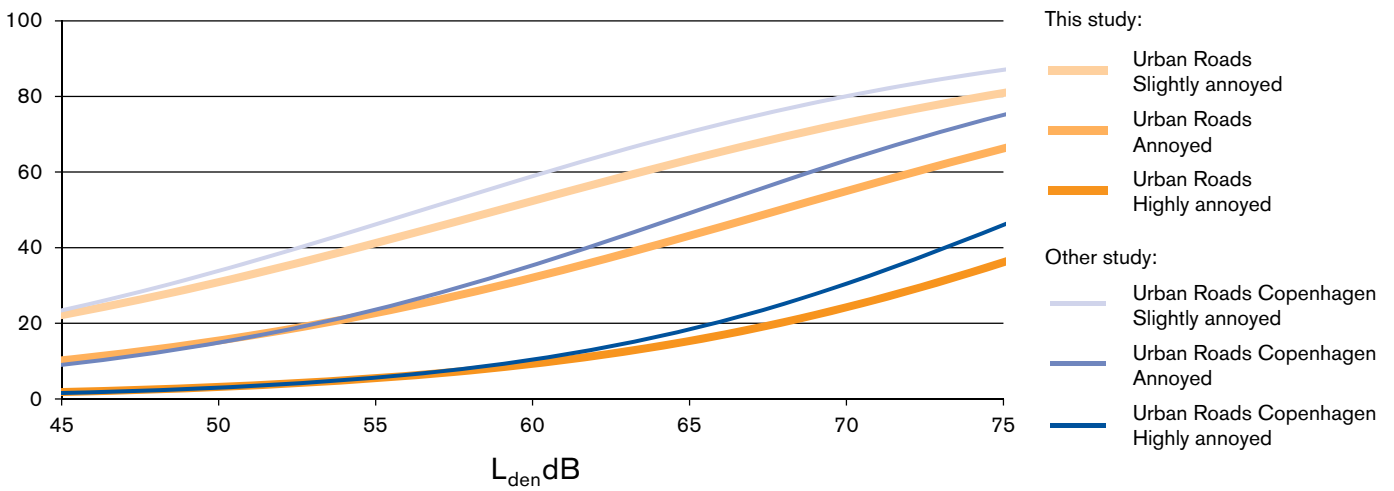


Figure 8.6
Dose-response curves at urban roads from this annoyance study and the questionnaire surveys conducted in Copenhagen in connection with renewal of wearing course to thin-course surfacing.

roads in 8.6 from the previous study and from this study are very similar, there are, however, more significant differences in the curves for motorways in figure 8.5.

8.4 Swedish results about the relationship between quiet side and minor noise annoyance

A number of research projects indicate that the experienced annoyance is affected by more factors than just the noise level at the most noise-impacted facade. Research shows that access to a quiet side of the dwelling can have an influence on the noise annoyance experience. A similar influencing factor is whether the bedroom of the dwelling faces the quiet side. In dwellings without these conditions, noise from the road will, all other things being equal, be experienced as more annoying. This is not as such new knowledge, but in recent years better documentation has been provided for the importance of a quiet side, and results have been achieved which quantify the effect of a quiet side and formulate the conditions, which must be met.

In the Swedish research programme "Ljudlandskap för bättre hälsa" /9/, figure 8.7 shows the proportion of people who are annoyed (% with the degree of annoyance "ganska störd" (rather annoyed), "mycket störd" (highly annoyed) or "oerhört mycket störd" (extremely annoyed)) by traffic noise at various noise levels, with and without a quiet side in their home. The figure shows that, at the same noise impact, the annoyance is smaller if the building has a quiet side compared to buildings without a quiet side. The proportion of people who are adversely affected by road traffic noise is almost the same (approx. 20%) in buildings with a diurnal average level ($L_{Aeq,24h}$) of 55 dB without a quiet facade (yellow column), as in a building with a noise level of 60 dB where there is access to a quiet facade (pink column). Access to a quiet side of the dwelling results in a reduction in the experienced annoyance in the same order as a reduction of the noise level by 5 dB at the most noise-impacted dwelling facade. The same trend is seen in this study, just more pronounced, where the difference between a dwelling with and without quiet side is more than 10 dB.

Figure 8.7

Experienced annoyance (% with the degree of annoyance "ganska störd" (rather annoyed), "mycket störd" (very annoyed) or "oerhört mycket störd" (extremely annoyed) from road traffic noise relative to noise level and access to a quiet dwelling facade (dB refers to the average noise level, $L_{Aeq,24h}$). The quiet side of the home had an average noise level of 45.5 dB (free field)

	Referens- område	Bebyggelse med tyst sida Bullernivå, mest exponerad sida			Bebyggelse utan tyst sida Bullernivå på båda sidor		
Andel i % som störs/påverkas negativt av vägtrafikbuller:	42-43 dB båda sidor	55 dB	60 dB	65 dB	55 dB	60 dB	65 dB
Allmän störning	3	11	21	38	22	34	57
Vila / återhämtning inomhus med stängt fönster	4	11	18	31	19	33	45
Vila / återhämtning på uteplats / balkong	3	11	21	25	20	26	40



9. Summary and conclusion

The purposes of this study were:

- To study whether the noise annoyance experienced by residents along motorways is greater than the noise annoyance experienced by residents along urban roads
- To compare the results with the general European noise annoyance curves (Miedema)
- To make suggestions for the possible reasons why the noise annoyance from motorways is greater than from urban roads

Overall, it can be concluded that people who live along motorways are significantly more annoyed by road traffic noise than people who live along urban roads when they are exposed to the same noise level on the dwelling facade. If we compare the noise annoyance curves for people who feel Annoyed, the annoyance is seen at a noise level which is approx. 6 - 13 dB lower for motorways compared to urban roads (in the range 53 dB to 63 dB along motorways, see figure 6.4).

For people who are exposed to the same noise level on the dwelling facade, there are 2-3 times as many peo-

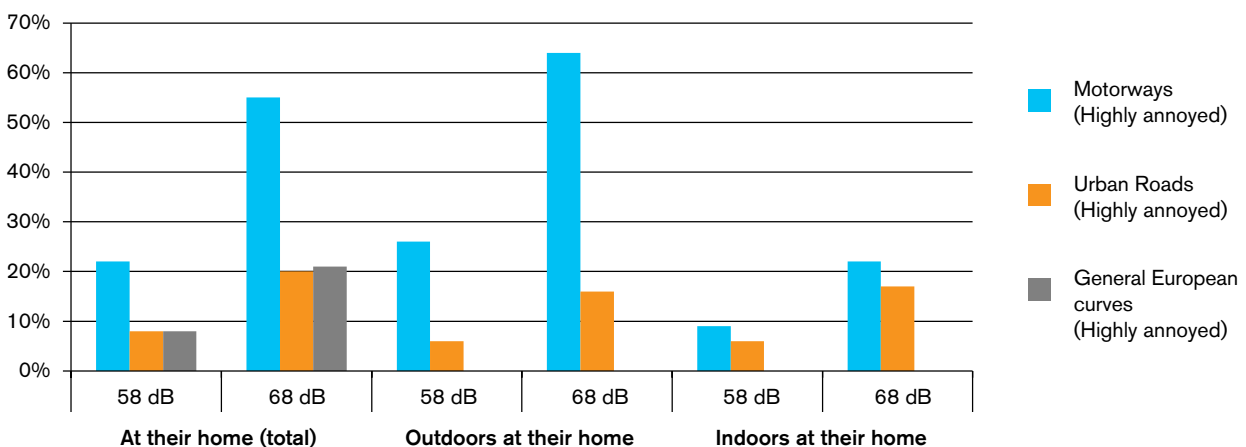
ple who live along motorways who feel Highly annoyed compared to urban road neighbours. This trend is even more clear when it comes to the outdoor annoyance at the home. However, there is only a small difference in the indoor annoyance, where residents at motorways feel slightly more annoyed than residents along urban roads.

The results from this dose-response survey have been compared with the previous, and widely respected, general European noise annoyance curves from Miedema. The results from this study of dose-response curves for road traffic noise from urban roads are virtually identical with the general European dose-response curves. However, there are large differences in dose-response relationship for motorways compared to the general European dose-response curves.

If, for instance, we compare the noise annoyance curves for respondents who feel Annoyed, the annoyance at the home is seen at a noise level which is approx. 9 - 14 dB lower at motorways compared to the European noise annoyance curve (in the range 50 dB to 63 dB along motorways, see figure 8.4).

The above points are summarised in figure 9.1 and compared with the noise levels 58 dB and 68 dB (L_{den}),

Figure 9.1
Proportion of people who feel Highly annoyed at noise levels of 58 dB and 68 dB (L_{den}) at their home (total), outdoors at their home and indoors in their home



which corresponds to the levels at which a home in Denmark is regarded as noise exposed (58 dB) and severely noise exposed (68 dB). It should be noted that the general European annoyance curves only apply to the general noise annoyance experienced at the home. There are no similar results for the noise annoyance experienced indoors and outdoors, respectively.

A number of factors influence how annoyance is experienced, such as the noise characteristics (for example, a motorway may sound different than an urban road, and the traffic composition, diurnal distribution and speed are different), the person who subjectively experiences the noise (the person's noise sensitivity, acceptance of noise, age, etc.), and the context in which the person experiences noise (e.g. in the home, indoors/outdoors, time, etc.) and not least the dwelling type.

Based on the available data, various contexts have been identified which influence the perception of noise from motorways and urban roads. This has been described in more detail in the report. A number of contexts relate in particular to the dwelling conditions, each of which are factors which indicate that respondents along urban roads are less annoyed than those along the motorways. Thus, it is found that:

- People who live in flats are less annoyed than people who live in single-family houses – and significantly more respondents live in flats along the urban roads.
- Access to a quiet facade in the home has a positive impact on the perception of annoyance – and significantly more homes in urban areas have a quiet facade.
- The overall perception of annoyance for people who live in single-family houses is mainly determined by the annoyance experienced outdoors in the garden, etc., while the overall annoyance experienced by peo-

ple who live in flats is to a large degree determined by the annoyance experienced indoors in the home. It must be assumed that the outdoor recreational areas are generally less protected for single-family houses compared to flats, where many flats have yards, where noise levels are typically low.

In addition, it should be noted that:

- Young people are less annoyed by traffic noise than elderly people - and relatively more young people live along the urban roads/in flats
- The degree of acceptance of the noise level to which you are exposed, has an influence on the annoyance experienced – the lower the acceptance of the noise impact, the greater the experience of annoyance. The respondents along the motorways generally have a lower degree of acceptance of the noise levels compared to the respondents along the urban roads.

As mentioned, a number of other factors may contribute to the results of the study on relationship between noise levels and the noise annoyance experienced than those mentioned above. As an example, a comparison of the dose-response curve for people who live in single-family houses shows that at a noise level of 60 dB, 2-3 times as many people are Highly annoyed by noise from motorways as people Highly annoyed by noise from urban roads. This indicates that it is far from only the dwelling type that determines the degree of annoyance.

It must be assumed that the characteristics also have an influence for the experienced annoyance. Motorways are characterised by high traffic intensity, high speeds, and a large proportion of heavy vehicles. This gives a different sound than the noise from a urban road which generally has less, but more complex traffic, lower speeds and a smaller proportion of heavy traffic.

10. References

- /1/ Arbejdsrapport nr. 1. Forskel mellem genevirkning af motorvejsstøj og støj fra andre veje, Miljøstyrelsen, 2013
- /2/ Rapport 447, Støjgener fra byveje og motorvej M3, Vejdirektoratet, 2013
- /3/ Rapport 442, Befolkningsreaktioner på støjreducerende vejbelægninger Vejdirektoratet, 2013
- /4/ European Communities EU Position paper on Doseresponse relationships between transportation noise and annoyance. ISBN 92-894-3894-0, European Communities, 2002
- /5/ Bekendtgørelse nr. 1309 af 21/12/2011 om kortlægning af ekstern støj og udarbejdelse af støjhandlingsplaner, Miljøministeriet, 2011
- /6/ Rapport 434, NORD2000 – Beregning af vejstøj i Danmark, Vejdirektoratet og Miljøstyrelsen, 2013
- /7/ ISO 15 666 Acoustics Assessment of noise annoyance by means of social and socioacoustic surveys. 2003
- /8/ Vejledning nr. 4, Støj fra veje. Miljøstyrelsen, 2007
- /9/ Ljudlandskap för bättre hälsa, Resultat och slutsatser från ett multidisciplinärt forskningsprogram, Göteborgs Universitet, Chalmers, Stockholms Universitet, 2008

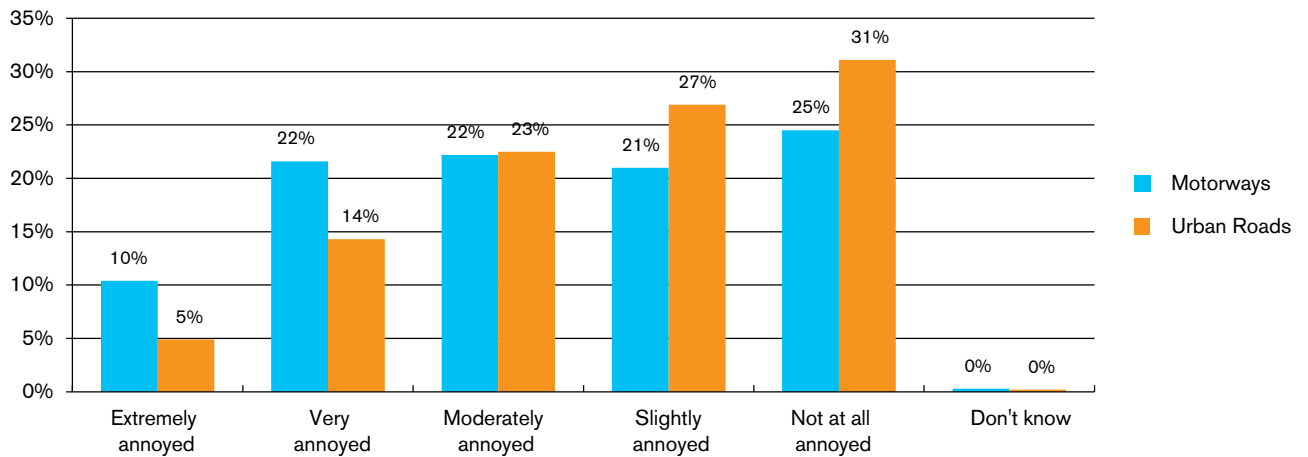


Appendix:

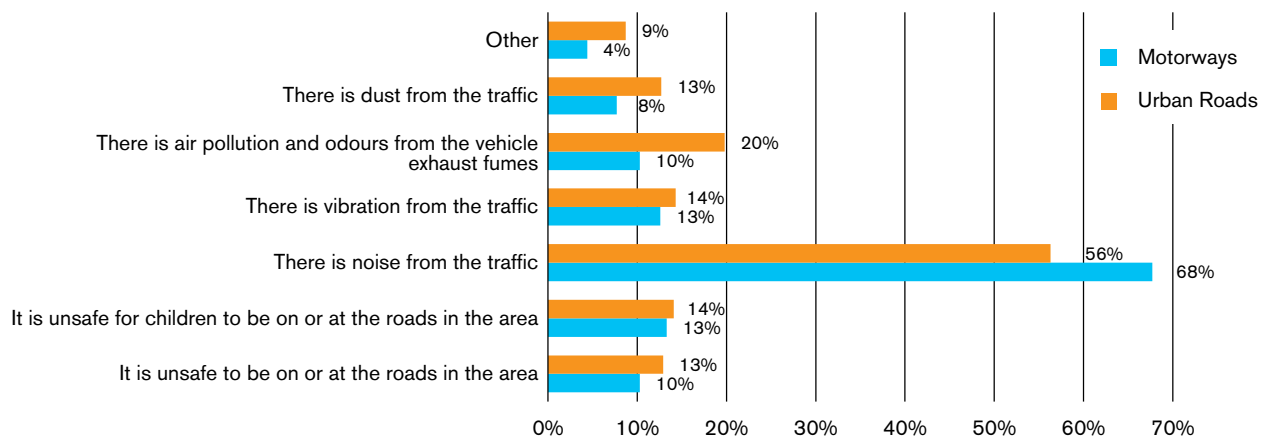
Descriptive statistics - answers to questionnaire by road type

This appendix presents the response rates to questions from the questionnaire survey. The response rates are broken down by road type (motorways and urban roads).

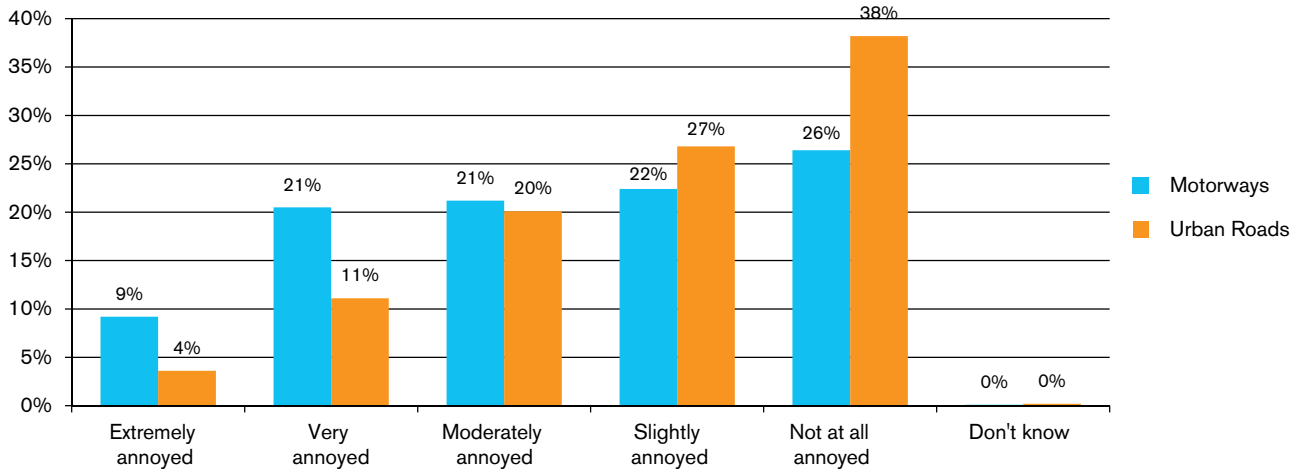
1. *"Thinking about the last year, how much does the traffic on the roads in your neighbourhood bother, disturb or annoy you?" (think in relation to all motorised vehicles such as passenger cars, buses, trucks and mopeds, motorcycles, etc.)*



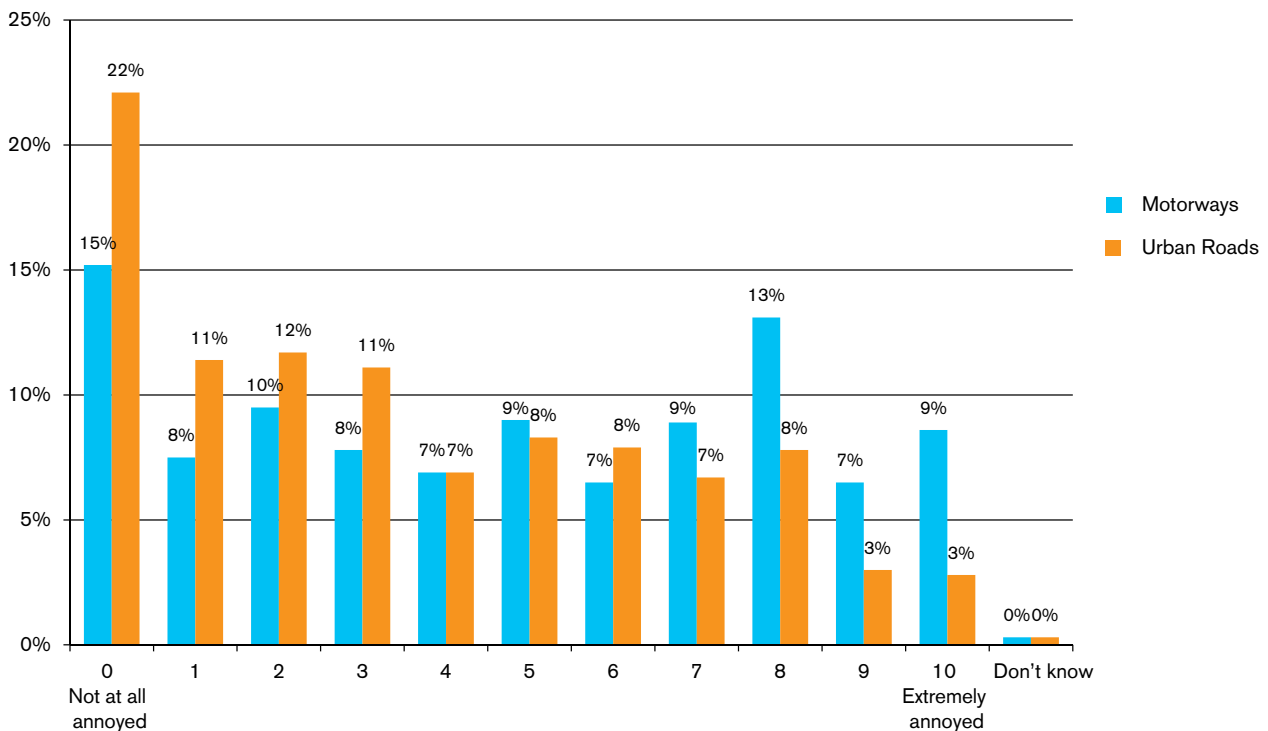
2. *"In what ways are you annoyed by road traffic in your neighbourhood?"*



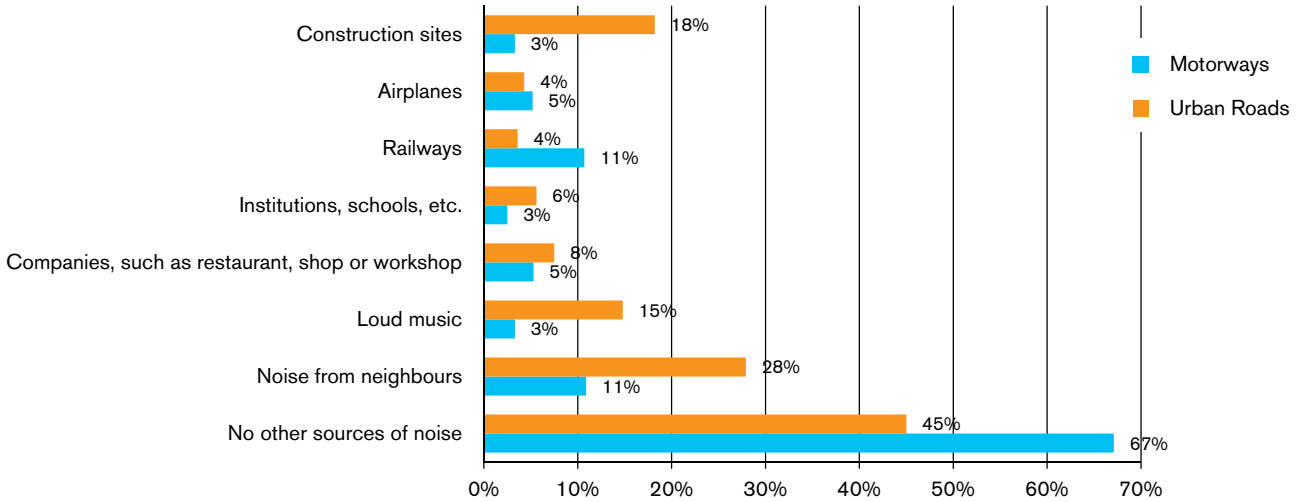
3. "Now you have to answer some questions about noise. You need to think about situations when you are at home" "Thinking about the last year, when you are at home, how much does the noise from road traffic bother, disturb or annoy you?".



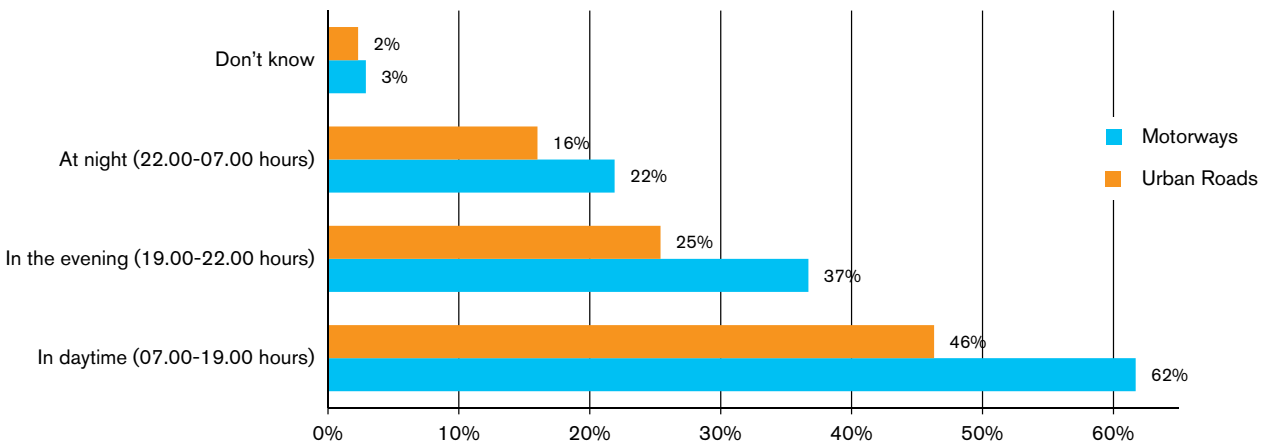
4. "To be sure of your answer to the previous question you will be asked the same questions once more. You just have respond on a different scale, which goes from 0 to 10. If you do not at all feel annoyed, choose 0; if you feel extremely annoyed, choose 10; if you are somewhere in between, choose a number between 0 and 10. "Thinking about the last year or so, when you are at home, how much does the noise from road traffic bother, disturb or annoy you?".



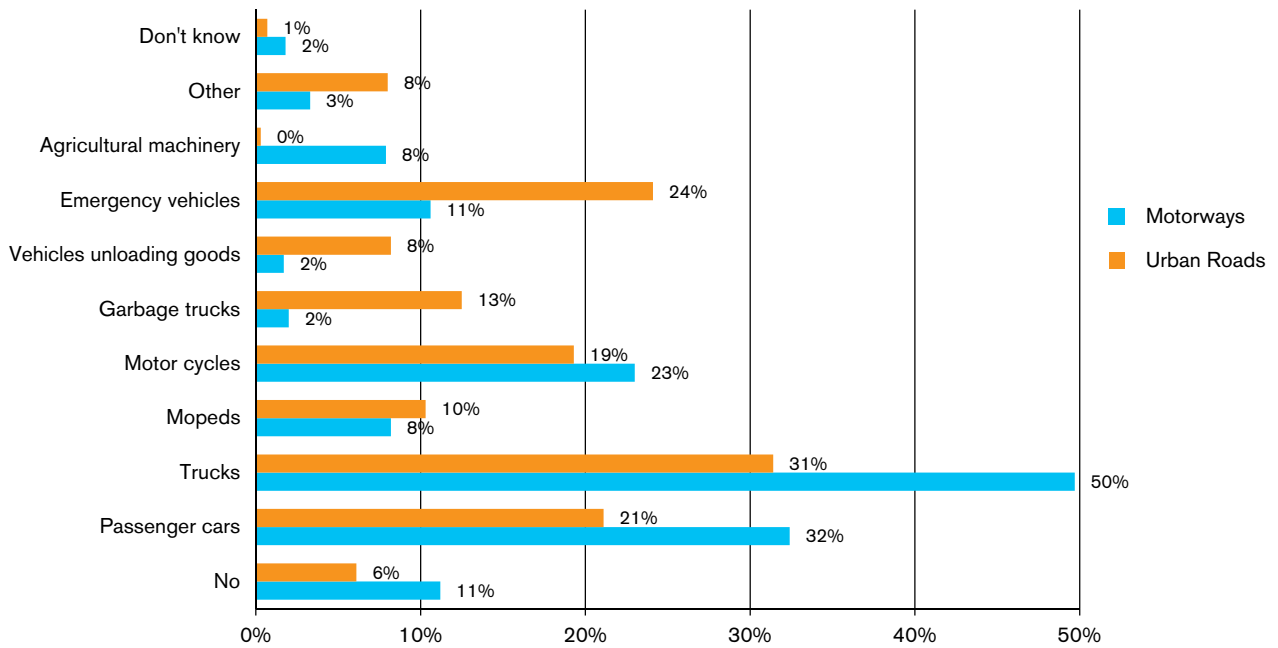
5. "Thinking about the last year or so, when you are at home, what sources of noise other than road traffic bother, disturb or annoy you?"



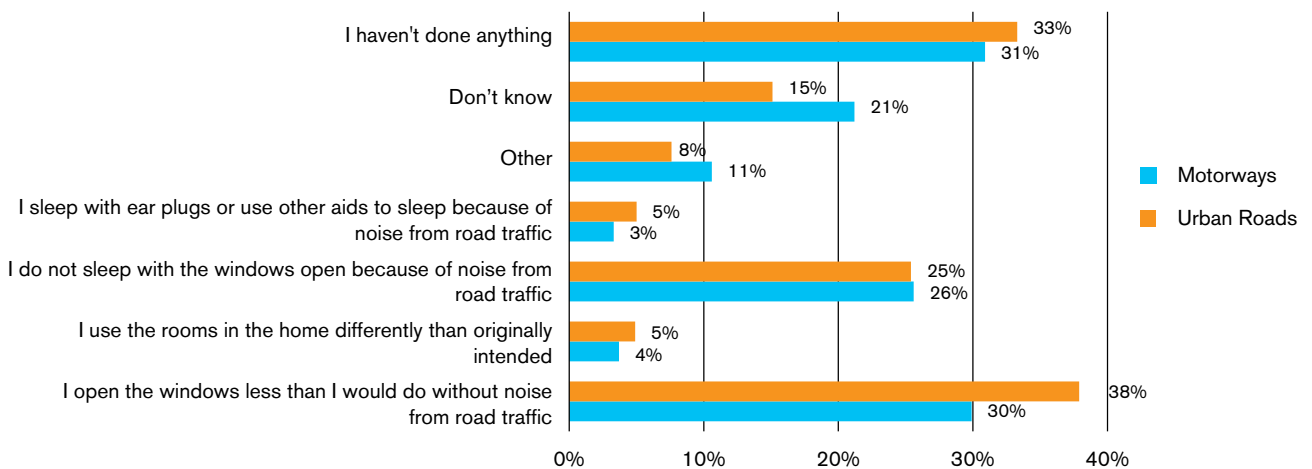
6. "During which periods of the day are you annoyed by noise from road traffic when you are at home?"



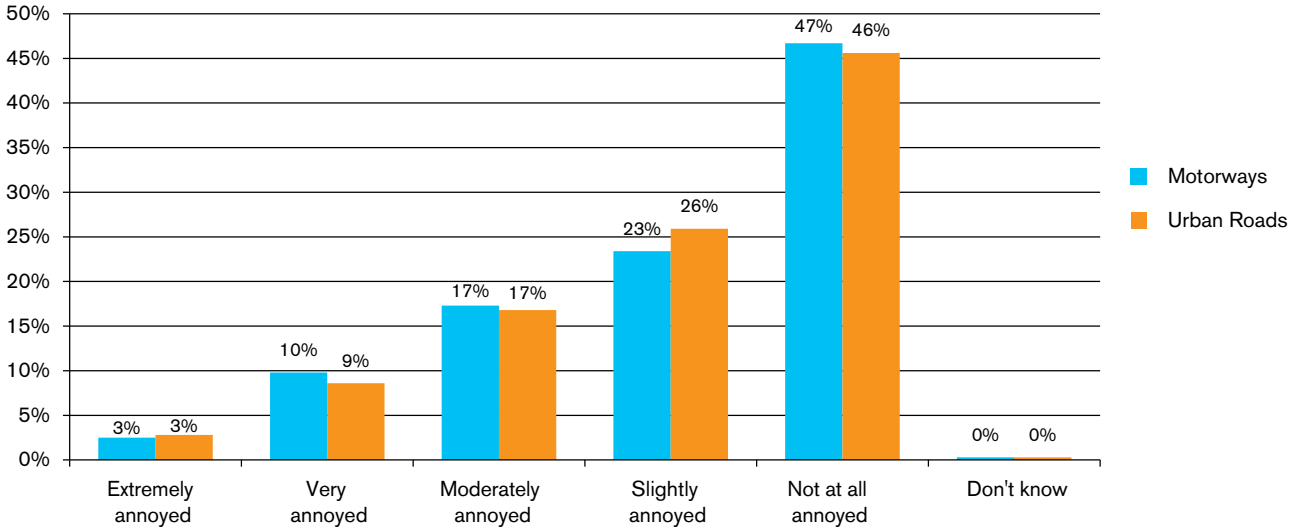
7. "Are there any special vehicle types, which are the cause of regularly occurring noise annoyance from road traffic?"



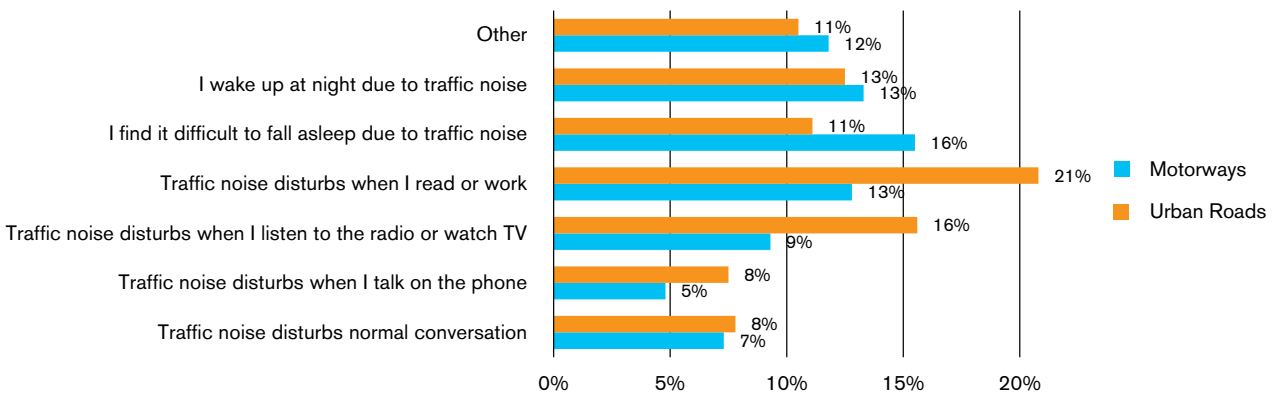
8. "Thinking about the last year or so, have you done anything because of noise from road traffic?"



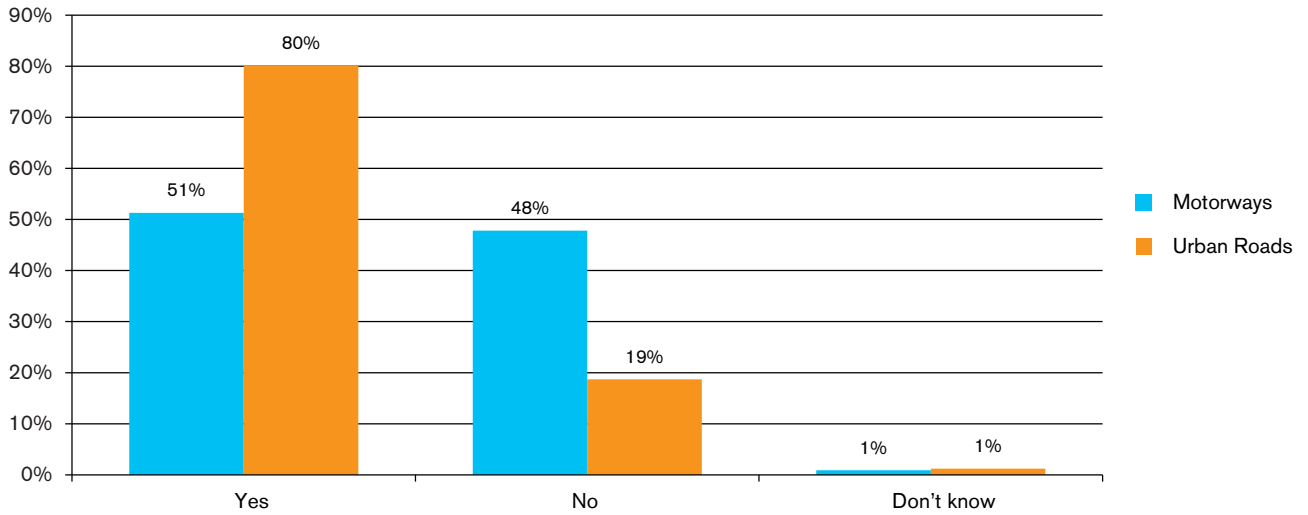
9. "You should still think of noise. Now you just have to focus on situations when you are inside your home." "Thinking about the last year or so, when you are inside your home, how much does the noise from road traffic bother, disturb or annoy you?"



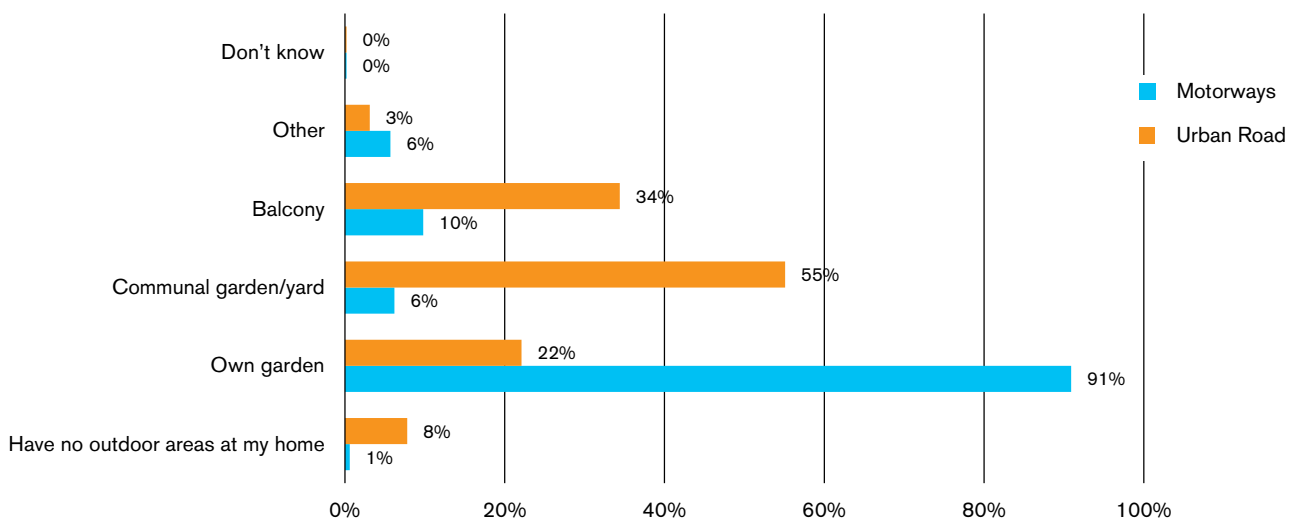
10. "Thinking about the last year or so, when you are inside your home, how does noise from road traffic bother, disturb or annoy you?"



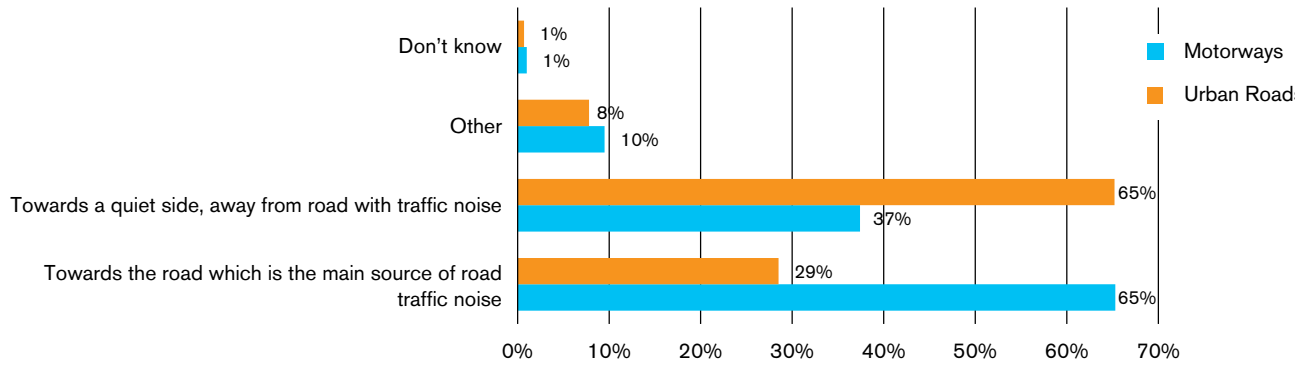
11. "From your home, can you see the road which is the main source of traffic noise at your home?"



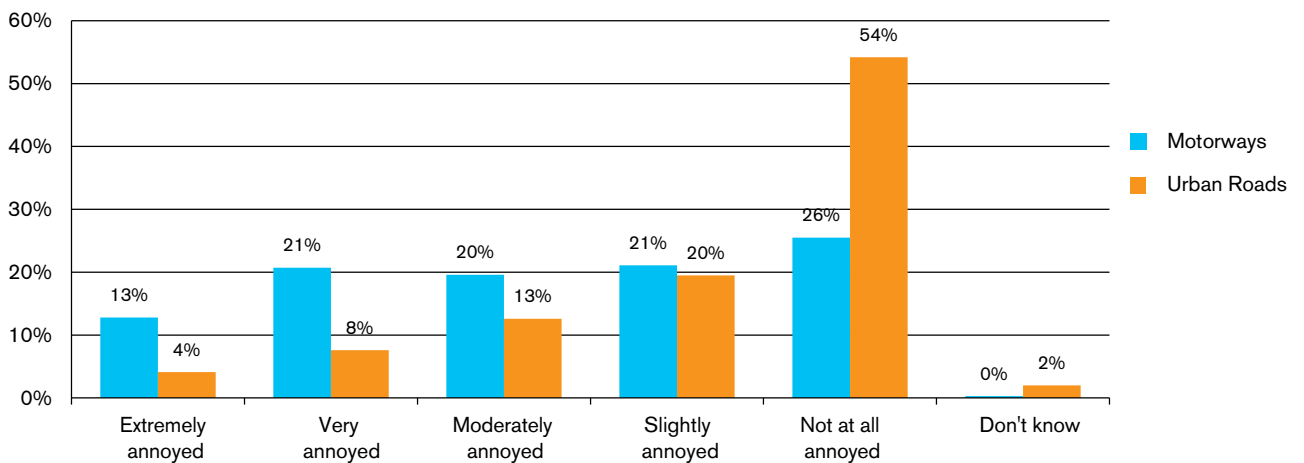
12. "You should still think of noise. Now you should just focus on situations when you are outside at your home, for example on a balcony, in the garden or in a yard." "What types of outdoor areas do you have at your home?"



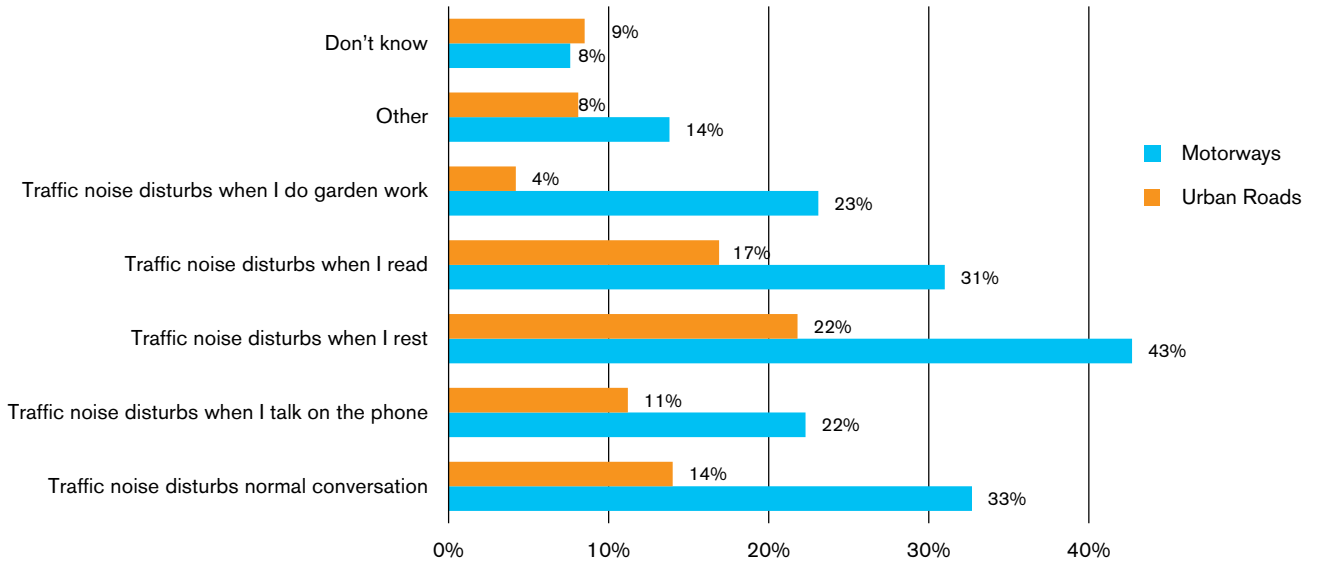
13. "In what direction does the yard or balcony face?"



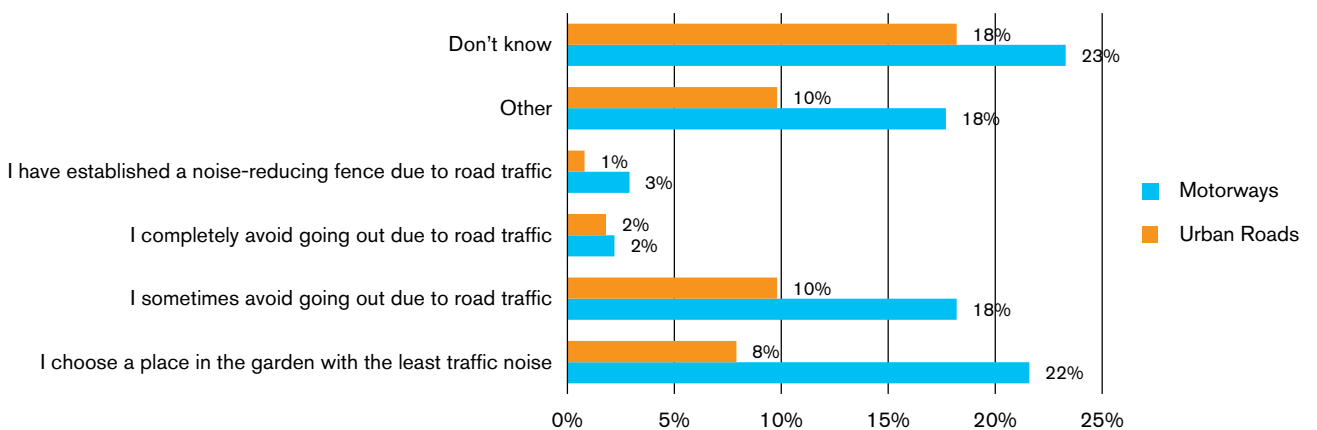
14. "Thinking about the last year or so, when you are outside in the garden, yard or on the balcony at your home, how much does the noise from road traffic bother, disturb or annoy you?"



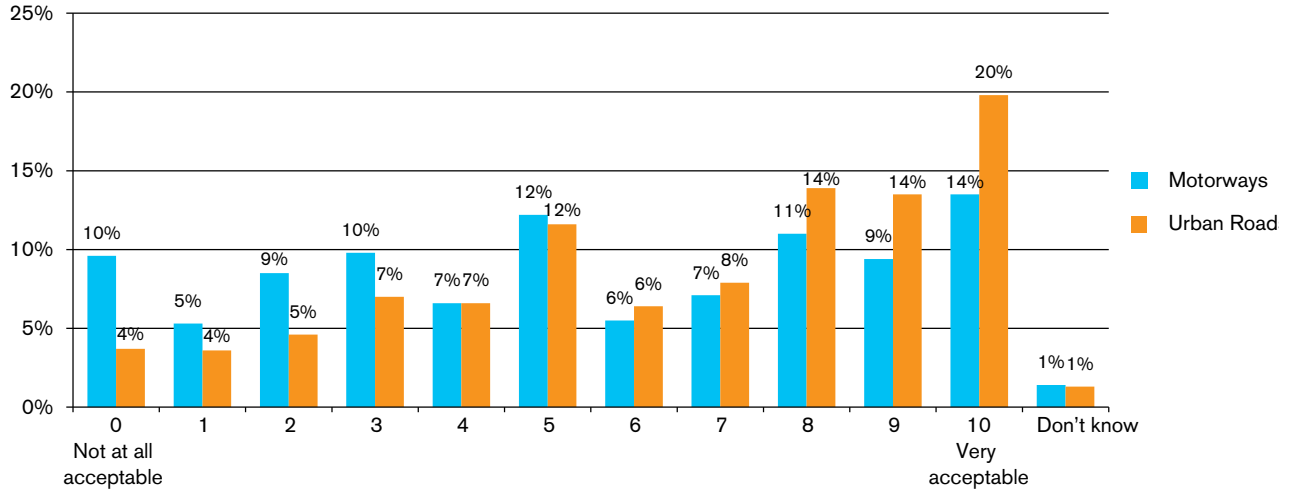
15. "Thinking about the last year or so, when you are outside in the garden, yard or on the balcony at your home, in what way does noise from road traffic bother, disturb or annoy you?"



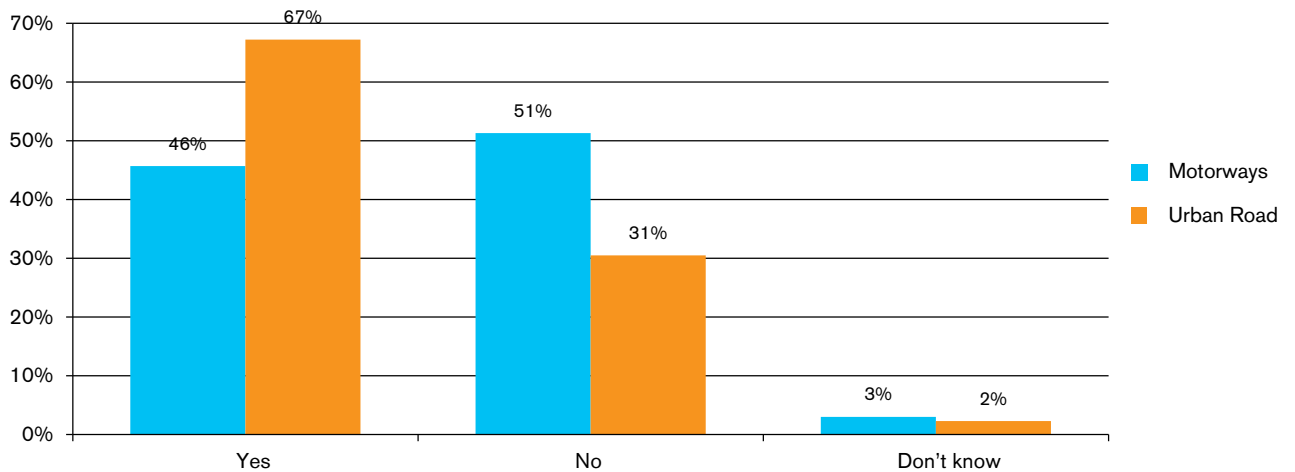
16. "Thinking about the last year or so, have you done anything because of noise from road traffic?"



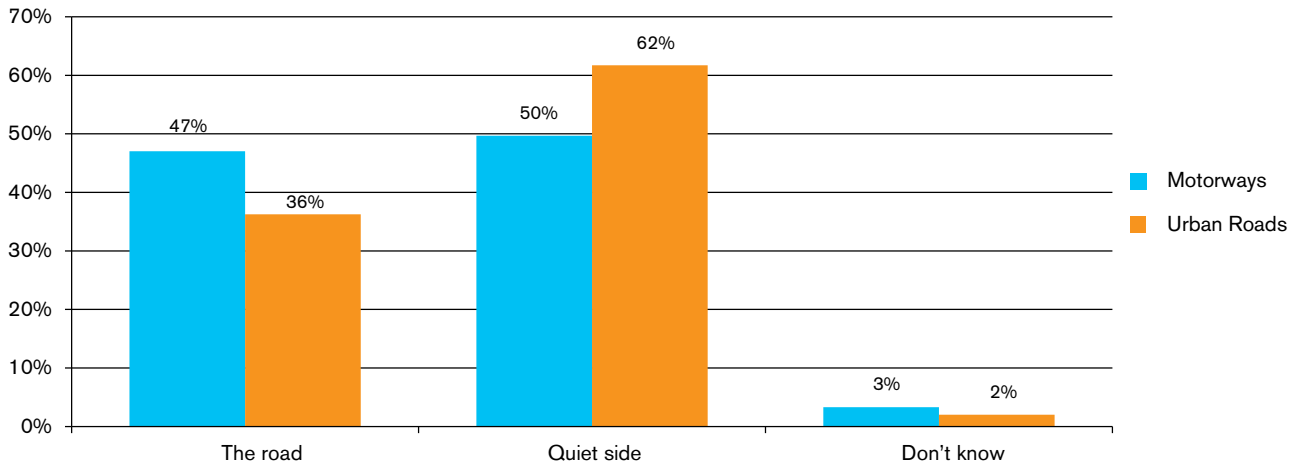
17. "Do you generally think that the noise level from road traffic in your home is acceptable?"



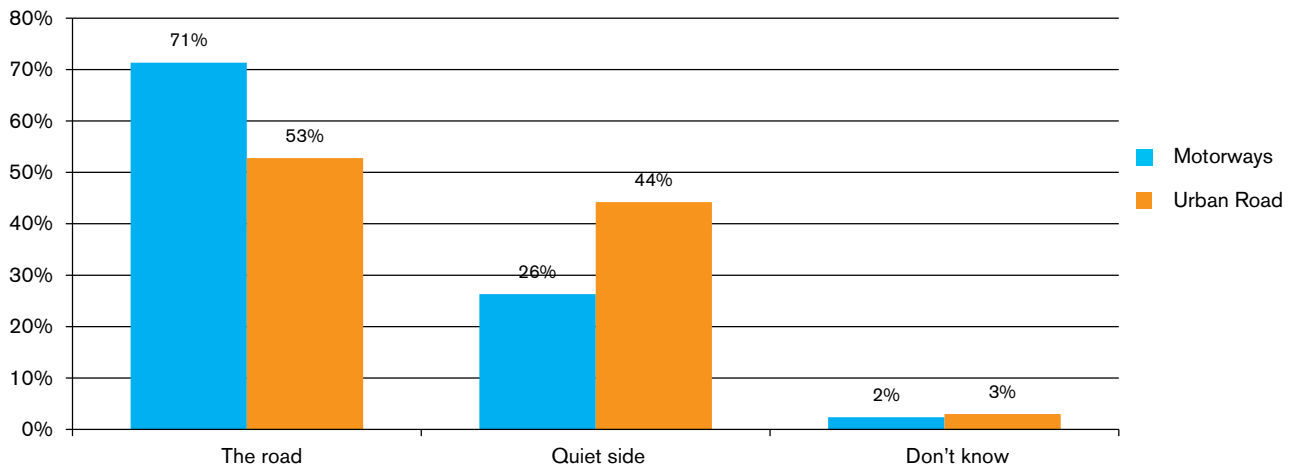
18. "Does your home have a quiet side where there is no noise from road traffic?"



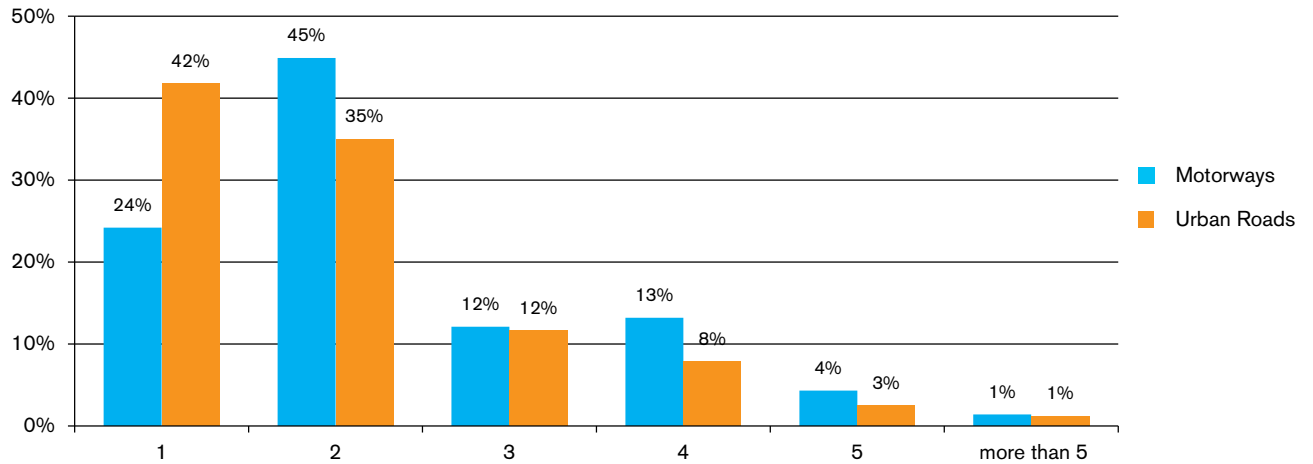
19. "Is your bedroom facing:"



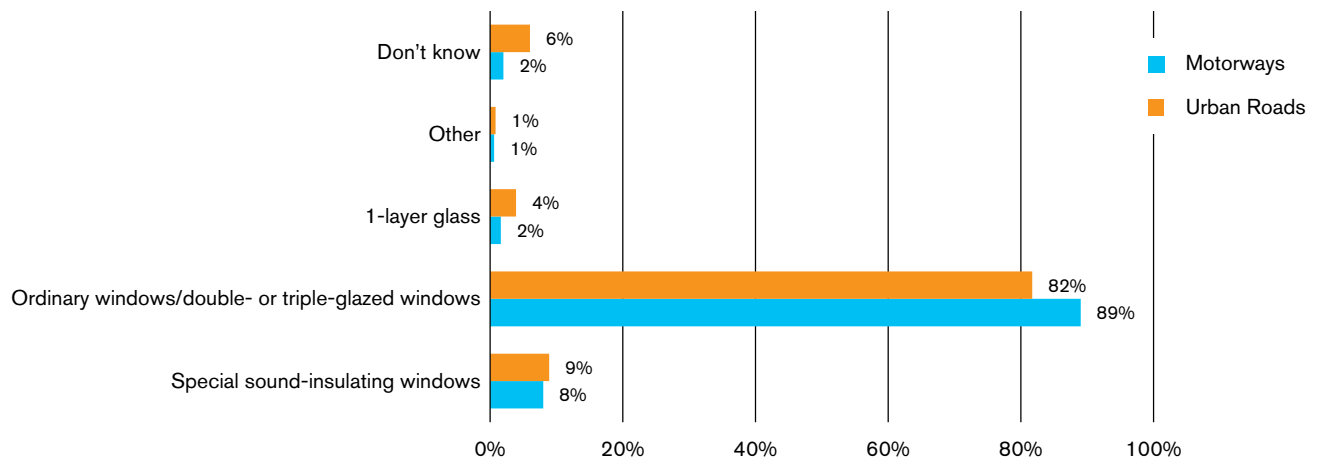
20. "Is your living room facing:"



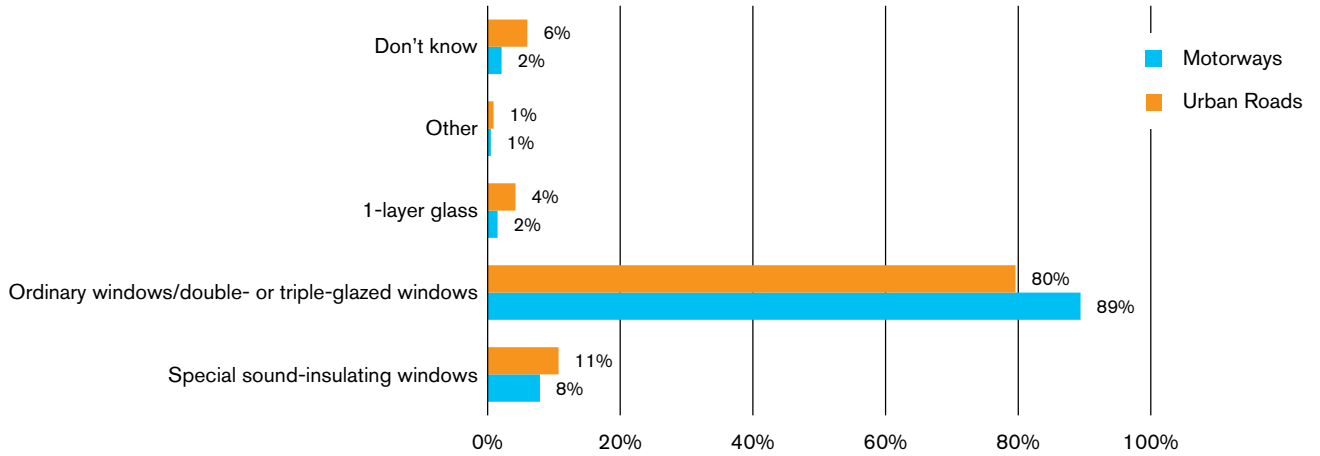
21. "How many people have permanent residence at the address?"



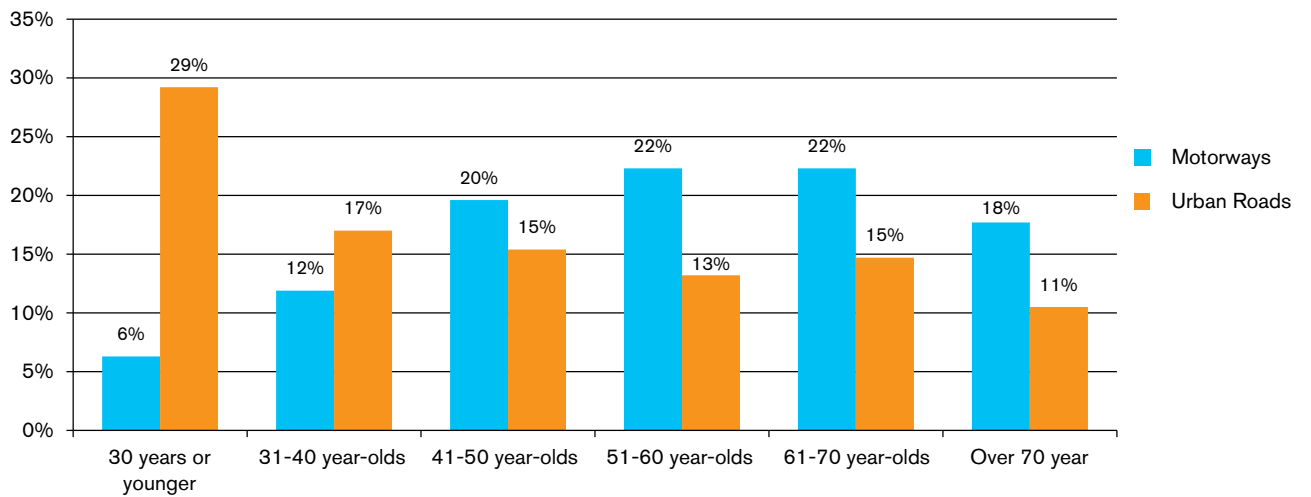
22. "What type of windows do you have in your bedroom?"



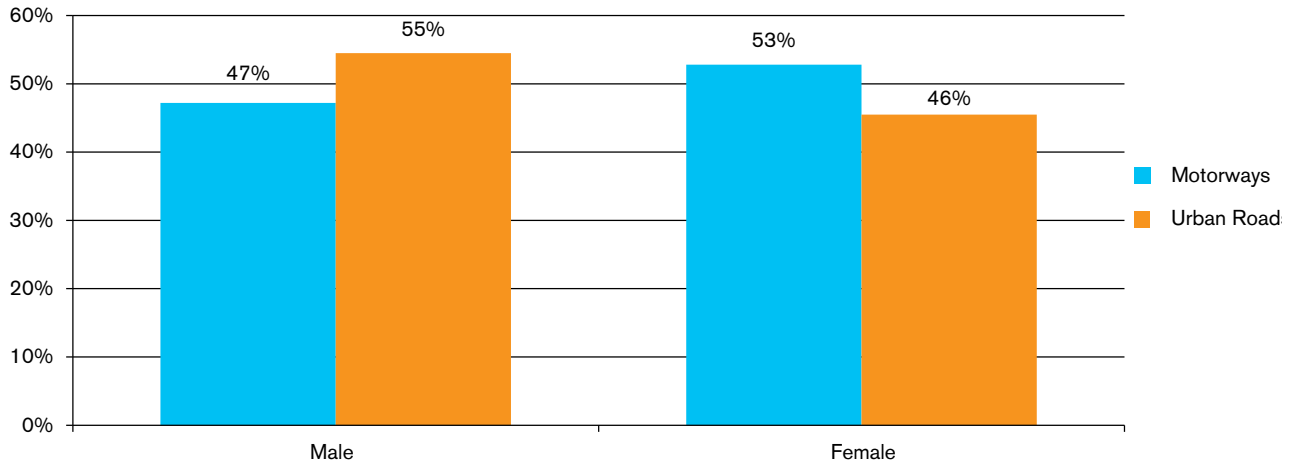
23. "What type of windows do you have in your living room?"



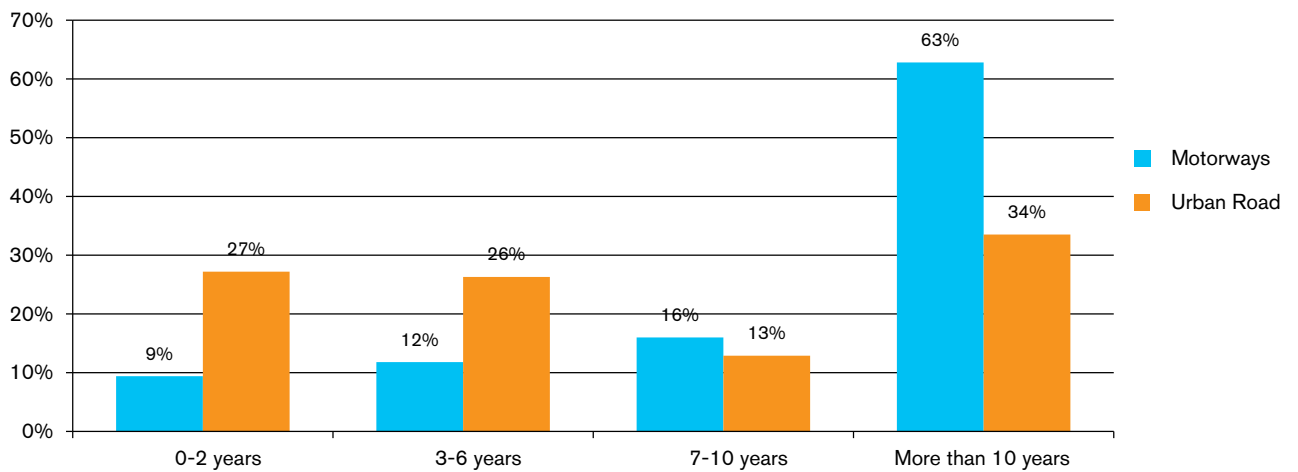
24. "In which year were you born?" (recoded to age categories)



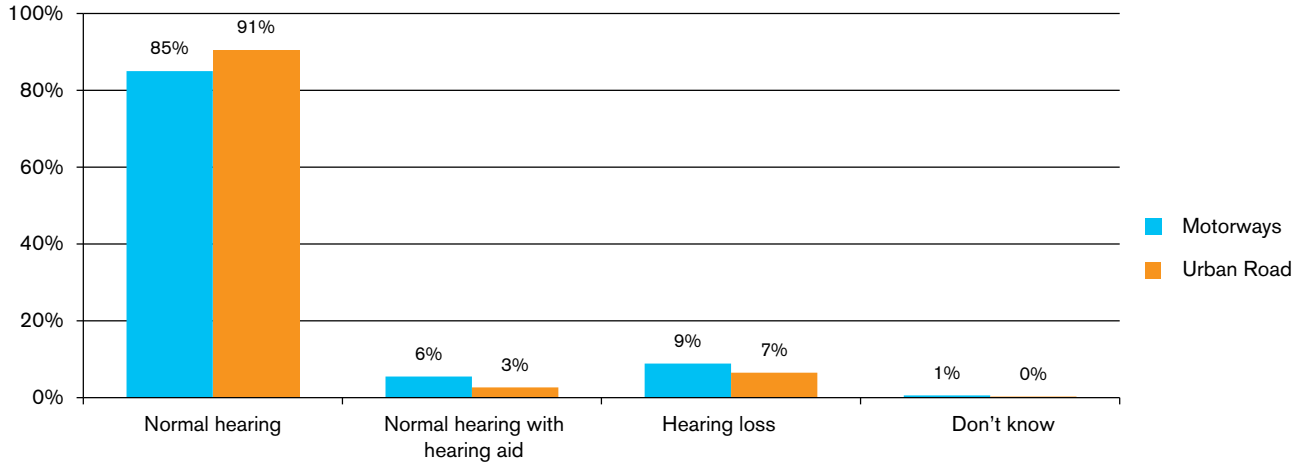
25. "Are you male or female?"



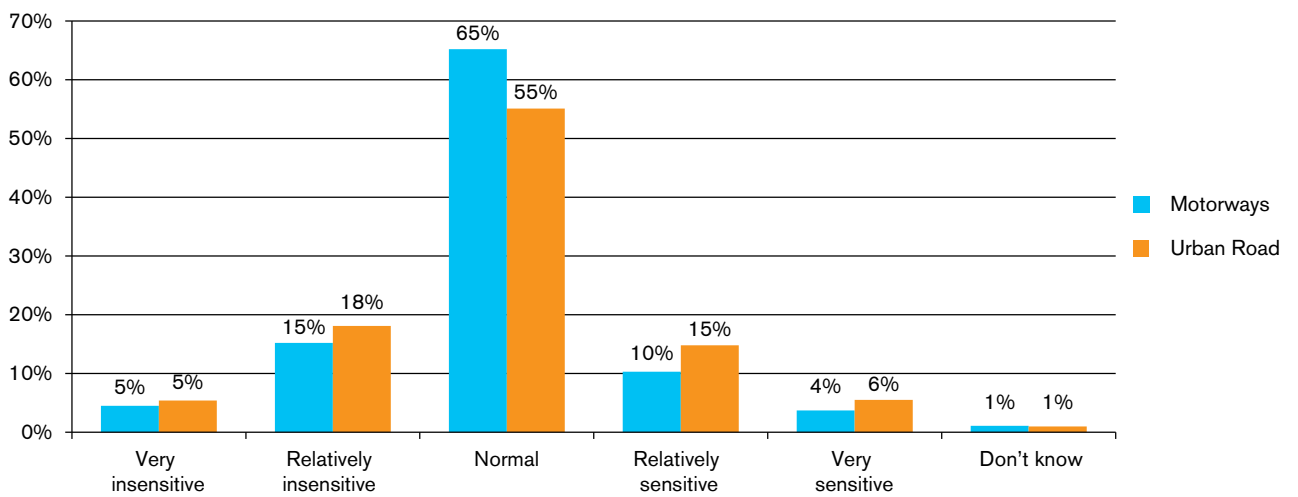
26. "For how long have you lived in your home?"



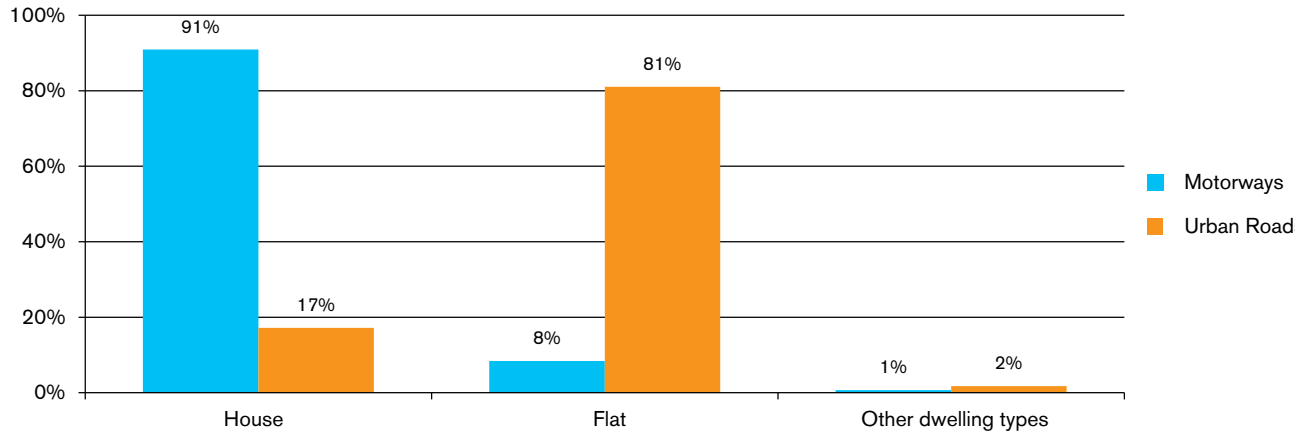
27. "How is your hearing?"



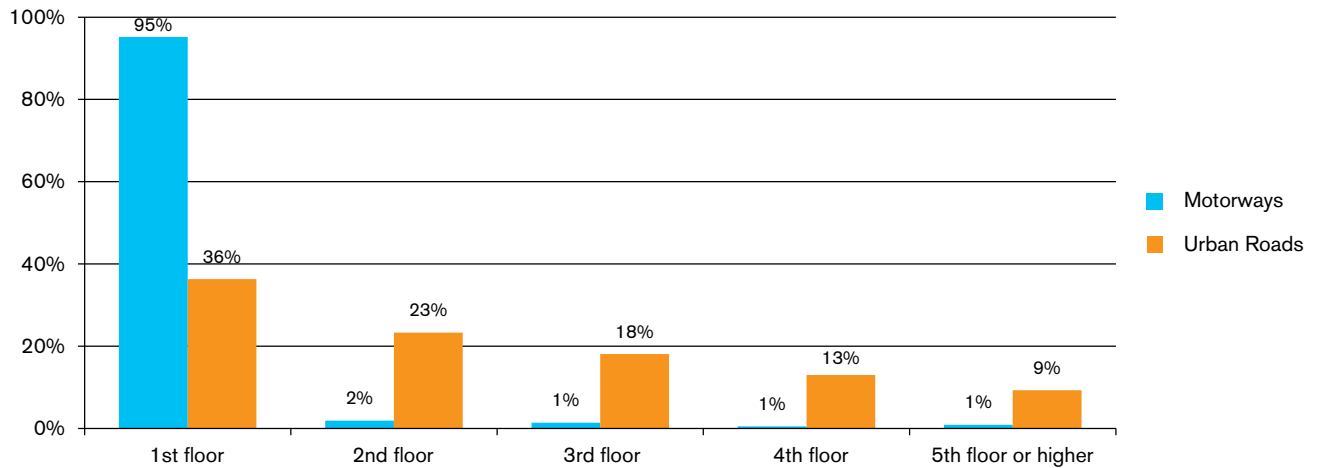
28. "How sensitive are you to noise?"



29. *What type of dwelling does the person live in*



30. *On which floor is the home located*



The Danish Road Directorate has five regional offices:

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