Community response to transport noise exposure in New Zealand

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Darran Humpheson, Tonkin + Taylor, Christchurch
Katrina Magill, Research New Zealand, Wellington

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NZ Transport Agency Waka Kotahi
Private Bag 6995, Wellington 6141, New Zealand
Telephone 64 4 894 5400; facsimile 64 4 894 6100
NZTAresearch@nzta.govt.nz
www.nzta.govt.nz

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[1] This research was conducted from April 2021 to October 2023.

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Abbreviations and acronyms

%HA	percentage of people highly annoyed – rating 8 or higher on the 11-point scale
CTL	community tolerance level
dB	decibel
ERF	exposure response function
L_{A10}	A (frequency)-weighted, F-time weighted sound level that is equalled or exceeded for 10% of the measurement time, commonly abbreviated as L_{10}
$L_{Aeq,16h}$	A-weighted continuous equivalent sound level over a 16-hour period from 7am to 11pm
$L_{Aeq(24h)}$	A-weighted continuous equivalent sound level over 24 hours
L_{den}	day/evening/night level – L_{Aeq} over a 24-hour period with the addition of 10 dB to sound levels at night (11pm to 7am) and 5 dB to sound levels in the evening (7pm to 11pm)
L_{dn}	day/night level – L_{Aeq} over a 24-hour period with the addition of 10 dB to sound levels at night (10pm to 7am)
OGPA	open-graded porous asphalt

Contents

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Executive summary

Noise annoyance

Environmental noise can harm human health and negatively impact people's daily activities at home, school and work and during leisure. The World Health Organization (WHO) 2018 environmental noise guidelines recommend maximum admissible noise levels to protect population health. Long-term annoyance, impaired wellbeing and self-reported sleep disturbance due to noise are classified by the WHO as health outcomes. Annoyance response is the most readily measurable and reliable indicator in self-reported socio-acoustic surveys.

Environmental noise caused by transportation can cause a range of disturbance and annoyance reactions among individuals. The threshold at which individuals will be annoyed by these sources of noise will vary depending on their expectations and sensitivity to noise. When combined at a population level, exposure response functions (ERFs) derived from the percentage of people reporting being highly annoyed for a given noise exposure level can be generated for different forms of transport. These exposure response relationships can be compared to similar research. Differences may exist due to non-acoustic factors that influence reported annoyance.

In 2016, a socio-acoustic survey was conducted in Auckland that considered the ERFs of people exposed to road-traffic and railway noise. The objective was to determine exposure response relationships based on a comparison of short-term changes in noise compared to existing steady-state (long-term) conditions. Due to a number of limitations, this objective could not be fulfilled. However the steady-state analysis did show that the percentage of people highly annoyed for a given noise exposure compared well with similar international studies, although in each case, the onset of annoyance occurred at marginally lower noise exposure levels.

The WHO 2018 guidelines include new ERFs derived from a meta-analysis of various studies. These new relationships showed that higher levels of reported annoyance are occurring at lower noise exposure levels than had previously been identified for transportation noise sources.

Study scope and methodology

To further assist with understanding New Zealanders' response to transportation noise, a second socio-acoustic study was undertaken to assess short-term and long-term response to transport noise exposure. Unlike the previous research and to align with the bulk of international transportation noise research, aircraft were included as a mode of transport. The scope of the study was also extended to include roads and railways outside Auckland. Aircraft study areas were defined around Auckland, Rotorua and Queenstown Airports.

The study commenced in 2021 and coincided with COVID-19 restrictions and the subsequent reduction in transportation activity within New Zealand. Socio-acoustic surveys were delayed until activity levels had returned to near normal levels, and they took place between September and December 2022. Due to the intervening period, it was not appropriate to assess short-term response. The 2016 survey questionnaire was used and expanded to include time-of-day factors, health and general wellbeing questions, interventions used to reduce annoyance and respondents' views of the noise source and those responsible for the relevant transportation infrastructure.

Sample populations for each mode of transport were identified, and potential respondents were then randomly sampled within those population groups. A total sample of n=2,212 completed the survey mostly on paper although some completed the survey online or by telephone. A sub-sample of n=808 completed the road-traffic survey, n=775 completed the railway element and n=629 completed the aircraft survey. This multi-survey approach was adopted to maximise response rates.

The findings of the study have been extrapolated to the New Zealand population exposed to transport noise on the basis that the wider exposed population have on average the same opinions as the sample population.

Road-traffic noise findings

Road-traffic noise was generally regarded as the most common source of noise annoyance by all respondents, regardless of which sample group they belonged to. When respondents were asked to identify which noise source currently bothers them the most when at home, 35% said they were most annoyed by road-traffic noise. This was also identified as the most annoying noise by 20% of the railway sample and 28% of the aircraft sample.

When asked specifically about their level of annoyance with road-traffic noise, 20% of the sample reported being highly annoyed (rating 8 or more on the 0–10 annoyance scale). Of those highly annoyed with road-traffic noise, 65% were highly annoyed when inside their home with the windows open, 51% were highly annoyed even with their windows closed and 61% were highly annoyed when at home outside. Two-thirds (66%) of those highly annoyed found the noise annoying both during the week and in the weekends, especially in the evening and early morning (between 7pm and 3am).

One-quarter or more of highly annoyed respondents reported that road-traffic noise affected:

- their ability to relax outdoors (37%)
- their ability to get to sleep (31%)
- how much sleep they get (26%)
- how easily they become irritated (26%)
- how stressful or anxious they feel (26%)
- their ability to read, work or study from home (25%).

In terms of actions and interventions to try and minimise the noise or at least the impact it has, 24% of all respondents (and 45% of those highly annoyed) said they currently keep their windows and doors closed when at home, while others said they spend less time outside and more time indoors (12% of sample respondents and 30% of those highly annoyed).

Around 40% of those highly annoyed by road-traffic noise strongly disagreed that their local council (40%), freight operators (38%) or NZ Transport Agency Waka Kotahi (37%) were doing their best to reduce road-traffic noise affecting their neighbourhood.

Railway noise findings

When railway sample respondents were asked to identify which noise source currently bothers them the most when at home, 9% said they were most annoyed by railway noise. To put this into perspective, more than double this proportion of the railway sample (20%) said they were more annoyed by road-traffic noise.

When asked specifically about their level of annoyance with railway noise, only 7% (n=44) of the sample reported being highly annoyed and 39% said they were not annoyed or bothered. Of those highly annoyed, 66% were highly annoyed when inside their home with the windows open and 42% with their windows closed. Two-thirds (65%) of those highly annoyed found the noise annoying both during the week and at weekends, especially late in the evening and early morning (between 7pm and 3am).

Most of those highly annoyed with the noise reported that their bedroom faced the train tracks (81%), which also explains why the main impacts were to do with difficulties sleeping. In turn, 28% of those highly annoyed reported that noise affects how stressful or anxious they feel (28%) and how easily they get irritated (25%).

Just over one-third of those highly annoyed strongly disagreed that their local council (34%) or KiwiRail (38%) were doing their best to reduce railway noise affecting their neighbourhood.

Aircraft noise findings

When asked to identify which noise source currently bothers them the most when at home, 30% of all aircraft sample respondents said they were most annoyed by aircraft noise. However, a similar proportion (28%) of aircraft sample respondents were most annoyed by road-traffic noise.

When asked specifically about their level of annoyance with aircraft noise, one in four of the sample (24%) reported being highly annoyed. Of those highly annoyed with aircraft noise, most were highly annoyed when inside their home with the windows open (81%) although 63% were also highly annoyed even with their windows closed. Aircraft noise was considered to be annoying both during the week and at weekends, particularly so in the evening and early morning (between 7pm and 7am).

Many impacts were noted with regard to aircraft noise, particularly among those who were highly annoyed. For example, one-third or more of highly annoyed respondents reported that the noise has affected:

- their ability to relax outdoors (47%)
- their ability to listen to music, the radio or TV (46%)
- how easily irritated they get (44%)
- their ability to get to sleep (42%)
- how stressful or anxious they feel (35%)
- their health and wellbeing in general (35%)
- how much sleep they get (33%)
- their ability to read, work or study from home (33%).

In terms of actions and interventions to try and minimise aircraft noise or at least the impact it has, 23% of respondents (and 54% of those highly annoyed) stated they currently keep their windows and doors closed when at home. Others said they spend less time outside when they are at home (9% of all people sampled and 23% of those highly annoyed), while 19% of those who are highly annoyed are planning to move from the area altogether.

Almost one-half of those highly annoyed by aircraft noise strongly disagreed that their local council (47%), airport company (45%) or airline/aircraft operators (49%) were doing their best to reduce the noise from aircraft affecting their neighbourhood.

Exposure response relationships

Socio-acoustic studies have consistently shown that a population’s sensitivity to environmental noise varies considerably between people and that ERFs differ depending on the source and attitudes, which are also related to non-acoustic factors. Differences could be due to changes in attitudes toward the source of noise, changes in noise exposure, differences in the cultures of those being surveyed, differences in study design, implementation or measurement or a combination of these factors. The WHO 2018 guidelines identify that, of the three sources of transportation noise, aircraft noise invokes the highest exposure response followed by road-traffic noise then railway noise. The studies used to inform the WHO 2018 guidelines also show that there are geographic variations in ERFs for the same source of noise, which include country/cultural differences.

Exposure response relationships were derived for each transportation mode. When compared to the WHO 2018 guidelines, the sampled New Zealand population is more sensitive to road-traffic noise, is less sensitive to railway noise and has similar sensitivities to aircraft noise. The study’s findings for road-traffic and railway noise are comparable to the findings of the previous New Zealand study.

Abstract

Environmental noise can harm human health and can negatively impact people's daily activities at home, school and work and during leisure. The World Health Organization (WHO) 2018 environmental noise guidelines recommend maximum admissible noise levels to protect population health. Long-term annoyance, impaired wellbeing and self-reported sleep disturbance due to noise are classified by the WHO as health outcomes. Annoyance response is the most readily measurable and reliable indicator in self-reported socio-acoustic surveys.

A New Zealand road-traffic and railway socio-acoustic study was performed in Auckland in late 2016. Analysis of the percentage of people highly annoyed compared well with similar international studies, although in each case, the onset of annoyance occurred at marginally lower noise exposure levels. The outcomes of this study were used to inform a second national study, which was conducted in late 2022. A total of 2,122 completed responses were collected across road-traffic, railway and aircraft noise study areas. Compared to the WHO 2018 guidelines, the New Zealand population exposed to transportation noise showed a greater annoyance sensitivity for road-traffic noise, a lower sensitivity for railway noise and similar sensitivity for aircraft noise. The study surveyed respondents' opinions on other sources of noise annoyance, time-of-day factors, their health and general wellbeing, interventions they may take to reduce annoyance and their views of the noise source and those responsible for the relevant transportation infrastructure.

1 Introduction

1.1 Background

The World Health Organization (WHO, 2018) continues to acknowledge that environmental noise can harm human health and can negatively impact people's daily activities at home, school and work and during leisure. Environmental noise is an important public health issue and features among the top environmental risks to health. Environmental noise can disturb sleep, cause psychophysiological effects, reduce performance and provoke annoyance responses and changes in social behaviour. It can cause negative impacts on physical and mental health and wellbeing depending on the degree of noise exposure. Annoyance response is the most readily measurable and reliable indicator in self-reported socio-acoustic surveys.

When defining acceptable thresholds to manage the adverse effects of noise, annoyance exposure response functions (ERFs) are defined based on the exposed population at large rather than the noise sensitivity of individuals.[2] These thresholds are derived from socio-acoustic studies that establish the relationship between a respondent's perceived level of annoyance against their noise exposure from specific sources such as road-traffic, railway or aircraft noise.

When aggregated across an exposed population, the term 'average annoyance response' is used. Over time, individuals who are newly affected by a noise source (introduction of a new noise-generating activity or choosing to move into an area where there is an existing source of environmental noise) may habituate to the source of noise. The degree of habituation will vary depending on the context of the noise source and is further complicated if people are pre-sensitised prior to the introduction of the new noise source – for example, by adverse publicity or from construction noise effects prior to a new road, railway or airport/runway being opened. Following the change, there will be a short elevation in ERF followed by a gradual decline back to the steady-state average annoyance response. There is a paucity of relevant research that has investigated the degree of this elevation in annoyance response, but for newly constructed roads, this habituation generally occurs over a period of 12–18 months and in some cases a number of years. It has been hypothesised that this is likely to be due to the original newly exposed population moving out and new residents moving in who are not sensitised to the source of the noise in the same way as the previous residents. This view is supported by the WHO when considering ERFs following the opening of a new runway or an increased number of aircraft movements.

In 2018, the WHO updated its 1999 environmental noise guidelines (WHO, 1999) and included ERFs for road-traffic, railway, aircraft, windfarm and leisure noise. The ERFs of the WHO 2018 guidelines are derived from a meta-analysis of various studies and illustrate that higher levels of reported annoyance are occurring at lower noise exposure levels than had previously been identified for transportation noise sources. In some cases, this variation in response between the various studies can be significant, especially if there are influencing factors other than noise exposure.

The WHO 2018 guidelines recommend maximum admissible noise levels to protect population health. Long-term annoyance and impaired wellbeing as well as self-reported sleep disturbance due to noise are classified by the WHO as health outcomes. Annoyance response is the most readily measurable and reliable indicator in self-reported social surveys. Therefore, ERFs for a certain decibel (dB) value can assist with establishing health outcomes of a population.

[2] Exposure response functions are a relationship between noise exposure level and the percentage of people who are highly annoyed (%HA).

Socio-acoustic studies have consistently shown that a person's sensitivity to environmental noise varies considerably, that ERFs differ depending on the source and that attitudes are also related to non-acoustic factors. Differences could be due to changes in attitudes toward the source of noise, changes in noise exposure (for example, changes in aircraft, operations, frequency of flights and times of occurrence), differences in the cultures of those being surveyed, differences in study design, implementation or measurement or a combination of these factors. The WHO 2018 guidelines identify that, of the three sources of transportation noise, aircraft noise invokes the highest ERF followed by road-traffic noise then railway noise. The studies used to inform the WHO 2018 guidelines also show that there are geographic variations in ERFs for the same source of noise, which include country/cultural differences.

1.2 Previous research

Previous New Zealand research commissioned by NZ Transport Agency Waka Kotahi (NZTA) in 2016 (Humpheson & Wareing, 2019) investigated the community response to road-traffic and railway noise and concluded that the New Zealand population is more sensitive to transportation noise than comparable international studies, including the European standard ERFs (Miedema & Oudshoorn, 2001). Humpheson and Wareing aimed to survey 1,200 respondents split evenly between two road-traffic study areas and a railway study area. One of the study's aims was to assess short-term changes in noise exposure following a change such as the opening of a new or altered road or a significant variation in traffic characteristics. All study areas were within the Auckland region to enable a relatively dense population to be surveyed. Telephone and paper questionnaires were conducted and the results combined with modelled noise exposure levels to establish ERFs for road-traffic noise (short-term and long-term effects) and railway noise.

A limitation of the Humpheson and Wareing research was that a balance had to be made between new roads that could be assessed, which were predominantly Roads of National Significance, and the population pool in the vicinity of these roading projects. The majority of the potential study areas were in less densely populated areas (an artefact of introducing a by-pass). This limited the size of the available population, which may have adversely affected the statistical findings.

Humpheson and Wareing observed that the short-term study area (Waterview Connection) had been subject to an extended period of construction works and the respondents rated 'building and construction' and 'road works' higher in terms of annoyance than the other two study areas. They concluded that respondents may have been sensitised to noise in general having been subjected to a major construction project and that their reported annoyance had been influenced in the lead-up to the road being open. Out of a list of 10 sources of environmental noise, road-traffic noise was rated highest, and for the railway study area, trains were rated the fifth most annoying noise source. The derived ERFs were found to compare well with other studies, although in each case, the onset of annoyance occurred at lower noise exposure levels.

Respondents were asked to provide general feedback on noise and other matters. It was noted that lifestyle impacts were a concern, which included general disturbance and interference with their quality of life. Interestingly, driver behaviour accounted for the greatest number of comments, with 'boy racers' and trucks being cited as the two most common sources of noisy events.

Three recommendations were made by Humpheson and Wareing to assist with future socio-acoustic studies:

- Survey across multiple study areas to improve the number of respondents as it was recognised that trying to achieve target numbers of completed interviews in small population areas is difficult.
- Include time of day and day of week annoyance response questions to investigate whether noise metrics used to describe transportation noise should be weighted during the evening and night periods.
- Survey the short-term Waterview study area once steady-state traffic flows have stabilised (a year after opening) to assess whether the ERF had changed.

1.3 Research purpose

NZTA commissioned Tonkin + Taylor in 2021 to carry out a Phase 2 community noise study. The aim was to reassess people's attitudes to sources of transportation noise to determine ERFs to compare with relevant international studies and the meta-analysis of the WHO 2018 guidelines. Research New Zealand assisted in the sampling methods and data interpretation and conducted the social surveys.

The scope of Phase 2 included aircraft, thereby covering all three main transportation modes.

1.3.1 Objectives of the research

The research objectives were to:

- define and quantify New Zealand community response to short-term increases in transportation noise exposure from different modes
- define and quantify New Zealand community response to long-term transportation noise exposure from different modes.

The broad tasks to achieve these objectives were to:

- prepare a literature review to provide context on the current level of knowledge on community noise exposure from different modes and the response to both short-term changes in exposure and long-term/steady-state conditions
- develop a peer-reviewed methodology to enable social surveys to be undertaken to establish the community response to noise from different transportation modes
- establish the noise dose/community response (ERF) for people subjected to long-term exposure to transportation noise
- establish the noise dose/community response (ERF) for people subjected to a short-term increase in transport noise exposure for areas that have experienced a recent change (ideally less than 18 months)
- prepare a research report detailing the community responses to transportation noise and to benchmark those responses to international literature and for road and rail against the New Zealand results found by Humpheson and Wareing (2019).

The outputs from this research will assist NZTA, policy makers and regulators in understanding the noise effects on communities affected by different transportation modes.

1.4 Special circumstances

This research study commenced in April 2021 during the COVID-19 pandemic. Due to limitations in the integrity of conducting socio-acoustic during a pandemic, the survey element of this study was delayed until COVID-19 restrictions in New Zealand had lifted and society and transport movements[3] had started to return to pre-pandemic levels of activity.

[3] Noting that domestic and international aircraft movements are unlikely to return to pre-pandemic levels for another 2–3 years.

2 Literature review

Transportation noise is known to cause disturbance among affected communities and, depending on the level of exposure, can have an adverse effect on health (WHO, 2018). Community response to noise is affected by a wide range of factors, both physical and psychological. Physical factors are easier to quantify and include the sound level as well as the number and frequency of events. Other important factors include the time of day or night that the events occur. Psychological factors are a lot more subjective and therefore much harder to quantify. These include people's perception of a noise source and whether they think it is reasonable as well as their general sensitivity to noise. Psychological or behavioural responses to noise start with disturbance – distraction from tasks, sleep disturbance and speech interference. At a higher level of noise, this leads to annoyance and actions such as making complaints.

A community's response to noise will vary widely due to different people's sensitivities and perceptions. There is no simple indicator that can determine how a certain level of noise will be perceived by a person, community or population. The subject of community response to noise is vast and constantly evolving. This literature review should be considered as a small but focused snapshot covering a range of opinions and findings. It represents a best-practice review of current knowledge and understanding as of 2022.

The scope of this literature review combines social survey methodologies and best practice with a review of overseas research into annoyance response to transportation noise.[4] Methods for deriving ERFs between social survey responses and noise exposure are discussed. Humpheson and Wareing (2019) undertook a literature review with a similar scope, although it excluded aircraft noise. This literature review therefore includes some of that study's findings.

2.1 Research methodologies and questionnaire development

Understanding community responses to noise requires gathering reliable information from people exposed to noise. ISO/TS 15666:2021 *Acoustics – Assessment of noise annoyance by means of social and socio-acoustic surveys* sets out internationally agreed specifications for social surveys that include questions on noise annoyance. It contains direction on the questions to be asked, response scales, key aspects of conducting the survey and reporting of the results. While adherence with ISO/TS 15666:2021 will not guarantee reliability in establishing a community response to the noise in question, it provides a benchmark for direct comparison with other studies.

2.1.1 Question design

ISO/TS 15666:2021 includes two recommended questions – one with a verbal rating scale and the other with a numerical rating scale. The verbal rating scale uses a 5-point rating system and asks respondents this question:

> *Thinking about the last [12 months or so], when you are here at home, how much does noise from [noise source] bother, disturb or annoy you? Not at all, slightly, moderately, very, extremely.*

The numeric rating scale uses a slightly modified question and an 11-point rating system:

> *Thinking about the last [12 months or so], when you are here at home, what number from 0 to 10 best shows how much you are bothered, disturbed or annoyed by [source] noise?*

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[4] The literature review was completed at the start of the study and only relevant literature up to the start of 2021 has been included.

The use of the phrase ‘12 months or so’ as a suggested timeframe is designed to capture opinion on the response to long-term/steady-state noise. The timeframe can be adjusted to fit the purpose of a study or to avoid pinpointing specific events within the last 12 months. Inclusion of ‘or so’ alongside the timeframe encourages a general response rather than a direct comparison of the last 12 months with any other period.

To account for international variances, translations of the standard annoyance response questions into other languages are included in Appendix B of ISO/TS 15666:2021. Translation into a language not included in the standard requires empirical studies to assess that the translated words are appropriately calibrated to the desired meaning. Direct translation cannot be relied upon, implying that both the verbal and numerical questions must be used unaltered. This is especially the case when making comparisons between studies to ensure consistency of findings.

This consistency also applies to the reporting of results in order to make comparisons across studies. ISO/TS 15666:2021 outlines minimum specifications for reporting core information from social and socio-acoustic surveys in scientific reports. This information is reproduced in Table 2.1.

Table 2.1 Minimum specifications for reporting core information from social and socio-acoustic surveys in scientific reports

Topic area	Topic	Required information
Overall design	Survey date	Year and months of social surveys
	Site location	Country and city of study sites
	Size selection	Any important, unusual characteristic of the study period or sites Map or description of study site locations relative to the noise source
	Site size	Rationale for site selection Site selection and exclusion criteria
	Study purpose	Number of study sites Number of respondents by site Statement of original study goals
Social survey sample	Sample selection	Respondent sample selection method (probability, judgemental, etc.) Respondent exclusion criteria (age, gender, length of residence, etc.)
	Sample size and quality	Response rate Reasons for non-response
Social survey data collection	Survey methods	Method (face to face, telephone, etc.)
	Questionnaire wording	Exact wording by primary questionnaire items (including answer alternatives)
	Precision of sample estimate	Number of responses for main analysis
Acoustics conditions	Noise source	Type of primary noise source (aircraft, road traffic, etc.) Types of noise source operations that are included or excluded Protocols to define the noise source (for example, minimum level, operations, days of week)
	Noise metrics	Give the complete description of any noise metric reported according to ISO 1996-1, ISO 1996-2, ISO 1996-3 or ISO 3891 (if applicable) Provide $L_{Aeq(24hr)}$, L_{dn} and L_{den} (or L_{Aeq} by time period) for all locations or provide conversion rule(s) to estimate $L_{Aeq(24hr)}$, L_{dn} and L_{den} under the specific study conditions from the study’s preferred metric Discuss the adequacy of the conversion rule(s) Provide impulse and/or tone corrections

Topic area	Topic	Required information
	Time period	Hours of day represented by noise metric Period (months, years) represented by noise metric
	Estimation/ measurement procedure	Estimation approach (modelling, measurement during sampled period, etc.)
	Reference position	Nominal position relative to noise source and reflecting surfaces Present exposure (or give conversion rule) for noisiest façade, specifying whether reflections from the façade are or are not accounted for
	Precision of noise estimate	Best information available on precision of noise exposure estimates
Basic dose/ response analysis	Dose/response relationships	Tabulation of frequency of annoyance ratings for each category of noise exposure

Source: ISO/TS 15666:2021

A social survey will feature a number of questions alongside the standardised noise annoyance questions. Historically in socio-acoustic surveys, the sound level is considered to contribute to one-third of total variance in the annoyance response measure. The remaining two-thirds are considered to split evenly between non-acoustic factors and an unexplained random variance (Guski, 1999). Further questions in a community noise study should provide an opportunity to understand potential non-acoustic factors that may influence community response.

Fields (1993) identified five social factors that can significantly affect the results of a socio-acoustic survey. These five factors are:

- fear of danger from the noise source
- noise prevention beliefs
- general noise sensitivity
- beliefs about the importance of the noise source
- annoyance with non-noise impacts of the noise source.

Alongside the ISO/TS 15666:2021 noise annoyance question, Lechner et al. (2019) included questions regarding:

- socio-demographics
- housing situation
- noise perception
- living conditions and quality of life
- subjective assessment of personal quality of life
- subjective assessment of personal sensitivity to noise
- subjective assessment of personal health
- annoyance/disturbance through noise
- sleep disturbance through noise
- noise coping measures
- mobility.

One limitation of social surveys is that answers are self-reported. Flindell et al. (2021) recommended including an open-ended question to qualify what residents had in mind when reporting an annoyance score. In the case of exposure to aircraft noise, Flindell et al. noted that respondents reported selecting their annoyance rating by a number of methods such as:

- averaging the perceived worst and perceived least worst situations
- thinking only of the perceived worst-case aircraft noise situation such as holding a BBQ outside in summer
- thinking of events assumed to occur when they are not present and selecting a response intended for the protection of people who are present
- misunderstanding the question and the intention of the researchers such as relating to aircraft noise in general or their attitude to the airport as a whole rather than to the specific effect
- avoiding any perceived risk of contributing to constraints that could be put on the airport that could limit employment or other opportunities.

A related effect was initially found by Hong et al. (2018), where respondents regularly reported zero annoyance to high noise levels as they thought reporting annoyance could be interpreted as being 'against government policy'. Flindell et al. (2021) also recommend the inclusion of trade-off questions to help categorise noise annoyance against a less transparent scale. This decreases policy response bias whereby respondents select the highest level of annoyance to show their objection to an activity. Presenting a trade-off against increased road-traffic congestion is a commonly used comparison along with monetary trade-offs in the form of a noise exposure tax from which the resident would benefit. However, the scenarios have failings around uniformity of experience both with current traffic congestion and financial situation. Flindell et al.'s conclusion encouraged development and trial of alternative trade-off questions and other methods that may provide a better understanding of community response than the established ERF curves.

Along with question content, question style is important. Corbetta (2003) presented an in-depth review of methods for undertaking social surveys and listed 21 factors that should be considered in developing a questionnaire. These were summarised by Humpheson and Wareing (2019, pp. 15–16):

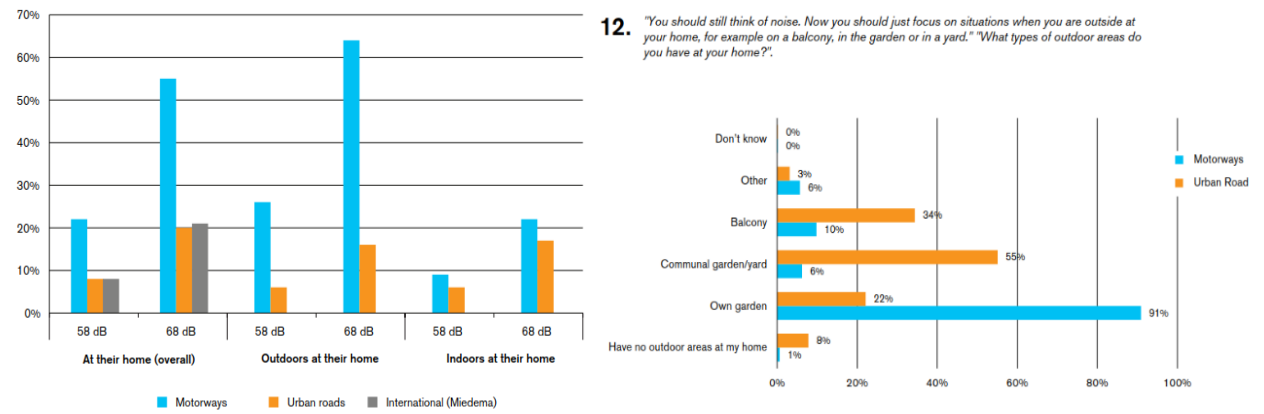
- **Simplicity of language and syntax:** It is important that any questions asked be accessible for all respondents. In the setting of a socio-acoustic study, care must be taken to ensure technical terminology is avoided. Use of complex syntax such as double negatives may further confuse respondents.
- **Question length and survey length:** The questions asked must be short enough to ensure the respondent does not lose the meaning of the question – questions should be concise, clear and simple. This rule also applies to overall questionnaire length as respondents may lose interest or become bored if it is too lengthy.
- **Number of response alternatives:** The number of response alternatives should be limited to a manageable number so that the respondent does not become confused. This is especially important in spoken interviews such as telephone interviews.
- **Use of slang, ambiguous or vague definitions, abstract questions and answers:** Terms that are not clear or use slang may confuse or alienate respondents. The use of clear terms also aids in developing a concise questionnaire. Abstract questions or questions that require abstract answers should be avoided as they can confuse or frustrate respondents.
- **Emotive terms or loaded questions:** The use of highly emotive terms may cause the respondent to answer in a non-objective way. Loading of a question may prime a respondent to answer in a positive or negative manner. Care should be taken in the wording of the question to avoid influencing the respondent's answer.

- **Non-discriminating questions or questions with unequivocal answers:** Non-discriminating questions do not yield variations between respondents (for example, a question where all respondents will answer yes), do not offer added information and unnecessarily increase the length of the survey. Questions without a clear answer or questions with multiple answers for the same underlying meaning cause confusion for the respondent.
- **Presumed behaviour:** Survey questions should not assume that the respondent acts or behaves in a certain way.
- **Memory effects:** Questions that require a respondent to remember a single event will encounter difficulty. Instead, asking a question about a timeframe is generally simpler for respondents to understand.
- **Question order:** The order of questioning can significantly impact the results of a survey. In structuring a survey, several factors need to be considered. The respondent must be eased into any difficult or complex questions, the respondent's interest and tiredness should influence the location of questions and the questioning should follow a logical sequence. Due to these factors, it is generally best to locate questions that require significant thought in the middle of the survey, and it is essential to ensure that the questioning avoids sudden changes in type or context.

The importance of gathering appropriate information was shown by Fryd et al. (2016). The Danish study included the questions recommended in ISO/TS 15666:2021 and found that motorway noise was significantly more annoying at an equivalent L_{den} noise level than other road classifications. The study also appeared to find that people younger than 30 years of age were significantly less sensitive to road-traffic noise annoyance than older respondents. However, the study also found that people living near motorways were majority home owner-occupiers with access to a private outdoor garden space.

Figure 2.1 shows that people exposed to urban road-traffic noise reported being similarly bothered whether they were inside or outside, whereas people exposed to motorway noise were significantly more bothered by the noise when they were outside. The figure also shows that respondents exposed to motorway noise were significantly more likely to have a private garden space than those exposed to urban noise. It is plausible that expectation of the noise environment and amount of time spent outdoors would be notably different for people with and without access to a private outdoor space.

Figure 2.1 Motorway versus urban road-traffic noise annoyance (reprinted from Fryd et al., 2016)

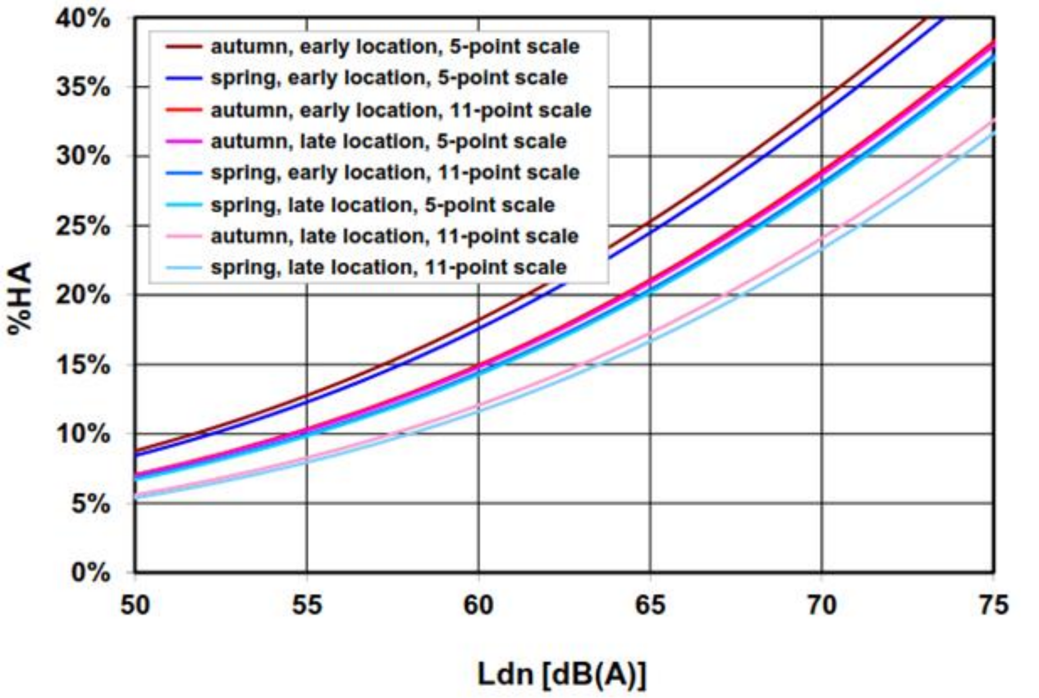


The ISO/TS 15666:2021 question generally asks respondents to report on disturbance 'when you are here at home' and time spent indoors and outdoors at the residence. However, differences in ownership, access and use of outdoor space can result in varied responses.

Brink et al. (2016) investigated the effect on the location of noise annoyance questions within a survey, the time of year the survey was undertaken and the scale used to define annoyance.

The ERF for each combination of variables is shown in Figure 2.2. The legend is ordered from highest annoyance response to least. The third and fourth annoyance curves and the fifth and sixth annoyance curves approximately match and are not easily distinguished in the figure.

Figure 2.2 Percentage highly annoyed (%HA) as a function of L_{dn} sound level (reprinted from Brink et al., 2016, p. 14)



Three variables are considered: season of sampling; location of noise annoyance questions in the survey; and scale of reported annoyance. %HA includes the top 40% of response options in the 5-point scale and the top 28% of responses in the 11-point scale.

Time of year was hypothesised to have an influence on the annoyance response due to variation in time spent outside in each season. It was found that higher annoyance was recorded in autumn by a small margin (surveys were undertaken in the northern hemisphere).

'Early location' and 'late location' refer to the stage in the questionnaire that the annoyance question was raised. Asking for a respondent's annoyance response early in the survey or reporting using the 5-point scale increased reported annoyance by a significant margin.

2.1.2 Survey methods

The method by which the survey is administered influences the results, scale and cost of the survey.

Table 2.2 summarises four of the major survey types as described by Corbetta (2023). Each survey type has clear strengths and weaknesses. The primary balance is between cost and time and the resultant quality of the data collected.

Table 2.2 Comparison of different survey interview types

Topic	Face to face	Telephone	Mail/self-completion	Web
Sample	Postcode address	Random digit	Postcode address	
Sample type	Probability	Probability	Probability	Non-probability
Turnaround time	Slow	Fast	Fast	Fast
Cost	High	Medium	Low	Very low
Interviewers required	Yes	Yes	No	No
Interview length	Up to 2 hours	Maximum ½ hour	Maximum 15 minutes	Maximum 15 minutes
Response rates	High	Medium	Low	Low
Main advantages	High response rates Better quality of data More complex questions Longer time to interview hence more data collected Interviewer rapport with the respondent	Low cost Able to reach a large number of geographically spread population Fast turnaround time	Low cost Able to reach a large number of geographically spread population	Low cost Able to reach a large number of geographically spread population Able to use visual aids in web surveys
Main disadvantages	High set-up costs Interviewers need training and supervision Long time in the field	Low response rate Sampling problems with key groups Unable to ask long or complex questions or use visual aids	Low response rate Poor-quality data if respondents misunderstand the questions No control over resident selection	Sampling issues (such as people with higher perceptions of noise issues) Poor quality of data Low response rates

Source: Corbetta (2003)

Humpheson and Wareing (2019) surveyed using telephone and self-completion questionnaires. Computer-assisted telephone interviewing is widely used for government studies as it is cost-effective and time-efficient as it requires no field work.

Phone interviews are considered to effectively balance these key considerations. However, it must be noted that they are also impacted by a number of factors:

- Some key groups may be hard to effectively sample, especially with the increasing number of people who only use mobile phones.[5]
- Interviewers are unable to ask complex questions or use visual aids.
- People are less inclined to answer personal questions over the phone.
- Response categories and the overall survey must be relatively short.

Stats NZ has produced a guide to good survey design that provides information for organisational planning and undertaking social surveys (Stats NZ, 2019). The guide identifies issues associated with planning, undertaking, commissioning, managing and processing a survey.

[5] Mobile phones may not be registered at the address where the intended respondent resides.

The main sections of the guide focus on:

- preparation for undertaking a survey
- survey management
- sample selection
- questionnaire development
- sources of error
- processing and presentation of survey results.

The preparation section presents a useful series of questions for defining the scope and scale of the survey. Initial planning should focus on identifying available timeframes and finances and establishing relationships necessary for undertaking the survey. It is also important to ensure the survey objectives are adequately defined and to accurately define the end user of the survey data to ensure the end results are as expected.

To effectively manage a survey, it is important that all the steps of the survey are well defined and that a plan is developed to manage each phase. Typical surveys require management of the following phases:

- **Planning:** Approvals for funding, engaging subcontractors, preparation of detailed timetables, approval of survey design and consultation with end users and advisors.
- **Consultation:** This includes end users, sponsors, contractors and designers.
- **Design:** Identify and fill key roles, identify required classifications and definitions and evaluate existing classifications and standards.
- **Pre-tests and pilot surveys:** Identify how and when these will be undertaken.
- **Operation:** Identify how data will be collected, who will collect the data, how interviewers are matched to respondents and what quality assurance will be implemented.
- **Non-response:** Identify what approach will be used in the case of non-responses and partial responses and how this data will be incorporated.
- **Processing and analysis:** Identify required data processing expertise, ensure necessary software is available and develop metrics for results and accuracy checking.
- **Reporting:** Develop templates for reporting data and identify how privacy and confidentiality will be handled and where results will be realised.
- **Risks:** Develop a plan for major issues that may arise during the survey such as low response rates, inaccurate data and insufficient time or resources.

The selection of a suitable sample population is fundamental to the accuracy of the survey results. Target populations (also called exposed populations) need to be identified. In this research study, this is residents who live in an area exposed to road-traffic, railway or aircraft noise. It is not practical to survey all residents in New Zealand who fall within this category so it is necessary to identify a suitable sub-group to be surveyed. This survey population should accurately represent the overall target/exposed population. A method for randomising the survey population is also required to ensure no biases are present in the selection process.

An often overlooked but vital component of survey design is the development and testing of a questionnaire. Poor questionnaires can lead to increases in non-sampling error, non-response, partial response or analysis costs. The questionnaire needs to be tested and refined using peer review and user testing.

Humpheson and Wareing (2019) completed 801 interviews, of which 551 were by telephone (inclusive of landline and mobile) and 250 were online. Recommendations for future surveys were aimed at obtaining more responses due to the response rate from telephone surveying being low. Considerations included combining results from multiple study areas, accepting a greater margin of error for results and potentially including face-to-face surveys.

The National Research Council (2002) presented information on conducting studies of welfare populations. While the study was targeted at welfare recipients, the methods for increasing telephone response rates were considered common across all telephone surveys. Study recommendations cover three subtopics:

- **Contacting subjects:** It was recommended to record histories of previous attempts to reach a survey participant. This allows the times and days of the week to be varied in future phone calls for a better chance of reaching the target person. When an answerphone is reached, the authors recommended leaving a message with the first call and every other call after that up to a maximum of four or five calls. This method is based on their belief that it will communicate the importance of reaching the person.
- **Obtaining cooperation:** Interviewer experience was found to be correlated with high respondent cooperation. Interviewers showing any type of hesitation or lack of confidence is correlated with high refusal rates. Groves and Couper (1998) presented results from an experiment on an establishment survey that showed significant improvement in cooperation rates once interviewers are provided with detailed training on how to handle reluctant respondents.
- **Questionnaire design:** Restricting the length of a survey at the expense of valuable information is not worthwhile as the length of phone surveys is not well correlated with response rate.

Most refusals occur at the introduction to the survey, and statements of utility of the survey were not found to increase response rates. However, stating that the study is government sponsored was considered to increase response rates. The widely agreed rule about introductions is that they need to be as short as possible. Following a refusal, the National Research Council recommends sending a letter to the address in an attempt to convince the respondent to participate and to recontact the subject 7–21 days after first refusal.

Alternatives to phone surveys may be necessary to increase the number of responses. Changing the mode of survey has been found to change how people respond to some questions. Bowyer and Rogowski (2017) found that telephone responses tend to result in the respondent selecting ‘no answer’ less often than when completing an online survey, whereas internet responses seem superior on alleviating social desirability biases. However, in the study, ‘no opinion’ was provided as a response option, and questions were asked where respondents may hold highly socially controversial opinions.

Christensen et al. (2014) found that non-response rate was higher in a self-administered questionnaire than a face-to-face interview. The increased non-response rate was more notable in men and in people aged under 24 years. It was also observed that the social desirability bias was notable in health-based questions. In face-to-face interviews, more people reported being overweight and to smoking daily. However, they also reported drinking less, exercising more regularly and having a higher quality of life. The study conclusion was that, even without an interviewer, there was a social desirability bias. This bias was exaggerated when an interviewer was present unless the interviewer would be able to observe whether the answer was truthful (for example, regarding obesity or smoking).

2.2 Determining the community noise response

2.2.1 Noise metrics

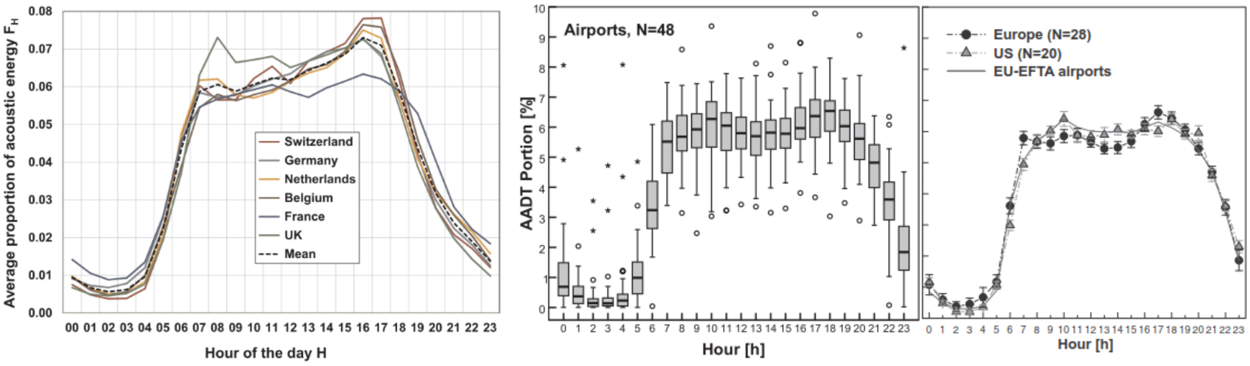
Defining community response requires reported annoyance to be equated with a measurement of sound of the source in question. Evidence from community noise studies (WHO, 2018) shows that noise annoyance is informed by long-term exposure. This cumulative exposure is the reason socio-acoustic studies investigate a population’s response to long-term noise and use exposure-based noise metrics. The energy averaged A-weighted sound level (L_{Aeq}) is a commonly used exposure based metric. It represents the total noise energy experienced and includes the A-weighting adjustment for human audibility.

Road-traffic noise in New Zealand is assessed against NZS 6806:2010 *Acoustics – Road-traffic noise – New and altered roads*, which uses the $L_{Aeq(24h)}$ metric. Aircraft noise is assessed using the L_{dn} metric in accordance with NZS 6805:1992 *Airport noise management and land use planning* and NZS 6807:1994 *Noise management and land use planning for helicopter landing areas*. L_{dn} is equivalent to L_{Aeq} with a 10 dB penalty added to noise at night (10pm to 7am). The 10 dB weighting specifically accounts for the intrusiveness of noise at night and its potential impact on sleep. The logarithmic nature of the dB unit exposure-based metric means that the higher-level events generally tend to control the resulting $L_{Aeq,t}/L_{dn}$.

Unlike road-traffic and aircraft noise, there is no relevant New Zealand standard for railway noise. In Europe, it is standard practice to use L_{den}, which applies a 5 dB weighting to the evening period (7pm to 11pm) and a 10 dB weighting at night (11pm to 7am). In the United States, the L_{dn} metric is commonplace.

Brink et al. (2018) published empirically derived conversion rules for converting between $L_{Aeq(24h)}$, L_{dn} and L_{den}. The conversion factors are derived from the average contribution of sound energy for each 1-hour period throughout the day from each traffic source. The proportion of noise energy in each hour from samples in their study is shown in Figure 2.3.

Figure 2.3 Proportion of daily sound energy in each hour of the day for road traffic (left) and aircraft (right) (reprinted from Brink et al., 2018)



The derived conversion terms for each traffic source are included in Tables 2.3 to 2.5.

Table 2.3 Conversion factor for road-traffic noise (reprinted from Brink et al., 2018)

↓ Desired metric ↓	↓ Known metric ↓												
	LDay[a]	LDay[b]	LDay[c]	LNight[a]	LNight[b]	LEvening[a]	LEvening[b]	LAeq24h	Lden[a]	Lden[b]	Ldn[a]	Ldn[b]	Ldn[c]
LDay[a] =		+0.1	−0.5	+7.1	+6.0	+1.6	+2.9	+1.3	−2.0	−2.3	−2.1	−1.8	−1.3
LDay[b] =	−0.1		−0.6	+6.9	+5.9	+1.5	+2.8	+1.2	−2.1	−2.4	−2.2	−1.9	−1.4
LDay[c] =	+0.5	+0.6		+7.6	+6.5	+2.1	+3.4	+1.8	−1.5	−1.8	−1.6	−1.2	−0.8
LNight[a] =	−7.1	−6.9	−7.6		−1.1	−5.5	−4.2	−5.7	−9.1	−9.3	−9.2	−8.8	−8.3
LNight[b] =	−6.0	−5.9	−6.5	+1.1		−4.4	−3.1	−4.7	−8.0	−8.3	−8.1	−7.7	−7.3
LEvening[a] =	−1.6	−1.5	−2.1	+5.5	+4.4		+1.3	−0.3	−3.6	−3.9	−3.7	−3.4	−2.9
LEvening[b] =	−2.9	−2.8	−3.4	+4.2	+3.1	−1.3		−1.5	−4.9	−5.1	−5.0	−4.6	−4.1
LAeq24h =	−1.3	−1.2	−1.8	+5.7	+4.7	+0.3	+1.5		−3.3	−3.6	−3.4	−3.1	−2.6
Lden[a] =	+2.0	+2.1	+1.5	+9.1	+8.0	+3.6	+4.9	+3.3		−0.3	−0.1	+0.3	+0.7
Lden[b] =	+2.3	+2.4	+1.8	+9.3	+8.3	+3.9	+5.1	+3.6	+0.3		+0.2	+0.5	+1.0
Ldn[a] =	+2.1	+2.2	+1.6	+9.2	+8.1	+3.7	+5.0	+3.4	+0.1	−0.2		+0.3	+0.8
Ldn[b] =	+1.8	+1.9	+1.2	+8.8	+7.7	+3.4	+4.6	+3.1	−0.3	−0.5	−0.3		+0.5
Ldn[c] =	+1.3	+1.4	+0.8	+8.3	+7.3	+2.9	+4.1	+2.6	−0.7	−1.0	−0.8	−0.5	

Table 2.4 Conversion factor for railway noise (reprinted from Brink et al., 2018)

↓ Desired metric ↓	↓ Known metric ↓												
	LDay[a]	LDay[b]	LDay[c]	LNight[a]	LNight[b]	LEvening[a]	LEvening[b]	LAeq24h	Lden[a]	Lden[b]	Ldn[a]	Ldn[b]	Ldn[c]
LDay[a] =		+0.0	+0.1	+0.7	+0.7	−0.4	−0.3	+0.2	−5.9	−6.0	−5.9	−5.5	−5.5
LDay[b] =	+0.0		+0.1	+0.7	+0.8	−0.4	−0.3	+0.2	−5.9	−5.9	−5.9	−5.4	−5.5
LDay[c] =	−0.1	−0.1		+0.6	+0.7	−0.5	−0.3	+0.1	−6.0	−6.0	−6.0	−5.5	−5.6
LNight[a] =	−0.7	−0.7	−0.6		+0.0	−1.1	−1.0	−0.5	−6.6	−6.7	−6.6	−6.2	−6.2
LNight[b] =	−0.7	−0.8	−0.7	+0.0		−1.1	−1.0	−0.6	−6.7	−6.7	−6.6	−6.2	−6.2
LEvening[a] =	+0.4	+0.4	+0.5	+1.1	+1.1		+0.1	+0.6	−5.5	−5.6	−5.5	−5.1	−5.1
LEvening[b] =	+0.3	+0.3	+0.3	+1.0	+1.0	−0.1		+0.4	−5.7	−5.7	−5.6	−5.2	−5.2
LAeq24h =	−0.2	−0.2	−0.1	+0.5	+0.6	−0.6	−0.4		−6.1	−6.1	−6.1	−5.6	−5.7
Lden[a] =	+5.9	+5.9	+6.0	+6.6	+6.7	+5.5	+5.7	+6.1		+0.0	+0.0	+0.5	+0.4
Lden[b] =	+6.0	+5.9	+6.0	+6.7	+6.7	+5.6	+5.7	+6.1	+0.0		+0.1	+0.5	+0.5
Ldn[a] =	+5.9	+5.9	+6.0	+6.6	+6.6	+5.5	+5.6	+6.1	+0.0	−0.1		+0.4	+0.4
Ldn[b] =	+5.5	+5.4	+5.5	+6.2	+6.2	+5.1	+5.2	+5.6	−0.5	−0.5	−0.4		+0.0
Ldn[c] =	+5.5	+5.5	+5.6	+6.2	+6.2	+5.1	+5.2	+5.7	−0.4	−0.5	−0.4	+0.0	

Table 2.5 Conversion factor for aircraft noise (reprinted from Brink et al., 2018)

↓ Desired metric ↓	↓ Known metric ↓												
	LDay[a]	LDay[b]	LDay[c]	LNight[a]	LNight[b]	LEvening[a]	LEvening[b]	LAeq24h	Lden[a]	Lden[b]	Ldn[a]	Ldn[b]	Ldn[c]
LDay[a] =		+0.0	−0.2	+7.6	+7.8	+0.0	+0.6	+1.3	−2.3	−2.2	−1.9	−1.2	−1.2
LDay[b] =	+0.0		−0.2	+7.6	+7.8	+0.0	+0.6	+1.3	−2.3	−2.1	−1.9	−1.2	−1.2
LDay[c] =	+0.2	+0.2		+7.8	+7.9	+0.2	+0.7	+1.5	−2.1	−2.0	−1.7	−1.0	−1.1
LNight[a] =	−7.6	−7.6	−7.8		+0.1	−7.6	−7.1	−6.3	−9.9	−9.8	−9.5	−8.8	−8.9
LNight[b] =	−7.8	−7.8	−7.9	−0.1		−7.8	−7.2	−6.4	−10.1	−9.9	−9.7	−8.9	−9.0
LEvening[a] =	+0.0	+0.0	−0.2	+7.6	+7.8		+0.6	+1.3	−2.3	−2.1	−1.9	−1.2	−1.2
LEvening[b] =	−0.6	−0.6	−0.7	+7.1	+7.2	−0.6		+0.7	−2.9	−2.7	−2.5	−1.8	−1.8
LAeq24h =	−1.3	−1.3	−1.5	+6.3	+6.4	−1.3	−0.7		−3.6	−3.5	−3.2	−2.5	−2.5
Lden[a] =	+2.3	+2.3	+2.1	+9.9	+10.1	+2.3	+2.9	+3.6		+0.2	+0.4	+1.1	+1.1
Lden[b] =	+2.2	+2.1	+2.0	+9.8	+9.9	+2.1	+2.7	+3.5	−0.2		+0.2	+1.0	+0.9
Ldn[a] =	+1.9	+1.9	+1.7	+9.5	+9.7	+1.9	+2.5	+3.2	−0.4	−0.2		+0.7	+0.7
Ldn[b] =	+1.2	+1.2	+1.0	+8.8	+8.9	+1.2	+1.8	+2.5	−1.1	−1.0	−0.7		+0.0
Ldn[c] =	+1.2	+1.2	+1.1	+8.9	+9.0	+1.2	+1.8	+2.5	−1.1	−0.9	−0.7	+0.0	

Miedema and Oudshoorn (2001) processed data for both L_{dn} and L_{den} metrics. L_{den} was found to be slightly more sensitive for road-traffic and aircraft noise (+0.2 dB and +0.6 dB, respectively). No difference was found for railways. These results were similar but not identical to the estimated factors provided in Tables 2.3 to 2.5.

L_{den} rather than L_{dn} is more commonly used for community response surveys, especially since it is widely used in Europe. This preference is supported in recent literature, including use in the WHO 2018 guidelines (Guski et al., 2017). The dB levels assigned to the WHO guidelines (WHO, 2018) mean that it is worthwhile being able to make a direct comparison with L_{den} rather than using other metrics. Exceptions could be made for aircraft noise where existing New Zealand aircraft noise contours are developed in terms of L_{dn} and $L_{Aeq(24h)}$ is used to assess road-traffic noise. Noise exposure data should therefore be in a format that can be directly compared to other studies or readily converted into other metrics using appropriate conversions.

Road-traffic noise in the United Kingdom and New Zealand is calculated using the calculation of road-traffic noise procedures (Department of Transport, 1988), which presents noise levels as $L_{A10,t}$ – the sound level exceeded for 10% of the time (t). Abbott and Nelson (2002) reported a conversion factor from L_{A10} to L_{Aeq}. The common conversion factor of $L_{A10} - L_{Aeq} \approx 3\ dB$ was considered robust for free-flowing traffic.

Detailed analysis of the relationship between L_{A10} using the calculation of road-traffic noise and L_{Aeq} led to the derivation of two recommended conversions.

For most roads and motorways:

$$L_{Aeq,1h} = 0.94 * L_{A10,1h} + 0.77dB$$

For non-motorway roads when traffic flows are below 200 vehicles per hour during the period 12am to 6am:

$$L_{Aeq,1h} = 0.57 * L_{A10,1h} + 24.46\ dB$$

The study included further relationships for when only $L_{A10,18h}$ data is reported. However, Abbott and Nelson advise use of the above relationships if hourly data is available.

When only the $L_{A10,18h}$ is known, the relationships for deriving L_{den} are as follows.

For non-motorway roads:

$$L_{den} = 0.92 * L_{A10,18h} + 4.20\ dB$$

For motorways:

$$L_{den} = 0.90 * L_{A10,18h} + 9.69\ dB$$

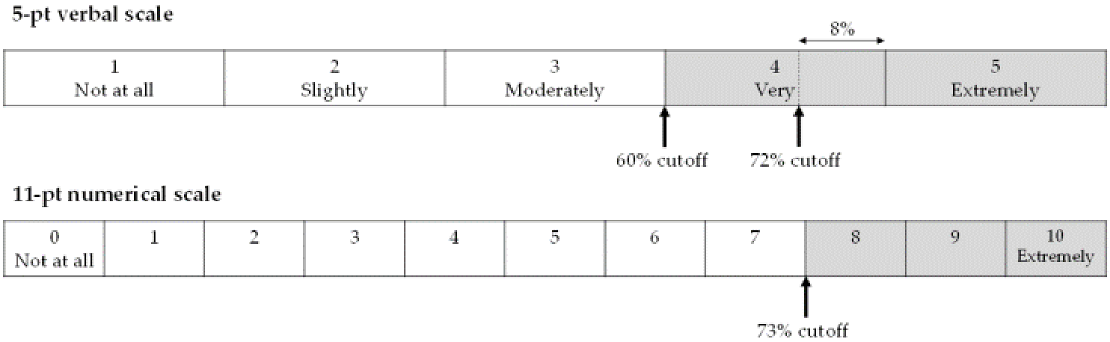
2.2.2 Community noise response

Deriving noise response curves from socio-acoustic surveys is currently considered the accepted method to determine community response to noise. Schultz (1978) first formulated ERF curves. Annoyance responses of 8, 9 and 10 on the 11-point scale were grouped into a class of highly annoyed and %HA plotted against the received noise exposure level (in L_{dn}). Comparison was made against other annoyance scales by defining highly annoyed as study participants whose responses were in the top 27–29% of the annoyance scale.

When using the 5-point scale, it is common to group the top two answers (very annoyed and extremely annoyed) into the highly annoyed group. Based off the 5-point scale descriptors, this approach sounds correct. However, these two answers occupy the top 40% of the scale.

Miedema and Vos (1998) subsequently multiplied the number of very annoyed responses by 0.4 to give the top 28% of the scale for better comparison with the 11-point scale. A visual representation of this difference in scale is included in Figure 2.4.

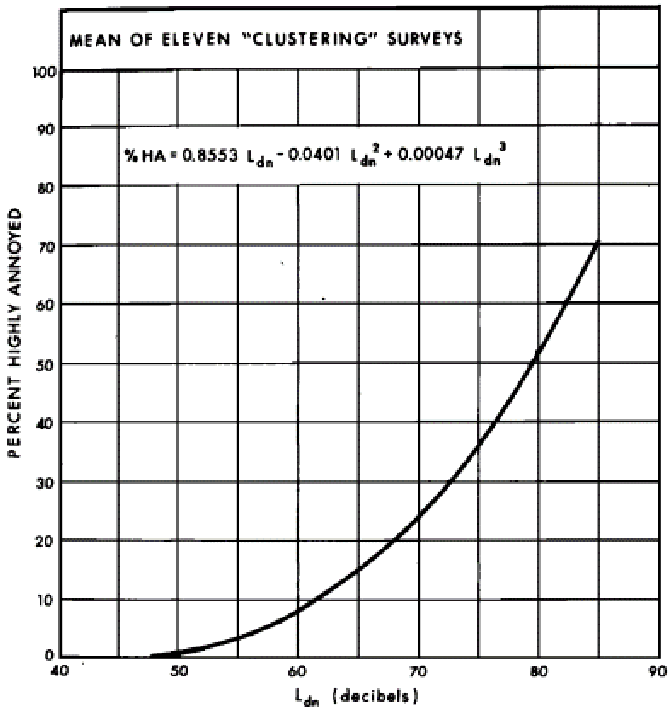
Figure 2.4 The 5-point verbal and 11-point numerical scales showing 60% and 73% cut-off points for highly annoyed (reprinted from Morinaga et al., 2021, p. 5)



Morinaga et al. (2021) performed a meta-analysis of 40 datasets that used the ISO/TS 15666:2021 11-point and 5-point scale annoyance questions. They concluded that there is no systemic difference in ERF relationships between 73%HA determined by the 11-point numerical scale and 72%HA determined by the 5-point verbal scale.

The original Schultz (1978) curve shown in Figure 2.5 presented a calculation of %HA with all noise sources (road-traffic, railway and aircraft noise) grouped. Due to the non-conformance of social studies at the time of the research, only the 11 studies that appeared to cluster were included as part of the response curve.

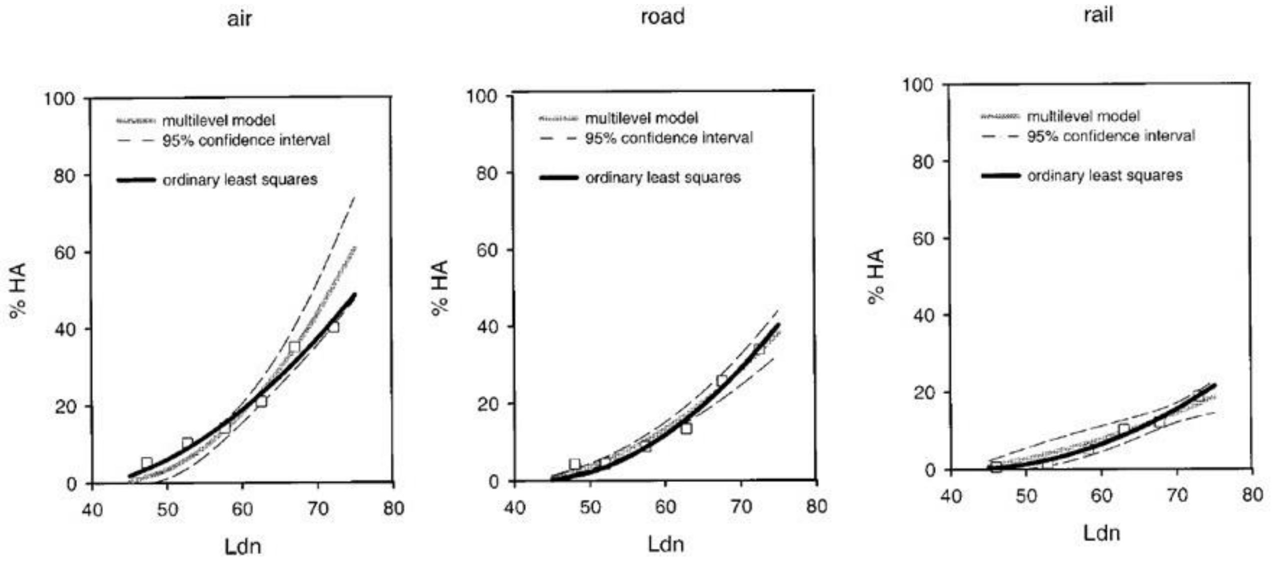
Figure 2.5 Schultz noise response curve (reprinted from Schultz, 1978, p. 382)



Updated exposure response curves were proposed by Miedema and Vos (1998), who conducted a meta-analysis of 55 community response surveys. Included in this meta-analysis were the 21 datasets assessed by Schultz (1978) and Fidell et al. (1991). ERF curves were produced separately for road-traffic, railway and aircraft noise and used the L_{dn}.

These response curves shown in Figure 2.6 became accepted as representing the European community response to noise. People exposed to aircraft noise reported being significantly more annoyed than people exposed to road-traffic or railway noise for the same noise exposure level. The response curves in Figure 2.6 were developed by setting the 0%HA value to 42 dB, as informed by their analysis.

Figure 2.6 Noise response curves (reprinted from Miedema & Vos, 1998)



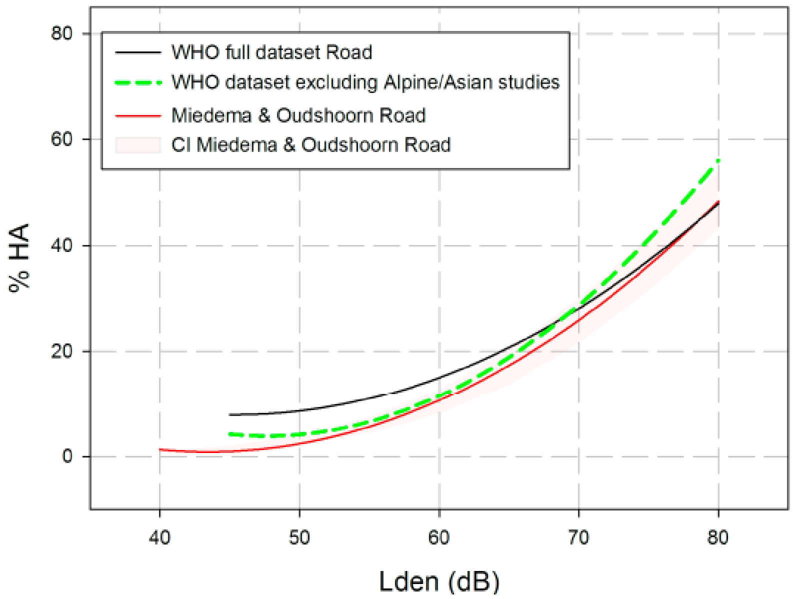
Miedema and Oudshoorn (2001) reprocessed the data from Miedema and Vos (1998) to attempt to better define relationship and confidence intervals. They developed third-order polynomial response curves for L_{den} and L_{dn} as opposed to the second-order response curves with respect to L_{dn} in Miedema and Vos. The relationship and 95% confidence intervals do not differ much from Miedema and Vos. The relationships are included alongside the results from Guski et al. (2017) in Figures 2.7 to 2.9.

Guski et al. (2017) conducted a similar meta-analysis of noise annoyance studies published between 2000 and 2014. The work was funded by the WHO to understand the community response to transport noise in Europe. ERF curves were derived from the relationship between %HA and L_{den} for each traffic source. Guski et al.'s findings were included in the WHO guidelines (WHO, 2018) and form the basis of the three ERFs for sources of road-traffic, railway and aircraft noise.

Guski et al.'s road-traffic study analysis included 25 studies, of which five were of alpine environments that include valleys. These studies were the only ones to assess the annoyance response down to 40 dB L_{den}, with three of the studies counting %HA using the upper 40% of the 5-point scale. These studies were excluded from the Guski et al. analysis as the factors were considered to skew the data significantly. Guski et al. also theorised that the 10 studies included from Asian countries returned a lower annoyance as respondents were likely living in air-conditioned housing, exposing them to a masking sound.

The response relationship for road-traffic noise is included in Figure 2.7. The analysis with alpine and Asian studies removed showed a similar relationship between road-traffic noise and annoyance as the European standardised curve of Miedema and Oudshoorn (2001).

Figure 2.7 Response curve for road-traffic noise (reprinted from Guski et al., 2017, p. 23)



Guski et al. (2017) assessed 11 studies addressing noise from railways. There were some notable variations between studies, but unlike the road-traffic noise analysis, there was not a large enough base of research to discard studies with potentially confounding variables. As a result, the analysis includes four studies in valleys or where there were public discussions about the negatives of railways and six studies where %HA had been defined as the upper 40% of responses.

The response relationships are included in Figure 2.8. The analysis by Guski et al. showed a greater annoyance from railway noise than the European standardised curve of Miedema and Oudshoorn (2001). Only the lowest two datasets approximately fit the relationship derived by Miedema and Oudshoorn.

Figure 2.8 Response curve for rail traffic noise (reprinted from Guski et al., 2017, p. 30)

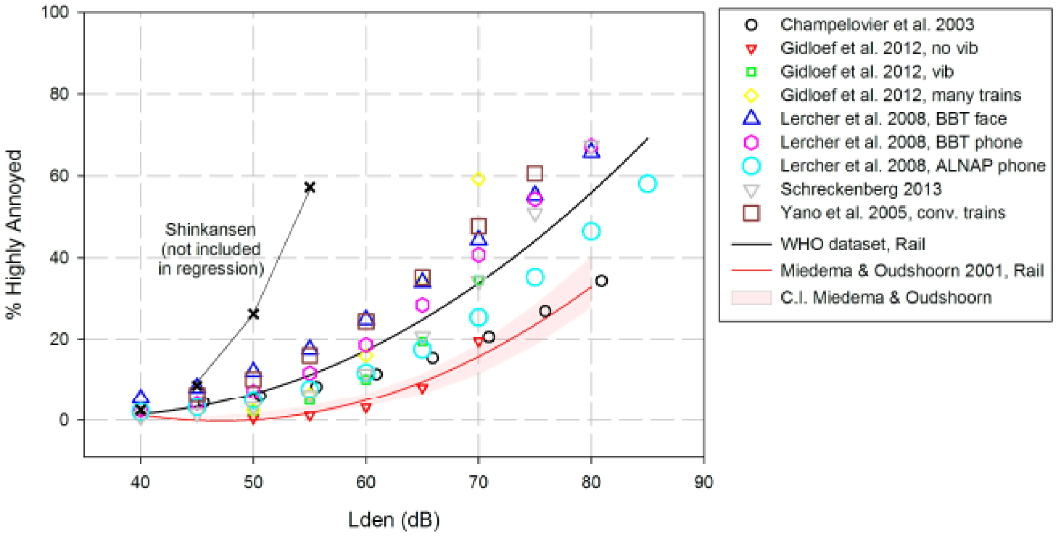
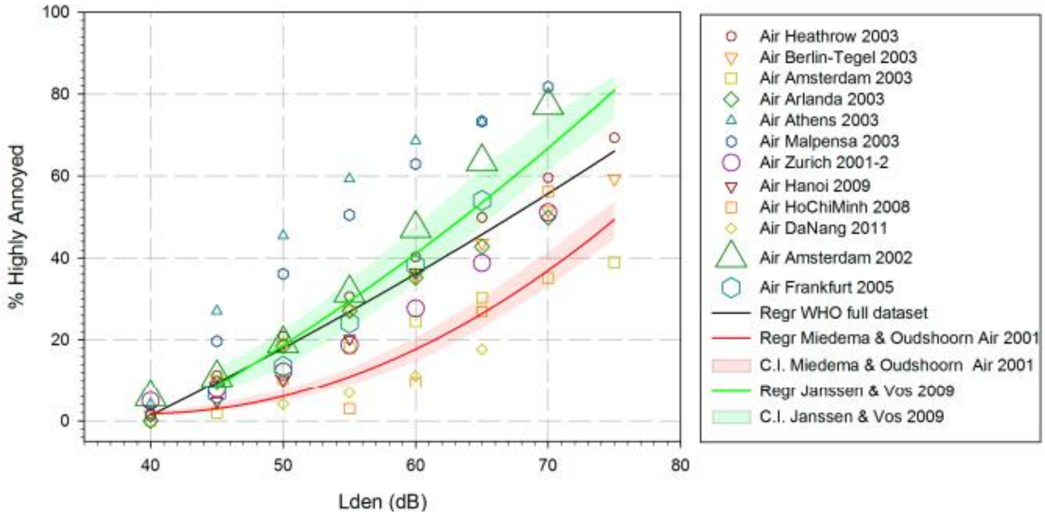


Figure 2.9 shows the 12 studies included in the meta-analysis of aircraft noise. The black line denotes the ERF relationship, and the size of the plotted data points indicates the number of participants in each study.

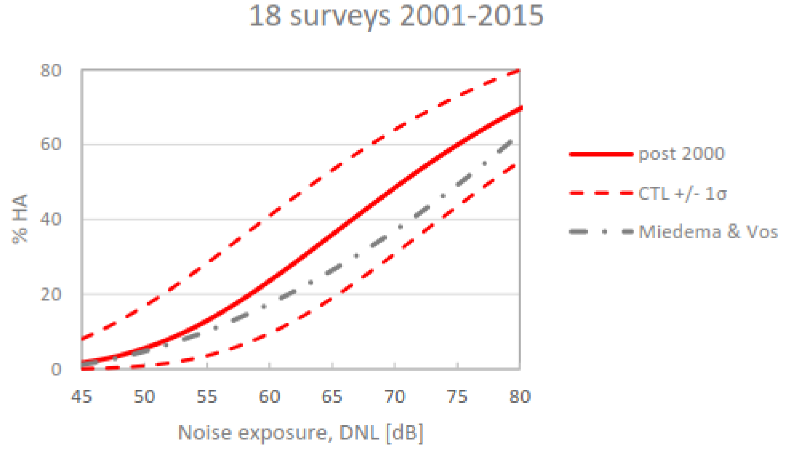
Figure 2.9 Response curve for aircraft noise (reprinted from Guski et al., 2017, p. 10)



The Air Athens and Air Malpensa data points showing the highest levels of annoyance were excluded from the pooled analysis in Babisch and van Kamp (2009). This was due to Athens Airport being operational for only 2 years at the time of the study and Malpensa Airport being located in Milan where an air crash resulted in 114 casualties 2 years prior. The resultant public discussion about air traffic and safety may have significantly influenced these values. High fear of accidents has been found to shift the annoyance response equivalent by as much as 20 dB of exposure (Fields, 1993; Miedema & Vos, 1999). Guski (1999) identified that non-acoustic effects are considered to account for one-third of the variation in response, with many of these location specific.

An alternative dataset of post-2000 aircraft noise annoyance surveys was proposed by Gjestland (2018), whose analysis was later responded to by Guski et al. (2019). Gjestland's dataset adhered to the selection protocol of Guski et al. (2017) and comprised 12 studies in Europe, five in Asia and one in the United States. Gjestland's response relationship compared to the curve of Miedema and Vos (1998) is shown in Figure 2.10. Results from this analysis are presented solely in terms of community tolerance level (CTL). The CTL values differ by only 3 dB from the Miedema and Vos curve.

Figure 2.10 Noise response curve (reprinted from Gjestland, 2018, p. 7)



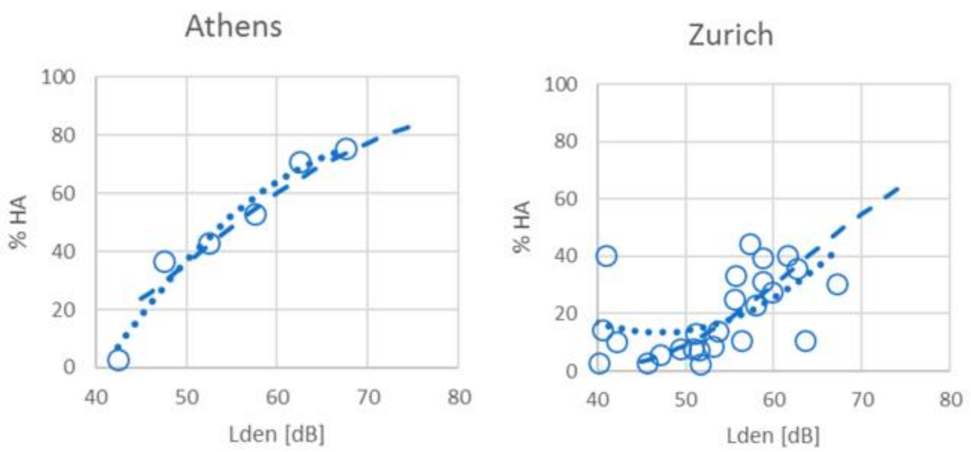
The CTL value favoured by Gjestland is a single number rating method for equating community noise response. This method fits the data to a standardised curve represented by the equation:

$$\%HA = 100e^{-\left(\frac{1}{10^{0.1(L_{dn}-L_{ct}+5.3dB)}}\right)^{0.3}}$$

Use of CTL assumes that %HA increases in a reliable and consistent pattern with increase in noise level. The practical application is described in Appendix H of ISO 1996-1:2016 *Acoustics – Description, measurement and assessment of environmental noise*. To fit a CTL curve to the data, the CTL equation is iterated for values of 0.1 CTL until the best least squares fit is reached between the %HA versus noise exposure data. Quoted CTL values represent the 50%HA point of the CTL curve.

Gjestland (2019) analysed correlation between CTL curves and polynomial regression lines fitted to aircraft noise annoyance data used in Guski et al. (2017). Little difference was seen between the correlation of the standardised CTL curve and the tailored polynomial fit. When applied holistically to the WHO aircraft noise dataset of Guski et al. (2017), the difference between 50%HA using the CTL method and polynomial regression was only 1 dB, as shown in Table 2.6. Graphical comparison also showed that CTL was less prone to variation from extreme data values as shown in Figure 2.11.

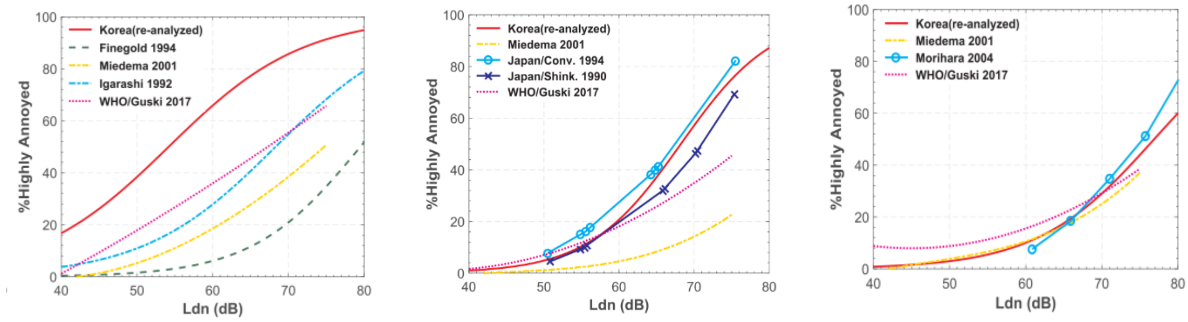
Figure 2.11 Comparison between CTL (dashed) and polynomial regression (dotted) (reprinted from Gjestland (2019, p. 5)



The community response to transportation noise in Korea was studied by Hong et al. (2018) over a 4-year period. Noise measurements were conducted at 52 locations along with interviews of 1,818 respondents living close to a survey site using a method of random interaction.

The survey population had a strong bias towards women, and a large portion of the study population were full-time mothers. This was considered a result of sampling based on people walking around residential areas during the day. The results are displayed in Figure 2.12. Respondents in the study were more annoyed by railway noise than the commonly accepted curves and much more annoyed by aircraft noise.

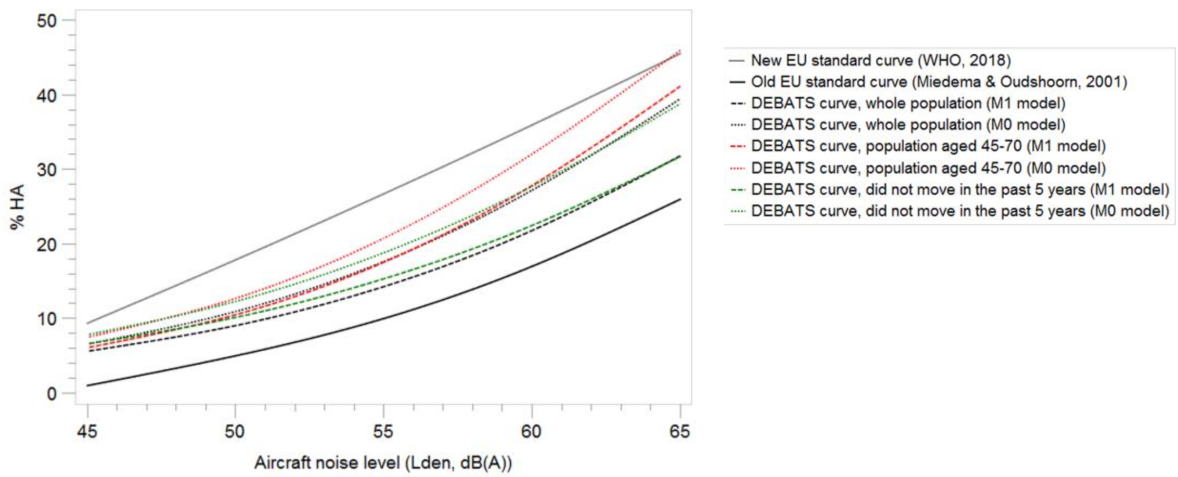
Figure 2.12 Noise response curves (reprinted from Hong et al., 2018)



Air Rail Road

The community response to aircraft noise in France was investigated by Lefèvre et al. (2020) in a study named DEBATS. Surveys were conducted of 1,244 people surrounding either Paris Charles de Gaulle Airport, Toulouse-Blagnac Airport or Lyon Saint-Exupéry Airport. The derived ERFs sat between the European standard curve (Miedema & Oudshoorn, 2001) and the more recent WHO curve. Two relationships were defined in the study. One was related only to L_{den} for direct comparison with the European standard curves (M0 model), and the other was weighted in an attempt to account for non-acoustic factors (M1 model). Both models are compared to the European standard curves along with potentially influential demographic groups within the study in Figure 2.13. The unweighted M0 model sits approximately half-way between the old and new European standard curves.

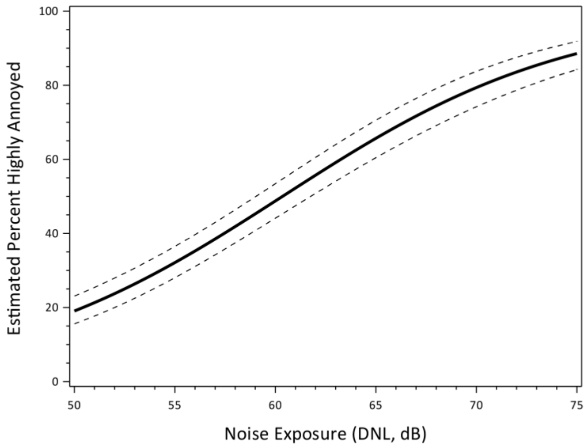
Figure 2.13 Noise response curves (from Lefèvre et al., 2020, p. 8)



In 2021, the United States Federal Aviation Administration (FAA) updated the dose-response curves of the 1992 Federal Interagency Committee on Noise (FICON, 1992). Questionnaires were mailed to invited participants over a 12-month period commencing in October 2015. Just over 10,000 people completed the questionnaires from a representative number of adult residents living around 20 US airports. A 5-point scale was used to rate an individual's response to aircraft noise.

When compared to the FICON study, the national dose-response curve showed substantially more people highly annoyed for a given day-night average sound level (DNL) for aircraft noise exposure. Miller et al. (2021) considered that differences between the derived national curve and the dose-response curves taken previously could be due to changes in people's attitudes towards noise, changes in the nature of the noise exposure, differences in the cultures of those being surveyed, differences in study design, implementation, or measurement or a combination of these factors (Figure 2.14). Miller et al. also noted that caution should be exercised when comparing the FAA's national dose-response curve with other curves, especially if curves are a meta-analysis of surveys undertaken over the last 50 years such as FICON and ISO curves.

Figure 2.14 United States national dose-response curve (solid line) with 95% confidence intervals on annoyance for a given DNL (dashed lines) (reprinted from Miller et al., 2021, p. 51)



A similar update of national dose-response curves was undertaken in the United Kingdom by the Civil Aviation Authority (CAA, 2021). The 2014 Survey of Noise Attitudes (SoNA) conducted 1,847 face-to-face interviews across nine airports. London Heathrow was the main focus with 1,410 interviews being conducted. Surveys were undertaken between October 2014 and February 2015 using summer 2014 noise exposure data ($L_{Aeq,16h}$). In addition to the summer average period being used (92-day period from 16 June to 15 September inclusive), additional periods were assessed:

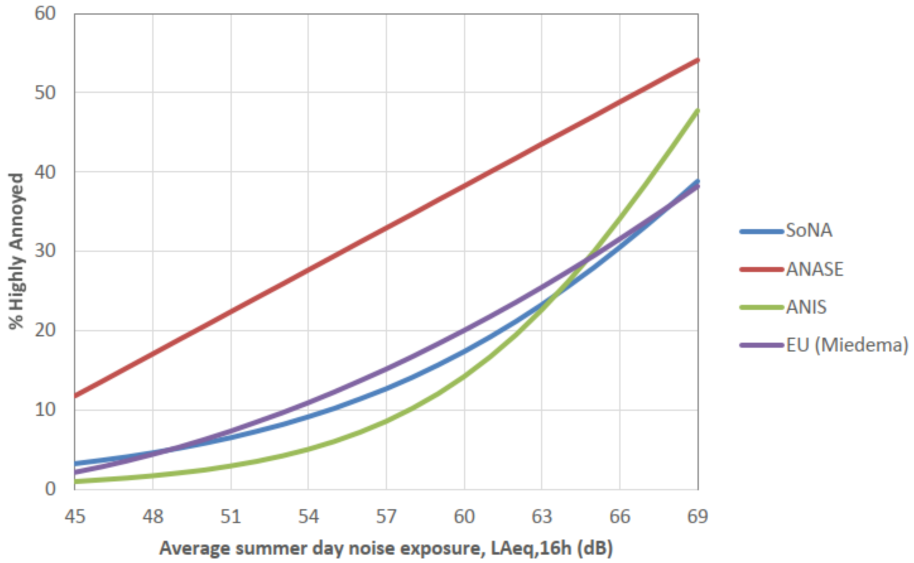
- 100% westerly mode.
- 100% easterly mode.
- 7-day average modal-split prior to interview.
- 30-day average modal-split prior to interview.
- The highest noise level from either the 100% westerly or 100% easterly modes.

Additional metrics were assessed, including L_{den} and N70 and N65 (number of aircraft movements above L_{Amax} of 70/65 dB). It was found that mean annoyance correlated well with average summer day noise exposure level ($L_{Aeq,16h}$) and there was no evidence that other indicators correlated better with annoyance. Figure 2.15 compares the derived SoNA ERF with other curves. The ANIS[6] curve is the existing UK aircraft noise ERF, and the ANASE[7] curve was a previous UK study published in 2007. SoNA found that L_{den} = $L_{Aeq,16h}$ + 1.5 dB rather than +2 dB proposed by Miedema and Oudshoorn (2001), and this adjustment was used to generate the EU standard curve in the figure. Although the 2018 WHO aircraft ERF curve is not included, the ANASE curve corresponds closely with the WHO response curve (Guski et al., 2017).

[6] Aircraft Noise Index Study.

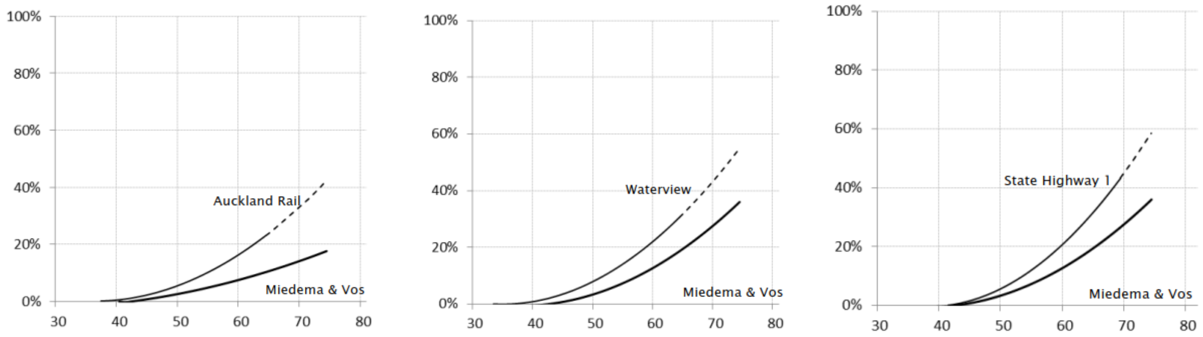
[7] Attitudes to Noise from Aviation Sources in England.

Figure 2.15 United Kingdom SoNA 2014 %HA curve for a given $L_{Aeq,16h}$ with comparison with other studies (reprinted from CAA, 2021, p. 55)



The only similar New Zealand community noise study available is the NZTA research by Humpheson and Wareing (2019). The study surveyed respondents subject to steady-state noise from State Highway 1 (SH1) prior to the opening of a new road (the Waterview Connection) and steady-state noise from a rail line in Auckland. The derived ERFs show greater sensitivity to noise than the curve of Miedema and Vos (1998). A comparison of the two curves is included in Figure 2.16. The Auckland railway was considered significantly more annoying than the European railway studied by Miedema and Vos. This may be a product of non-acoustic factors such as public perception or acoustic factors not captured in the L_{dn} rating such as character or impulsivity of noise events that can vary depending on the condition of railway lines. Annoyance from railway noise was equivalent to that found in Korea (Hong et al., 2018).

Figure 2.16 Noise response curves (reprinted from Humpheson & Wareing, 2019, p. 64)



Waterview and SH1 both show greater annoyance than Miedema and Vos. At the time of the survey, the Waterview Connection had not opened. However, residents may have already been sensitised to the impending change in the noise environment due to construction noise. Morinaga et al. (2020) found in a study on airport runway modifications that a period of construction can result in higher annoyance scores following completion even when the final noise exposure is less than the noise prior to construction. Regarding noise from SH1, Humpheson and Wareing recommended that noise barriers may be effective not just in reducing sound but in demonstrating an effort to control sound. In cases where residents feel that all reasonable steps are being taken to decrease noise, the annoyance level is usually decreased.

To enable comparison, the 10%HA and 50%HA points from each study are included in Table 2.6 and the ERF equations are included in Table 2.7. The 10%HA point has been chosen because that was the guideline exposure level used in the WHO guidelines. The WHO Guideline Development Group (GDG) selected 10%HA based on their aim of selecting ‘noise exposure levels above which the GDG is confident that there is an increased risk of adverse health effects’ (WHO, 2018, p. 20).

Table 2.6 10%HA and 50%HA from each study

Study	Road		Rail		Air		Metric
	10%HA	50%HA	10%HA	50%HA	10%HA	50%HA	
Schultz, 1978	61	79	61	79	61	79	L_{dn}
Miedema & Vos, 1998	57	80	64	104	56	72	L_{dn}
Miedema & Oudshoorn, 2001	56	79	66	85	55	75	L_{den}
Guski et al., 2017	59	78	54	77	45	67/66*	L_{den}
Gjestland, 2018	-	-	-	-	-	71*	L_{den}
Hong et al., 2018	60	77	55	68	35	54	L_{dn}
Humpheson & Wareing, 2019	54/52	71/72	55	-	Not surveyed	Not surveyed	L_{dn}

Table 2.7 ERF equations from each study

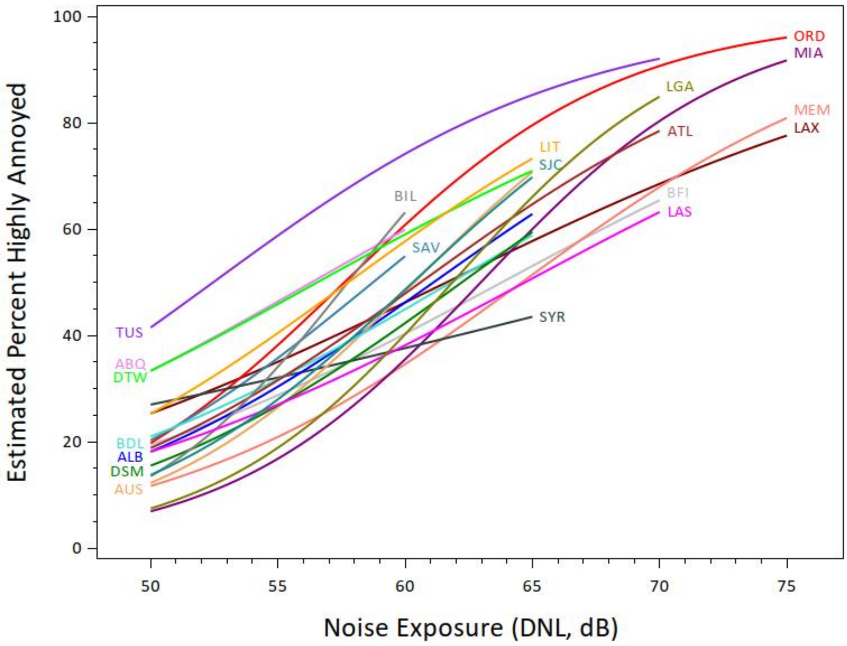
Study	Noise response relationship
Schultz, 1978	$\%HA = 0.8553L_{dn} - 0.0401{L_{dn}}^2 + 0.00047{L_{dn}}^3$
Miedema & Vos, 1998	$\%HA_{road} = 0.24(L_{dn} - 42) + 0.0277(L_{dn} - 42)^2$ $\%HA_{rail} = 0.28(L_{dn} - 42) + 0.0085(L_{dn} - 42)^2$ $\%HA_{air} = -0.02(L_{dn} - 42) + 0.0561(L_{dn} - 42)^2$
Miedema & Oudshoorn, 2001	$\%HA_{road} = 9.868 * 10^{-4}(L_{den} - 42)^3 - 1.436 * 10^{-2}(L_{den} - 42)^2 + 0.5118(L_{den} - 42)$ $\%HA_{rail} = 7.239 * 10^{-4}(L_{den} - 42)^3 - 7.851 * 10^{-3}(L_{den} - 42)^2 + 0.1695(L_{den} - 42)$ $\%HA_{air} = -9.199 * 10^{-5}(L_{den} - 42)^3 + 3.932 * 10^{-2}(L_{den} - 42)^2 + 0.2939(L_{den} - 42)$
Guski et al., 2017	$\%HA_{road} = 116.4304 - 4.7342 * L_{den} + 0.0497 * {L_{den}}^2$ $\%HA_{rail} = 38.1596 - 2.05538 * L_{den} + 0.0285 * {L_{den}}^2$ $\%HA_{air} = -50.9693 + 1.0168 * L_{den} + 0.0072 * {L_{den}}^2$
Gjestland, 2018	CTL 71
Hong et al., 2018	$\%HA_{road} = \frac{100}{1 + e^{-0.13 * L_{dn} + 9.993}}$ $\%HA_{rail} = \frac{100}{1 + e^{-0.163 * L_{dn} + 11.12}}$ $\%HA_{air} = \frac{100}{1 + e^{-0.113 * L_{dn} + 6.122}}$
Humpheson & Wareing, 2019	Not included

2.3 Non-acoustic factors

As noted above, Guski (1999) identified that non-acoustic effects are considered to account for one-third of the variation in response, with many of these location specific. Therefore differences between individual ERF curves could be due to changes in people’s attitudes towards the source of noise, changes in their noise exposure (for example, changes in aircraft, operations, frequency of flights), differences in the cultures of those being surveyed, differences in study design, implementation or measurement or a combination of these factors.

Non-study design factors are best demonstrated by Miller et al. (2021) as shown in Figure 2.17, which shows the ERF curves for 20 US airports. At 65 dB L_{dn}, for example, there is an approximate 40% difference in proportion of the sampled population who are highly annoyed (from the least annoying to the most annoying airport). This variation can be considered a location-specific influence.

Figure 2.17 Individual ERF curves for 20 airports (reprinted from Miller et al., 2021, p. 49)



The SoNA study (CAA, 2021) undertook a multivariate analysis to determine whether the presence or absence of being highly annoyed was associated with a non-acoustic factor. These factors were:

- length of residence
- self-reported noise sensitivity rating
- expectation of possibility of hearing noise from the airport prior to moving to their current home
- expectations on experiencing more or less noise next summer
- age
- socio-economic status
- presence of double glazing.

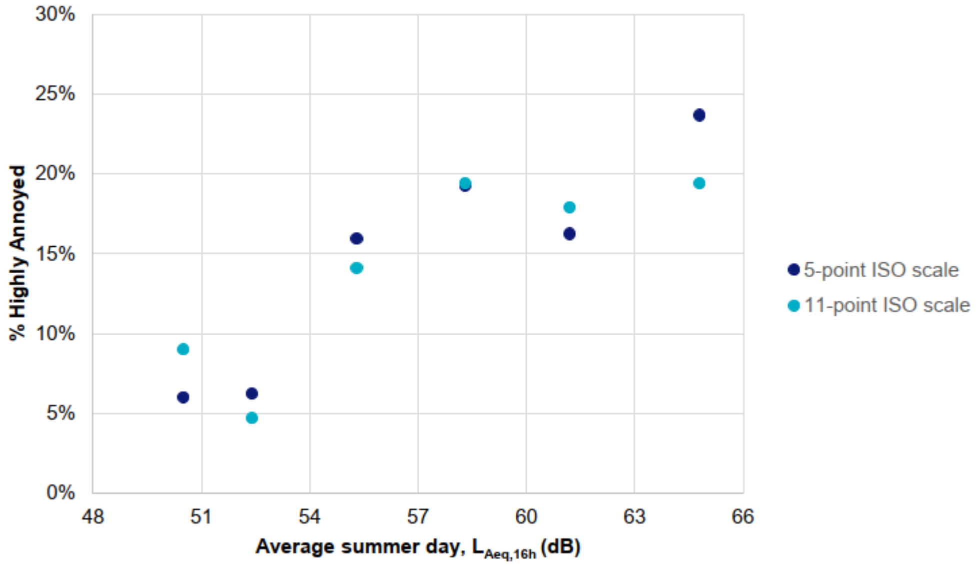
The study found that noise sensitivity approximated social grade and expectations – both prior to moving to an area exposed to aircraft noise and in the future – and influenced reported aircraft noise annoyance and that these non-acoustic factors may be as important as the noise exposure level.

The survey method can also have a bearing on the responses as can when the annoyance question is posed to the respondent. Morinaga et al. (2021) found that the L_{den} value corresponding to 10%HA using the 5-point verbal scale was approximately 5 dB lower than that of the 11-point numerical scale and concluded that some correction is required to compare annoyance responses measured by the 5-point verbal and the 11-point numerical scales. Based on the WHO 2018 guidelines reference ERF curve, a 5 dB shift could change the %HA by ~10 points – for example, instead of ~18%HA at 50 dB L_{den}, a 5 dB reduction would mean that ~9% of people are highly annoyed.

The SoNA study (CAA, 2021) reported the %HA for the two ISO scales. Unlike the findings of Morinaga et al. (2021), the differences between the 5-point and 11-point scales differed with varying noise exposure level, as can be seen in Figure 2.18.

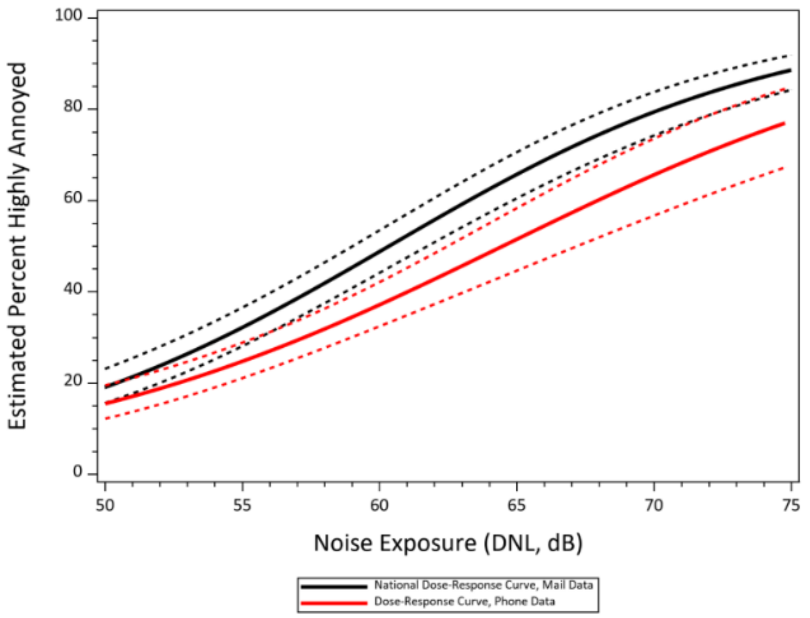
Unlike Morinaga et al.'s findings, there are no apparent factors why the annoyance rating changes between the two scales for different noise exposure levels, and there is no consistent pattern to account for the differences between the two scales.

Figure 2.18 Differences in 5-point and 11-point scale highly annoyed analysis (reprinted from CAA, 2021, p. 51)



Fidell et al. (2022) reanalysed the data from Miller et al. (2021), particularly Figure D-1, which is shown in Figure 2.19. Fidell et al. identified that the ERF curve derived from the phone survey data at 50%HA is ~65 dB L_{dn}, whereas the ERF for the mail survey at 50%HA is ~60 dB L_{dn}. Below 60 dB L_{dn}, the variance between mail and phone response declines. Above 60 dB, the variance increases until it reaches 70 dB, where it starts to decline. Fidell et al. concluded that Miller et al.'s findings show that people are less likely to categorise themselves as highly annoyed over the phone than they are in postal/paper interviews.

Figure 2.19 National curve (black line) and telephone survey (red line) with 95% confidence intervals (reprinted from Miller et al., 2021, p. D-6)



Care is therefore needed when comparing studies as non-acoustic factors may influence the derived ERFs.

2.3.1 Multiple noise sources

A significant proportion of the community can be expected to be exposed to noise from multiple sources – combinations of road-traffic and railway noise or road-traffic and aircraft noise or all three. Numerous models have been proposed to predict the %HA of people exposed to multiple noise sources when their exposure to single noise sources is known. Marquis-Favre et al. (2021) assessed a number of these against field annoyance measurements. The study included 301 people exposed to road-traffic and railway noise, 212 exposed to road-traffic and aircraft noise and 189 people exposed to road-traffic, railway and aircraft noise. Existing models were split into two groups: psychophysical annoyance models (derived from sound levels) and perceptual annoyance models (derived from annoyance scores). The models were fitted to the gathered data through linear regression. ERF equations of each model along with the results of the linear fit are included in Tables 2.8 to 2.10.

Table 2.8 Predicted annoyance for respondents exposed to road-traffic and aircraft noise

Psychophysical model	*Equation*	$R^2_{adjusted}$	*Intercept*	*Slope*	*correlation*
Energy summation	$A_{Total} = 0,097^{a} * L_{den,\ Total} - 0,883$	0,028 [a]	4,648 [a]	0,032 [a]	0,180 [a]
Independent effects	$A_{Total} = 0,047 * L_{den,\ Road} + 0,139^{a} * L_{den,\ Air} - 4,121$	0,085 [a]	4,404 [a]	0,094 [a]	0,307 [a]
Energy difference	$A_{Total} = 0,184^{a} * L_{den,\ Total} - 0,126^{a} * \lvert L_{den,\ Road} - L_{den,\ Air}\rvert - 4,260$	0,090 [a]	4,368 [a]	0,099 [a]	0,315 [a]
Mixed	$A_{Total} = 0,047 * L_{den,\ Road} + 0,139^{a} * L_{den,\ Air} - 4,121 + 0,001 * \lvert L_{den,\ Road} - L_{den,\ Air}\rvert$	0,085 [a]	4,404 [a]	0,094 [a]	0,307 [a]
Quantitative	$A_{Road} = 0,111^{a} * L_{den,\ Road} - 2,012$; $R^2_{adjusted} = 0,043^{a}$				
	$A_{Air} = 0,209^{a} * L_{den,Air} - 5,098^{a}$; $R^2_{adjusted} = 0,152^{a}$				
	$k = 15$: $A_{Total} = 0,117^{a} * L_t - 2,620$	0,095 [a]	4,318 [a]	0,099 [a]	0,315 [a]
	$k = 10$: $A_{Total} = 0,113^{a} * L_t - 2,236$	0,097 [a]	4,320 [a]	0,101 [a]	0,318 [a]
Annoyance equivalents	$A_{Total} = 0,123^{a} * L_t - 2,475$	0,045 [a]	4,595 [a]	0,050 [a]	0,223 [a]
Perceptual model	*Equation*	$R^2_{adjusted}$	*Intercept*	*Slope*	*correlation*
Strongest component	$A_{Total} = 0.840^{a} * \max(A_{Road} ; A_{Air}) + 1.194^{a}$	0,754 [a]	0,194 [a]	0,840 [a]	0,869 [a]
Linear regression	$A_{Total} = 0,521^{a} * A_{Road} + 0,482^{a} * A_{Air} + 0,412^{a}$	0,760 [a]	1,145 [a]	0,762 [a]	0,873 [a]
Mixed	$A_{Total} = 0,491^{a} * A_{Road} + 0,497^{a} * A_{Air} + 0,220^{a} * \lvert A_{Road} - A_{Air}\rvert + 0,105$	0,784 [a]	1,025 [a]	0,787 [a]	0,887 [a]
Vector summation	$A_{Total} = \sqrt{A^2_{Road} + A^2_{Air} + 2 * A_{Road} * A_{Air}\cos(\alpha)}\ \alpha = 115,3°$	0,775 [a]	1,091 [a]	0,835 [a]	0,881 [a]

Table 2.9 Predicted annoyance for respondents exposed to road-traffic and railway noise

Psychophysical model	*Equation*	$R^2_{adjusted}$	*Intercept*	*Slope*	*correlation*
Energy summation	$A_{Total} = 0,147^{a} * L_{den,\ Total} - 5,162^{a}$	0,062 [a]	5,005 [a]	0,065 [a]	0,256 [a]
Independent effects	$A_{Total} = 0,134^{a} * L_{den,\ Road} + 0,017 * L_{den,\ Rail} - 5,042^{a}$	0,065 [a]	4,979 [a]	0,071 [a]	0,267 [a]
Energy difference	$A_{Total} = 0,143^{a} * L_{den,\ Total} + 0,032 * \lvert L_{den,\ Road} - L_{den,\ Rail}\rvert - 5,123^{a}$	0,065 [a]	4,970 [a]	0,071 [a]	0,267 [a]
Mixed	$A_{Total} = 0,086^{a} * L_{den,\ Road} + 0,072^{a} * L_{den,\ Rail} + 0,082^{a} * \lvert L_{den,\ Road} - L_{den,\ Rail}\rvert - 5,881^{a}$	0,076 [a]	4,849 [a]	0,084 [a]	0,291 [a]
Quantitative	$A_{Road} = 0,155^{a} * L_{den,\ Road} - 5,933^{a}$; $R^2\ _{adjusted} = 0,088^{a}$				
	$A_{Rail} = 0,119^{a} * L_{den,\ Rail} - 3,455^{a}$; $R^2\ _{adjusted} = 0,089^{a}$				
	$k = 15$: $A_{Total} = 0,199^{a} * L_t - 9,307^{a}$	0,105 [a]	4,788 [a]	0,108 [a]	0,329 [a]
	$k = 10$: $A_{Total} = 0,198^{a} * L_t - 8,927^{a}$	0,105 [a]	4,803 [a]	0,108 [a]	0,328 [a]
Annoyance equivalents	$A_{Total} = 0,156^{a} * L_t - 5,598^{a}$	0,070 [a]	4,997 [a]	0,074 [a]	0,271 [a]
Perceptual model	*Equation*	$R^2_{adjusted}$	*Intercept*	*Slope*	*correlation*
Strongest component	$A_{Total} = 0.884^{a} * \max(A_{Road} ; A_{Rail}) + 0.769^{a}$	0,843 [a]	0,769 [a]	0,885 [a]	0,918 [a]
Linear regression	$A_{Total} = 0,562^{a} * A_{Road} + 0,422^{a} * A_{Rail} + 0,923^{a}$	0,736 [a]	1,405 [a]	0,738 [a]	0,859 [a]
Mixed	$A_{Total} = 0,455^{a} * A_{Road} + 0,513^{a} * A_{Rail} + 0,436^{a} * \lvert A_{Road} - A_{Rail}\rvert + 0,152$	0,844 [a]	0,829 [a]	0,846 [a]	0,919 [a]
Vector summation	$A_{Total} = \sqrt{A^2_{Road} + A^2_{Air} + 2 * A_{Road} * A_{Air}\cos(\alpha)}\ \alpha = 112,8°$	0,842 [a]	0,743 [a]	0,891 [a]	0,918 [a]

Table 2.10 Predicted annoyance for respondents exposed to road-traffic, railway and aircraft noise

Psychophysical model	*Equation*	$R^2_{adjusted}$	*Intercept*	*Slope*	*correlation*
Energy summation	$A_{Total} = 0,003 * L_{den,Total} + 6,389^{a}$	<0,001	6,581 [a]	<0,001	0,008
Independent effects	$A_{Total} = 0,017 * L_{den,\ Road} + 0,112^{a} * L_{den,\ Air} - 0,045 * L_{den,\ Rail} + 1,736$	0,085 [a]	5,878 [a]	0,100 [a]	0,315 [a]
Quantitative	$A_{Road} = 0,057^{a} * L_{den,\ Road} + 1,867$; $R^2_{adjusted} = 0,041^{a}$				
	$A_{Rail} = 0,067^{a} * L_{den,\ Rail} + 0,246$; $R^2_{adjusted} = 0,039^{a}$				
	$A_{Air} = 0,109^{a} * L_{den,Air} + 0,446$; $R^2_{adjusted} = 0,067^{a}$				
	$k = 10$: $A_{Total} = 0,061 * L_t + 1,523$	<0,001	6,589 [a]	<0,001	0,021
	$k = 15$: $A_{Total} = 0,062 * L_t + 1,396$	<0,001	6,584 [a]	<0,001	0,029
Annoyance equivalents	$A_{Total} = 0,056 * L_t + 2,876$	0,017	6,447 [a]	0,018	0,133
Perceptual model	*Equation*	$R^2_{adjusted}$	*Intercept*	*Slope*	*correlation*
Strongest component	$A_{Total} = 0,860^{a} * \max(A_{Road} ; A_{Air} ; A_{Rail}) + 0,487$	0,594 [a]	2,533 [a]	0,691 [a]	0,771 [a]
Linear regression	$A_{Total} = 0,594^{a} * A_{Air} + 0,275^{a} * A_{Road} - 0,006 * A_{Rail} + 1,241^{a}$	0,566 [a]	2,808 [a]	0,573 [a]	0,757 [a]

The perceptual models correlated well with the survey data. A significantly weaker correlation was observed from the psychophysical models.

Aircraft noise was considered to be more annoying than the other noise sources, which are of similar annoyance to one another. This is supported by the survey component of the study where respondents were asked if each specific noise source would be bearable by itself – 63% agreed or quite agreed that railway noise alone would be bearable, 60% agreed or quite agreed that road traffic noise alone would be bearable, whereas only 22% agreed or quite agreed that aircraft noise alone would be bearable.

Lechner et al. (2019) conducted a similar study in Innsbruck with a pool of 1,031 face-to-face interviews. A quadratic relationship was derived between sound level and annoyance:

$$A'_{total} = -0.08498 * L'_{total} + 0.00251 * {L'_{total}}^2$$

where:

$$A'_{road} = -0.08498 * L_{road} + 0.00251 * {L_{road}}^2$$
$$A'_{rail} = -0.09641 * L_{rail} + 0.00263 * {L_{rail}}^2$$
$$A'_{air} = -0.00424 * L_{air} + 0.00164 * {L_{air}}^2$$

The model demonstrated a ρ=0.298 correlation.[8] Given it is a psychoacoustic model, the correlation cannot be expected to be as strong as a model based on empirical annoyance scores.

2.4 Summary

Gathering community responses requires a large-scale survey with sufficient resources and sources of information such as noise exposure level data. Included in the survey should be the ISO/TS 15666:2021 standard question regarding noise annoyance along with numerous other questions to understand more about the responses. It is important to know:

- how their annoyance response changes at different times of the day
- how their annoyance response varies in different locations within their house
- what level of outdoor access they have and amount of time spent outdoors
- what hours they are usually at home
- what their opinions are on the transport activities causing the noise
- how favourable they are to the organisations that manage the local road/railway/airport
- what quality of glazing and sound insulation they have
- what measures they take in their day-to-day life in response to noise
- how sensitive to noise they consider themselves
- how annoyed they are by other environmental noise sources
- financial situation
- home ownership status
- education level.

The above questions could be asked in a multiple-choice format. It is also recommended that open-answer questions and trade-off questions are included. Open-answer questions should be used to understand how respondents decide on their noise annoyance rating. Trade-off questions are beneficial to get respondents to consider the annoyance in the context of their lives outside of an 11-point numerical scale. Effectively gathering responses from a trade-off question will require provision of information (such as modelled noise levels) to help respondents make an informed decision.

[8] Where 0 is no correlation and 1 is perfect correlation.

ERF curves will help define a relationship between %HA and the noise exposure level. The %HA should be defined as respondents who answered 8, 9 or 10 (within a range of 0–10) on the 11-point annoyance scale. Defining highly annoyed on the 5-point scale should be done with the top two responses (very annoyed and extremely annoyed) and where the very annoyed response is weighted by 0.4. This will define %HA as the top 40% and top 28%, which can then be compared to answers on the 11-point scale.

The noise exposure level is usually expressed in either L_{dn} or L_{den}. Recently, L_{den} has been favoured although the difference is minimal between the two noise descriptors and easily corrected.

A second-order or third-order polynomial best-fit relationship should be derived between %HA and noise exposure level to represent the ERF curve. Calculating the CTL is also advised to allow for wider comparison with more international studies.

3 Noise exposure levels

Noise exposure data at a respondent level is needed to derive ERFs for road-traffic, railway and aircraft noise. A combined road-traffic and railway noise model was developed by AECOM as part of the NZTA *Social cost (health) of land transport noise exposure in New Zealand* research study (Evans *et al.*, 2023). The outputs of the AECOM model were used to derive noise exposure levels at an address level of detail. Aircraft noise exposure levels were derived from published aircraft noise contours using geospatial analysis also at an address level of detail. This chapter provides a brief overview of the AECOM noise modelling and derivation of aircraft noise exposure levels. Road-traffic and railway noise exposure levels were based on 2021 input data. Aircraft noise exposure levels were based on 2019 data.

The modelling methodology is detailed within the draft AECOM modelling report we accessed. An outline of the methodology is reproduced below. However, the finalised AECOM report, at time of publishing, should be relied upon to obtain a full understanding of the modelling methodology.

3.1 Road-traffic noise

Road alignments, terrain and building details were imported into the road-traffic and railway model developed by AECOM. The road-traffic model included:

- highways
- regional roads
- arterial roads
- buildings and land parcels within 300 m of road alignments
- terrain data within 300 m of road alignments.

Road alignments included data on the posted speed limit, road surface condition, annual average daily traffic numbers and percentage of heavy vehicles comprising the total traffic.

Noise exposure levels were calculated using the calculation of road-traffic noise methodology (Department of Transport, 1988), which presents a result in terms of $L_{10,18h}$. This was adjusted to $L_{Aeq(24h)}$ by subtracting 3 dB in accordance with the Noise Advisory Council (1978). L_{den} was then calculated using Method 3 for non-motorway roads (Abbott & Nelson, 2002). The conversion used from this report is:

$$L_{den} = 0.92 * L_{A10,18h} + 4.20\ dB$$

3.1.1 Model limitations

The model accuracy relied upon the validity of the calculation of road-traffic noise, and noise monitoring to validate the results was not undertaken. The model only predicts the average noise exposure level at receivers and therefore discrete events such as from truck engine braking, loud exhausts or audio tactile road markings (rumble strips) are not included in the model. Any roads without a complete dataset of information for calculation of road-traffic noise were removed from the study.

3.2 Railway noise

Railway alignments were obtained from the KiwiRail Network Map.[9] The AECOM railway model included:

[9] https://catalogue.data.govt.nz/dataset/kiwirail-network-map1

- main truck lines
- secondary main lines
- branch lines
- buildings and land parcels within 300 m of rail alignments
- terrain data within 300 m of rail alignments.

Each trunk line included a posted speed limit, which was assumed to be the operational speed of trains. Noise levels were calculated using the calculation of rail noise (Department of Transport, 1995).

3.2.1 Model limitations

The model relied upon the calculation of rail noise, which predicts noise at the wheel-level based on the speed, length of the train, type of track and track support system. Individual train source noise levels were gathered from measurements undertaken by AECOM.

Aspects not included in the model include:

- noise from track sidings, rail stabling yards or other types of supporting or maintenance infrastructure
- acceleration and deceleration around train stations
- any possible variation in speed to account for track conditions or rail gradients
- any variation in noise from maintenance-based influences such as variability in rail head roughness
- noise from the use of klaxon horns or other safety devices such as warning bells or PA systems
- private rail networks
- rail corridors without rail volume data.

3.3 Aircraft noise

Airport companies may publish annual aircraft noise contours as required by a condition of consent, designation or part of their monitoring or noise management plan requirements. These contours show areas exposed to noise using the L_{dn} noise metric as required by NZS 6805:1992. Generally, aircraft noise contours are produced from 55 to 65 dB L_{dn}, and these contours tend to be modelled on the busiest 3 months of the year. Noise levels at individual properties can be interpolated and extrapolated from these contours. Geospatial tools were developed to undertake this analysis, including the use of published flight tracks to extrapolate the contours down to 45 dB L_{dn}.

3.3.1 Model limitations

Due to the COVID-19 pandemic, aircraft noise levels at individual properties were based on contours published for the year 2019. These contours reflect a greater level of aircraft activity than took place when the social surveys were being conducted. For example, at Auckland Airport, movement numbers in 2022 were at approximately 70% of movement numbers in 2021, whereas for Queenstown Airport, movement numbers were at 87% of pre-COVID-19 levels.[10] This reduction would equate to a 1.6 dB reduction in the L_{dn} assuming that the mix of aircraft types remain the same.

The study was reliant on the availability of the published contours and no quality assurance steps were undertaken to validate the contours. As with other forms of noise modelling, aircraft noise contours are subject to some degree of uncertainty. A 2 dB variation is typical between modelled and actual noise levels.

[10] Auckland Airport – December 2022 monthly traffic preview – issued 24 January 2023.

4 Study area selection

4.1 Background

The study objective required surveying people exposed to each of the three transportation sources of interest – road-traffic, railway and aircraft noise. This chapter describes which study areas in New Zealand were selected, why those areas were selected and the process by which they were chosen. The method for selecting individual respondents is covered in chapter 5.

Quantifying community response to new and altered roads requires socio-acoustic surveys being completed within 12–18 months of the opening of the road. Unlike the roading network, no significant changes to the rail network or changes to airports have occurred since 2019. Therefore, the short-term assessment was limited to suitable roading projects.

Due to the effects of the COVID-19 pandemic, the socio-acoustic surveys were completed in 2022, which meant that the intervening period between study areas being selected (and the noise exposure levels being modelled) and conducting the surveys was more than 18 months. The intervening time meant that the newer roads were considered established enough that the annoyance response would have normalised. Therefore, for the purposes of this research study, it was agreed that only steady-state conditions would be investigated. Those study areas originally selected for the short-term assessment were included in the full assessment.

ERFs are known to be influenced by factors other than noise exposure level. Some of these factors can vary based off variables that are specific to an area such as local circumstances and perception of the mode of transport among the community. As recommended by Humpheson and Wareing (2019), multiple study areas across the country were surveyed to increase the response rate and to minimise any uncertainties arising from these non-acoustic factors.

4.2 Selection criteria

The four main criteria were:

- properties exposed to more than 40 dB $L_{Aeq(24h)}$ from road-traffic or railway noise[11]
- properties exposed to more than 45 dB L_{dn} from aircraft noise[12]
- selections covering each common road surface – open-graded porous asphalt (OGPA), urban chipseal, rural chipseal, asphalt.
- further than 200 m from any road or rail not in the study area of interest.

Population centres around busy sections of railway are often close to arterial road transport routes. To identify sufficient study areas near railways, judgement was used to identify which nearby roads would not influence the community opinion of the railway noise – areas where the railway noise is more dominant.

It is inevitable that the selection of specific study areas needs to include some reliance on judgement. This is sometimes described as the judgement sampling aspect of the multiple layers of sampling in a study of this nature. This judgement sampling needs to take account of practical details about feasibility and cost-effective use of survey resources and the availability of reliable data. These points are addressed in the following description of the sampling of study areas.

[11] Using AECOM 2021 modelling results.

[12] Based on published noise contours with extrapolation below 55 dB L_{dn}.

A sample number of 2,000 responses was targeted with a minimum of 500 from each survey type (500 responses were originally sought from the short-term change study sample).

4.3 Survey areas

Responses from people exposed to a range of noise exposure levels were required to derive reliable ERFs. Responses are known to be influenced by the opinions and attitudes of groups unrelated to their noise sensitivity. Therefore, survey areas were selected to provide a spread of responses both geographically and in terms of noise exposure level.

4.3.1 National spread

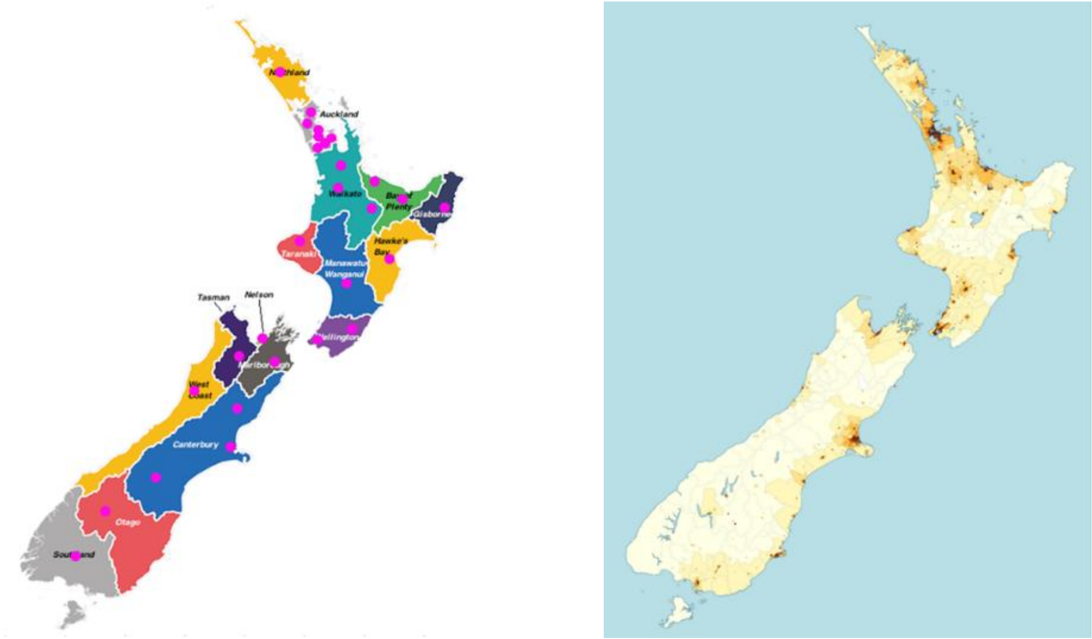
Sample areas were selected across the country and stratified based on population numbers. This method gathers a sample population representative of the New Zealand population while maintaining geographic diversity.

Population distribution data sourced from the 2018 census was used to identify population centres. Table 4.1 presents the population distribution across the regions based off 30 sample groups, and Figure 4.1 maps the sample areas against a New Zealand population heatmap. This information was used as an initial screening of suitable population centres across the North and South Islands. This distribution was used as a guide for selecting road-traffic and railway samples across the country. New Zealand has 28 airports that service scheduled flights, with five airports serving international destinations. The largest regional and international airports are located near population centres. The airport selection process is discussed in section 4.6.

Table 4.1 New Zealand regional population distribution

Region	Population		Samples
	#	%	
Auckland	1,415,550	33.4%	9
Canterbury	539,433	12.7%	3
Wellington	471,315	11.1%	3
Waikato	403,638	9.5%	2
Bay of Plenty	267,744	6.3%	2
Manawatū-Whanganui	222,672	5.2%	1
Otago	202,470	4.8%	1
Northland	151,689	3.6%	1
Hawke’s Bay	151,179	3.6%	1
Taranaki	109,608	2.6%	1
Southland	93,342	2.2%	1
Tasman	47,154	1.1%	1
Nelson	46,437	1.1%	1
Gisborne	43,653	1.0%	1
Marlborough	43,416	1.0%	1
West Coast	32,148	0.8%	1

Figure 4.1 Proposed sample spread – New Zealand population density



A principal objective of this research was to define and quantify New Zealand community response to transportation noise. This statement implies that the study sample areas are representative of the wider New Zealand population so that the results of the survey can be extrapolated to all New Zealanders. However, the study needed to focus on only those people who are exposed to the range of transportation noise exposure levels and other criteria set out in section 4.2, not the wider New Zealand population. Therefore, extrapolation to the wider population of all New Zealanders cannot be readily made – only to those exposed to transportation noise.

Those exposed to the range of transportation noise exposure levels covered in this study are the relevant population for this survey. The terms 'relevant population' and 'exposed population' are used interchangeably to identify this specific population. They are represented in this study by sampling people living in the specific areas selected for this survey. Further discussion on this matter is included in chapter 7.

4.4 Road-traffic noise

AECOM's national noise model was used to identify study areas along with address data, road classification information and New Zealand population information. Quantifying a national response relationship for road-traffic noise required a spread of geographic locations and road types along with a range of noise exposure levels and sufficient total responses for the result to be representative of the exposed population. The selection process was therefore iterative and used an element of judgement.

4.4.1 Identifying road categories

Geospatial data for the national road network was used to classify each section of road based on three categories contained within the New Zealand road classification data:

- Road type – state highway, arterial, regional.
- Road region – urban, rural.
- Road surface – OGPA, asphalt, chipseal.

The nine combinations of road attributes present on New Zealand roads are shown in Figure 4.2 and Table 4.2. A geospatial analysis was performed to find the proportion of each road classification in terms of length.

Figure 4.2 Road classification

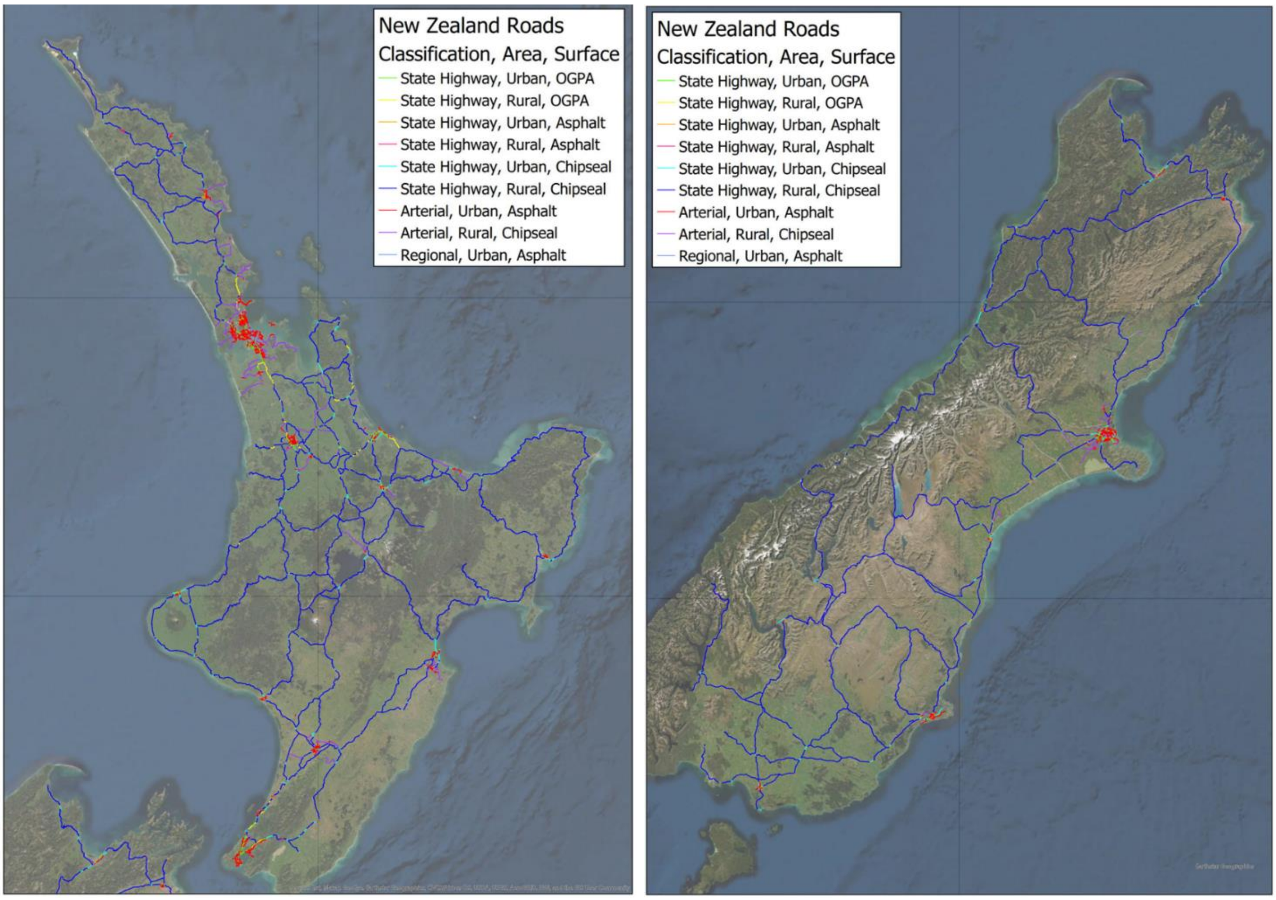


Table 4.2 Road classification lengths

Road classification	Length of road	
	Metres	%
1 State highway, urban, OGPA	615,109	4.2%
2 State highway, rural, OGPA	286,302	2.0%
3 State highway, urban, asphalt	145,280	1.0%
4 State highway, rural, asphalt	43,012	0.3%
5 State highway, urban, chipseal	631,603	4.3%
6 State highway, rural, chipseal	9,723,213	66.2%
7 Arterial, urban, asphalt	2,039,255	13.9%
8 Arterial, rural, chipseal	943,404	6.4%
9 Regional, urban, asphalt	253,658	1.7%

4.4.2 Identifying possible sample groups

Potential sample areas were selected by cross-referencing the New Zealand road classification data in Figure 4.2 against desired study areas based on population distribution discussed in section 4.1. Locations of each road type were analysed in combination with nationwide building outlines to estimate the size of potential sample groups. This shortlist of sample locations was refined based on the following criteria:

- Was the group large enough?
- Would there be contamination from other sources such as commercial industry or airports?
- Was the group isolated/only exposed to one road classification?

Sample areas of each road type are presented in Table 4.3 with the expected number of suitable properties.

Table 4.3 Approximate sample sizes per region

	Region	City/town	Suburb/area	Estimated sample size
1 State highway, urban, OGPA	Auckland	South	Goodwood Heights	325
	Waikato	Hamilton	Melville	325
	Bay of Plenty	Papamoa		550
	Wellington	Wellington	Johnsonville	600
			Takapu Valley	250
	Canterbury	Christchurch	Redwood	140
			Heathcote Valley	335
			Aidanfield	100
			Total	**2,625**
2 State highway, rural, OGPA	Auckland	Auckland	Puhoi–Warkworth	75
			Drury–Mercer	140
	Waikato	Hamilton	Tamahere	75
	Bay of Plenty	Papamoa		190
			Total	**480**
3 State highway, urban, asphalt	Northland	Whangārei	Woodhill	425
	Auckland	Auckland	Greenhithe	100
	Otago	Queenstown		100
	Southland	Invercargill		83
			Total	**708**
4 State highway, rural, asphalt	Waikato	Hamilton	Tamahere	<50
	Canterbury	Amberley		100
	Otago	Palmerston		few
	Southland	Edendale		23
			Total	**123**
5 State highway, urban, chipseal	Bay of Plenty	Tauranga	Pyes Pa	900
			Hairini	558
	Waikato	Tūrangi		990
	Manawatū	Feilding		2,070
	Wellington	Upper Hutt	Timberlea	810
		Greytown–Carterton–Masterton		2,610
	Canterbury	Christchurch	Halswell	360
			Northwood	504
	Southland	Invercargill		1,800
		Bluff		720
			Total	**11,322**

	Region	City/town	Suburb/area	Estimated sample size
6 **State highway, rural, chipseal**	Northland	Mangōnui		1,170
		Kerikeri		270
		Whangārei	Maunu	513
	Auckland	SH16 Kumeū–Kaukapakapa		558
	Waikato			>3,000
	Hawke's Bay	Hastings		477
	Manawatū	Taumarunui		900
		Levin		342
	Wellington	Paremata/Whitby		513
	Nelson	Nelson	Moutere	459
	Otago	Clyde		702
	Southland	Invercargill		900
			Total	**9,804+**
7 **Arterial, urban, asphalt**	Auckland			>3,000
	Waikato	Hamilton		>3,000
	Nelson	Nelson		2,750
	Manawatū	Palmerston North		2,250
	Wellington	Wellington		>3,000
	Canterbury	Christchurch		>3,000
		Timaru		1,250
	Marlborough	Blenheim		1,750
	Southland	Invercargill		1,500
			Total	**21,500+**
8 **Arterial, rural, chipseal**	Auckland	Warkworth–Matakana		250
		Auckland	Coatesville–Dairy Flat	500
			Swanson	500
			Pukekohe	125
			Hunua	100
	Waikato	Te Awamutu–Cambridge		65
	Hawke's Bay	Hastings		90
	Manawatū	Palmerston North	Rangiotu	145
	Canterbury	Springston–Lincoln		325
			Total	**2,100**
9 **Regional, urban, asphalt**	Auckland	Auckland	New Windsor	240
			East Tamaki	525
	Manawatū	Palmerston North		150
	Canterbury	Christchurch	Woolston–Linwood	<50
			Northcote	135
			Total	**1,050**
			Overall total	**34,711**

4.4.3 Final survey areas

The study area list was refined by removing smaller groupings and areas where a varied range of noise exposure levels were known to not exist such as urban roads with low speeds (60 km/h and less) and low traffic flows. The refined list is provided in Table 4.4 to achieve approximately 30 survey groups.

Table 4.4 Refined list of road study areas

	Region	City/town	Suburb/area	Road	Adjusted sample size
1 State highway, urban, OGPA	Auckland	South	Goodwood Heights	SH1	325
	Waikato	Hamilton	Melville	SH3	325
	Bay of Plenty	Papamoa		SH2	550
	Wellington	Wellington	Johnsonville	SH1	600
			Takapu Valley	SH1	250
			Total		**2,050**
5 State highway, urban, chipseal	Bay of Plenty	Tauranga	Pyes Pa	SH 29A & SH36	900
			Hairini	SH29A	558
	Waikato	Tūrangi		SH1	990
	Manawatū	Feilding		SH54	2,070
	Wellington	Upper Hutt	Timberlea	SH2	810
		Greytown-Carterton-Masterton		SH2	2,610
	Southland	Invercargill		SH1	1,800
			Total		**9,738**
6 State highway, rural, chipseal	Northland	Mangōnui		SH2	1,170
		Whangārei	Maunu	SH1	513
	Auckland	SH16 Kumeū–Kaukapakapa		SH16	558
	Waikato			SH1	>3,000
	Nelson	Nelson	Moutere	SH60	459
	Southland	Invercargill		SH6	900
			Total		**6,600**
7 Arterial, urban, asphalt	Auckland				>3,000
	Waikato	Hamilton			>3,000
	Nelson	Nelson			2,750
	Manawatū	Palmerston North			2,250
	Wellington	Wellington			>3,000
	Canterbury	Christchurch			>3,000
		Timaru			1,250
	Marlborough	Blenheim			1,750
	Southland	Invercargill			1,500
			Total		**21,500+**
			Overall total		**40,000+**

Within each chosen sample group, dwellings were sub-grouped into four noise bands in a similar manner to Humpheson and Wareing (2019), as shown in Table 4.5, and the distribution of potential respondents over each road type, as shown in Table 4.6.

Table 4.5 Road survey area distribution

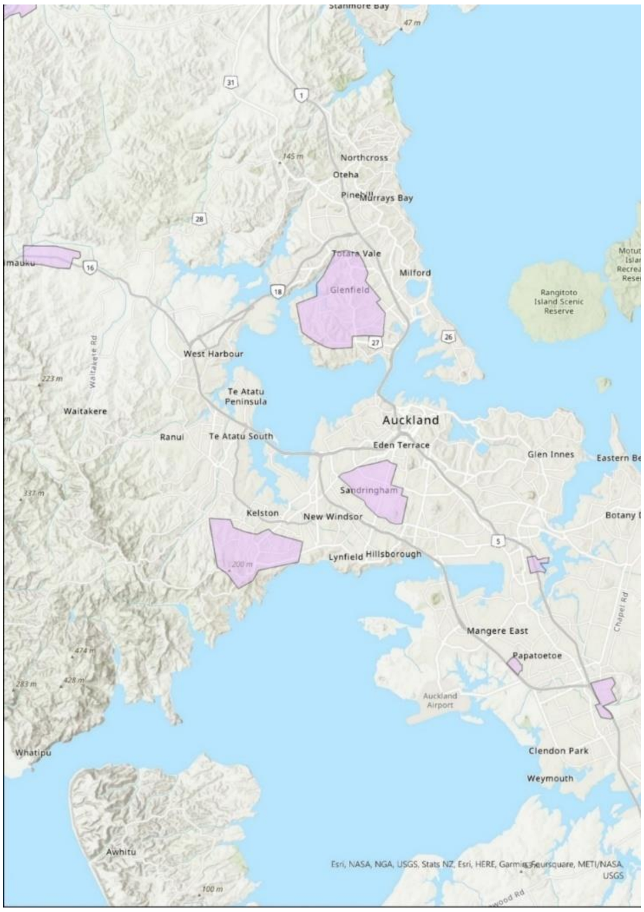
	Low	Medium	High	Very high	Total
	<45 dB $L_{Aeq(24h)}$	45–54 dB $L_{Aeq(24h)}$	55–59 dB $L_{Aeq(24h)}$	60+ dB $L_{Aeq(24h)}$	
North Island	50,587	25,219	4,794	8,720	89,320
South Island	15,334	6,986	1,604	4,383	28,307
Total	**65,921**	**32,205**	**6,398**	**13,103**	**117,627**

Table 4.6 Road survey area distribution by road type

	State highway, urban, OGPA	State highway, urban, chipseal	State highway, rural, chipseal	Arterial, urban, asphalt
North Island samples	5,916	9,823	3,069	43,932
South Island samples	0	1,873	1,702	27,119
Total	**5,916**	**10,242**	**4,771**	**71,051**

The combination of state highway and residential study areas around Auckland are shown in Figure 4.3.

Figure 4.3 Road-traffic sample areas (purple) around Auckland



4.5 Railway noise

AECOM's national noise model was also used to identify railway study areas along with address data and New Zealand population information. Study areas were selected by mapping the location of rail lines and identifying populations nearby that were more than 200 m from nearby roads. The spatial distribution of sample groups was informed by the population distribution map in Figure 4.1.

A study objective was to investigate the ERF to freight traffic noise. Data in the AECOM model did not differentiate between freight and passenger rail traffic.

It was assumed that survey areas in Wellington and Auckland are exposed to a mix of passenger and freight traffic, while areas outside of these centres, including the whole South Island, are predominantly exposed to freight traffic.

Railways are spread across the country as shown in Figure 4.4.

Figure 4.4 New Zealand railways

4.5.1 Selected study areas

The selected railway study areas are listed in Table 4.7. Within each chosen sample group, dwellings were sub-grouped into four noise bands. Table 4.8 shows the distribution of samples for the purposes of selecting respondents.

Table 4.7 Railway study areas

Region	City/town	Sample size (filtered)	Total samples per island
Southland	Invercargill	350	
Otago	Dunedin	1,513	
	Careys Bay	479	
Canterbury	Christchurch	64	
	Casebrook	381	
	Phillipstown	407	
	Redwood	113	
	Hornby	337	
	Rangiora	169	
	Lyttelton	231	
Marlborough	Blenheim	418	4,462
Wellington	Ngaio	208	
	Johnsonville	144	
	Lower Hutt	1,539	
	Upper Hutt	1,328	
	Carterton	712	
Manawatū	Palmerston North	441	
	Feilding	838	
	Marton	680	
	Ohakune	281	
Taranaki	Hāwera	172	
Bay of Plenty	Tauranga	673	
	Te Puke	313	
Waikato	Te Awamutu	671	
	Hamilton	1,155	
Hawke's Bay	Hastings	521	
	Napier	192	
Auckland	Pukekohe	524	
	Papakura	752	
	Meadowbank	485	
	Middlemore	622	
	Henderson	1168	
	Manurewa	937	
Northland	Whangārei	356	
	Hikurangi	142	14,714
	Overall total		**19,176**

Table 4.8 Distribution of railway study areas

	Low	Medium	High	Very high	Total
	<45 dB $L_{Aeq(24h)}$	45–54 dB $L_{Aeq(24h)}$	55–59 dB $L_{Aeq(24h)}$	60+ dB $L_{Aeq(24h)}$	
North Island	238	7,658	2,757	4,041	**14,694**
South Island	1,172	1,785	489	537	**3,983**
Total	**1,410**	**9,443**	**3,246**	**4,578**	**18,677**

The inclusion of Clendon Park and Red Hill in Figure 4.5 shows the effort taken to select areas around population centres near railways while being far enough away from major roads that rail noise dominated.

Figure 4.5 Railway sample areas (green) near Auckland

4.6 Aircraft noise

Airport companies typically publish aircraft noise contours as part of their yearly management plans. The contours will generally show areas exposed to noise at 55 dB and 65 dB L_{dn}. Interpolating between these contours and extrapolating below 55 dB L_{dn} with knowledge of the flight tracks can determine the aircraft noise exposure level at individual homes. Airports were identified where aircraft either fly over or near residential areas and there is a sufficient range in noise exposure. Auckland, Tauranga, Rotorua, Wellington and Queenstown Airports were initially selected. A summary of these airports is presented in Table 4.9 along with the aircraft noise contours in Figures 4.6 to 4.10. Christchurch Airport was not considered in the study despite its size due to the low number of people within the 55 dB L_{dn} contour.

Table 4.9 Airports near residential population centres

Airport	Aircraft	Comments
Auckland	Jet and turboprop	Air traffic reduced by 48% in 2020 when compared to 2019, resulting in a ~6 dB reduction in the contours. This is expected to have increased in 2021 although not to 2019 levels. Therefore, actual exposure is an estimate until 2021 contours are developed. Residential areas overflown. Management plan and contours updated yearly.
Tauranga	Turboprop	Existing contours developed in 2009 as part of a 30-year masterplan. Current contours can be approximated using Airways movement data and knowledge of the masterplan movement numbers. Residential areas overflown but below 55 dB L_{dn}.
Rotorua	Turboprop	Contours from December 2019 to February 2020. Management plan and contours updated yearly. Residential areas overflown.
Wellington	Jet and turboprop	Current contours available to research group. Decrease in flight numbers is expected when compared to the 2019 contours. Residential areas not overflown.
Queenstown	Jet and turboprop	Contours from January to March 2020. Residential areas overflown. Management plan and contours updated yearly.

4.6.1 Selected study areas

Tauranga Airport was not considered suitable due to the small sample size and limited range in noise exposure levels. Wellington Airport was also not considered suitable due to a scheduled hearing that would have occurred during the surveying period and the perceived risk that increased engagement/media attention may bias reported annoyance.

The selected airports were therefore Auckland, Rotorua and Queenstown.

Within each chosen sample group, dwellings were sub-grouped into three noise bands, which differ to those used for the road and rail groupings. The aircraft noise data was sourced from published data, whereas the road and rail noise data was obtained from AECOM's national noise model. As extrapolation of aircraft noise data below 45 dB L_{dn} is subject to significant uncertainty (ground track and vertical flight profile), the low noise band was limited to 45–50 dB L_{dn}.

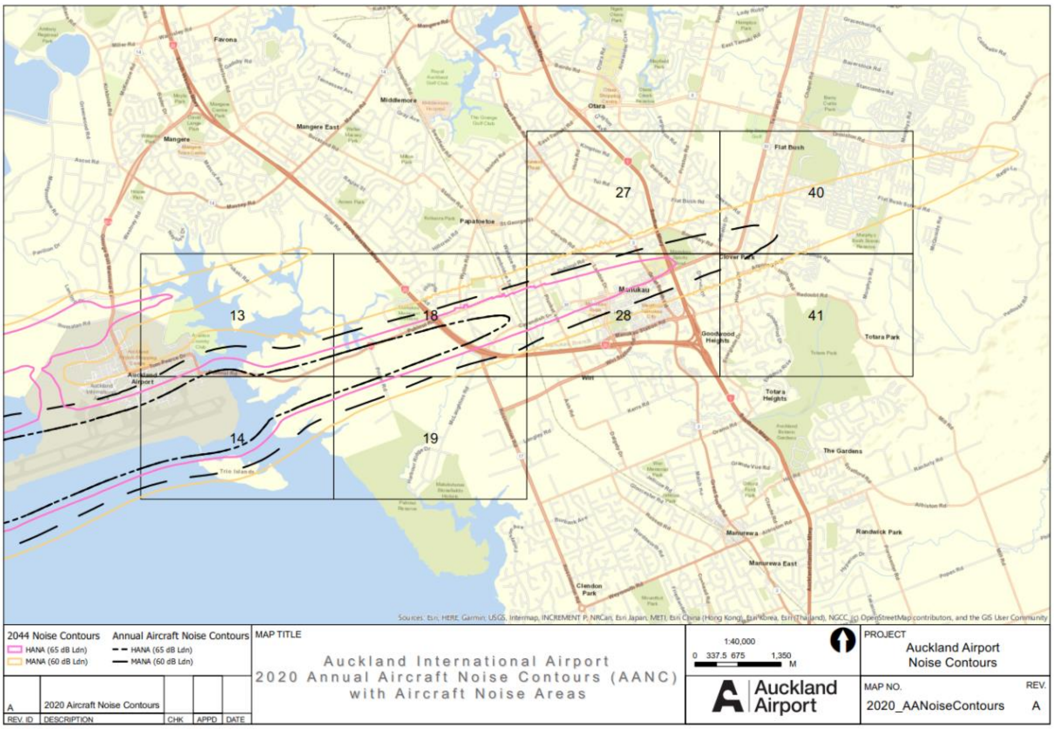
Table 4.10 shows the distribution of samples for the purposes of selecting respondents.

Table 4.10 Distribution of potential airport study participants

	Low	Medium	High	Total
	<50 dB L_{dn}	50–60 dB L_{dn}	>60 dB L_{dn}	
Auckland Airport	4,940	9,590	1,305	**15,835**
Rotorua Airport	907	307	1	**1,215**
Queenstown Airport	1,440	698	96	**2,234**
Total	**7,287**	**10,595**	**1,402**	**19,284**

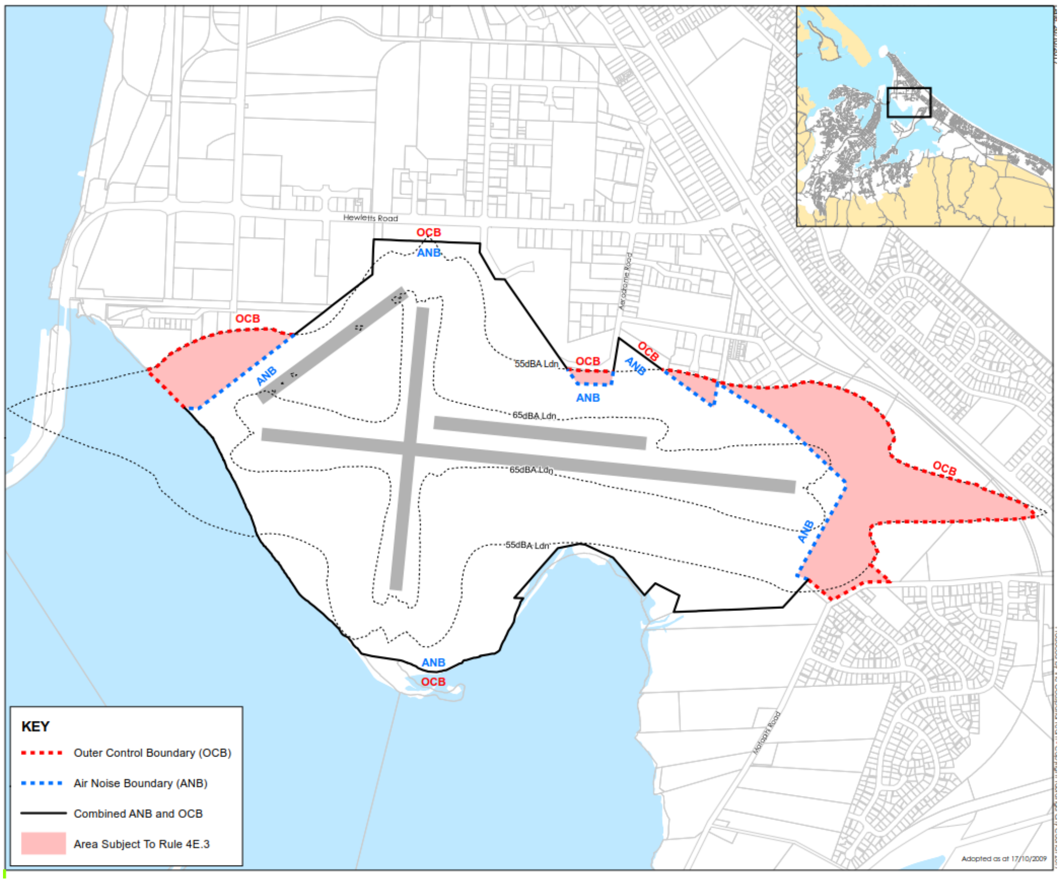
To minimise the influence of other transportation modes, areas within 200 m of State Highway 1 and State Highway 20 were omitted from the Auckland sample. No omissions were made for the Rotorua or Queenstown samples.

Figure 4.6 Auckland Airport aircraft noise contours



Source: Auckland International Airport Limited

Figure 4.7 Tauranga Airport aircraft noise contours



Source: Tauranga City Plan

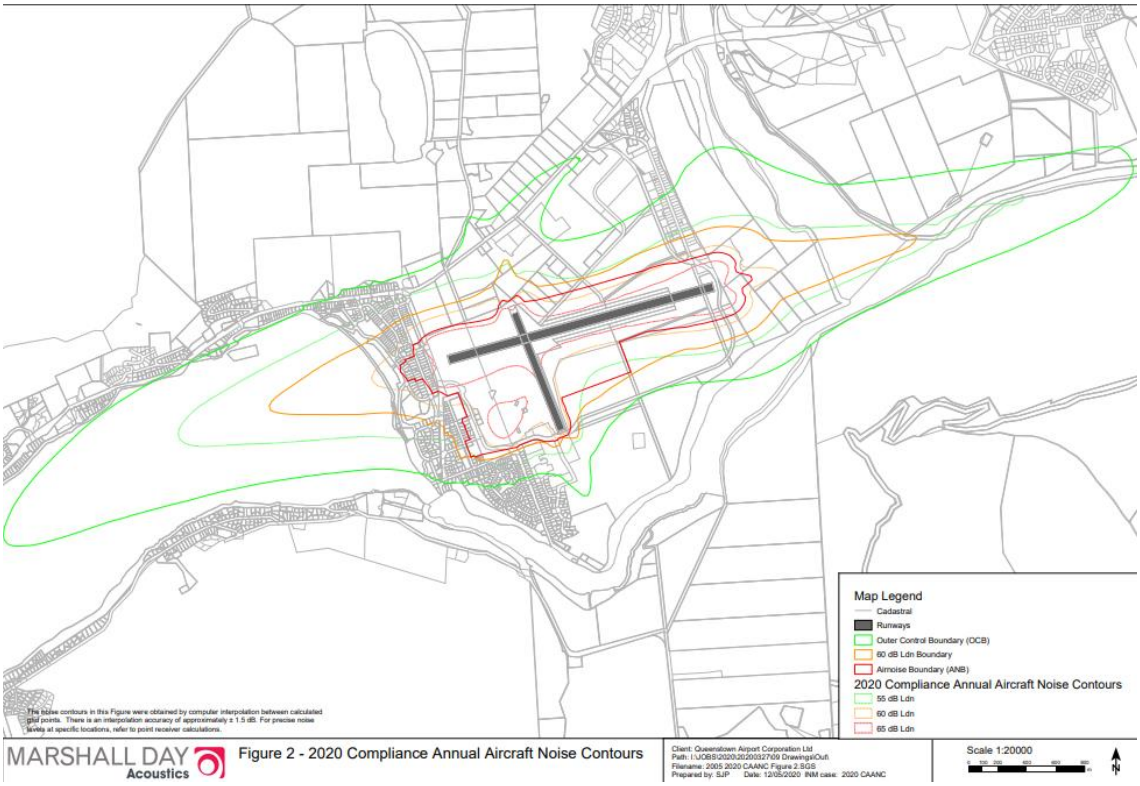
Figure 4.8 Rotorua Airport aircraft noise contours

Source: Rotorua Airport

Figure 4.9 Wellington Airport aircraft noise contours

Source: Wellington International Airport Limited

Figure 4.10 Queenstown Airport aircraft noise contours



Source: Queenstown Airport Corporation

5 Survey design

Socio-acoustic surveys were conducted between September 2022 and January 2023 by Research New Zealand. This chapter provides an overview of the sampling methodology, questionnaire design, pre-survey testing, respondent recruitment and response rates.

5.1 Sampling methodology

Households invited to participate in this research were selected within individual census meshblocks from pre-identified areas (see chapter 4). This enabled the capture of a representative spread of noise exposure bands, typically 40–65+ dB $L_{dn}/L_{Aeq(24h)}$.

Road-traffic study areas were selected for a representative cross-section of road types, road, surfaces and traffic volumes and for recent new or modified roads. Railway study areas comprised national freight and passenger routes, with freight services being predominantly in the South Island. Aircraft study areas focused on residential dwellings within close proximity to Auckland, Rotorua and Queenstown Airports. Road-traffic and railway $L_{Aeq(24h)}$ noise data was derived from AECOM’s national noise model, and aircraft data was derived from published 2019 L_{dn} aircraft noise contours. L_{den} data was then used in the noise response analysis to ensure greater commonality with international work. Other noise metrics were calculated based on published adjustment factors (Brink et al., 2018).

Noise exposure data at a dwelling level was provided to Research New Zealand and cross-referenced to electoral roll records using postal address information to ensure that the details were current and to obtain more detailed information for recruitment purposes, including contact names and flat/apartment numbers.

As no telephone numbers are available via the electoral rolls, the sample was also sent to a third-party provider for tele-matching. The tele-match rate was 7% (approximately 15,000 out of a total sample of 205,250 individuals). Tele-matching rates in general have been declining over time as more people are removing their landlines and using mobile phones or no longer listing their contact details in public directories such as the White Pages. The tele-matching company that provides public contact details has access to some mobile phone lists but these are not as extensive as the landline listings used to be.

The research team concluded the tele-matched sample was the most appropriate sample pool to use for this study due to the benefit of being able to easily contact these people by telephone. However, it was recognised that there was a trade-off against the wider representation that could have been achieved by random sampling from the entire pool of 205,250 individuals. The demographics of those who could be tele-matched compared to those not tele-matched are likely to have differed. This trade-off was addressed in the survey by the use of data weighting (see section 6.1). One further benefit of using the tele-matched electoral roll records is that it ensured that all respondents had lived within the study areas for at least some minimum period of time, thereby removing the need to enquire whether respondents had lived at their address for less than 12 months.

5.2 Survey development

The survey questionnaire was largely based on that used by Humpheson and Wareing (2019) with standardised noise annoyance questions based on ISO/TS 15666:2021. The survey design also considered the findings from a literature review investigating the short-term effects of noise and how this has been benchmarked against pre-existing noise exposure or proxy sites. The questionnaire was designed in collaboration with NZTA, steering group members and a peer reviewer. The questionnaire was cognitively pre-tested and piloted in September 2022 prior to the survey proper being launched in October 2022.

The purpose of the pilot was to test the proposed survey processes and likely response to each survey and to identify any potential issues and how they might be addressed before the survey proper was launched. More specifically, the pilot was used to:

- review the sampling and recruitment methods
- assess the likely overall participation rate
- assess the likely response for each survey mode (paper, online and computer-assisted telephone interviewing)
- review the data collected as a further confirmation that the questionnaire was being responded to as intended and questions/instructions were being understood.

The pilot report is in Appendix A and the final questionnaires are in Appendix B. Only changes were made to the explanation of questions 11 and 12 to improve clarification. Due to no changes in the actual questions used, the questionnaires collected as a result of the pilot study were also included in the final dataset.

5.3 Recruitment and survey implementation

To achieve the intended target response of n=2,000 survey completions, just under 14,000 respondents were invited to take part in this research.

All invited respondents were initially sent a paper version of the questionnaire in the mail. A letter included in the survey pack outlined the purpose of the survey and what was involved in taking part. Respondents were informed that they could complete the survey by returning the paper questionnaire or completing it online or they could do the survey by telephone either when contacted by one of Research New Zealand's interviewers or by contacting Research New Zealand directly by telephone (toll free). The average interview length when the surveys were completed by telephone was 20 minutes.[13]

The letter informed potential respondents that their participation in the research was voluntary and that, if they did choose to take part, their data would remain anonymous and confidential. The letter also highlighted that, if they did complete the survey, they would be entered into a prize draw of one of three $250 petrol or grocery vouchers. The survey invitation letters were printed on joint Tonkin + Taylor and Research New Zealand letterhead and signed by the lead researcher at Research New Zealand (see Appendix C).

Follow-up telephone calls were made (where a phone number was available) to help encourage response among those in the aircraft and road-traffic samples. If the respondent indicated to the telephone interviewer that they would prefer to complete the survey online, their email address was recorded and an email containing a direct link to the survey was provided. Email and text reminders were also sent where possible to further encourage response. Follow-up calls were not necessary for the railway sample respondents due to the relatively high number of paper returns (see Table 5.1).

5.4 Response rate, achieved sample and confidence intervals

A total of 13,854 respondents were invited to participate in the survey. By the final cut-off date (19 January 2023), a sample of n=2,212 respondents had completed the survey, exceeding the original target of n=2,000.

[13] The introduction to the questionnaire indicated that it was likely to require 10–15 minutes to complete. There are several reasonable reasons for this difference:

- The average time to complete is almost always longer than the typical time to complete, as measured by the median of such a distribution.
- It is arguable that the demographic questions are not really part of the survey itself and may be experienced by respondents in that way.

This represents an overall participation rate of 16%. As the target number was reached, there was no need to resample from the remaining sample of 191,396.[14] Table 5.1 provides a breakdown of the number of surveys completed for each transportation mode and survey method.

Table 5.1 Number of surveys completed for each mode

	Total	Road	Railway	Aircraft
Invited to take part in survey	13,854	4,483	6,038	3,333
Survey completed online	383	155	118	110
Survey completed on paper	1,344	295	655	394
Survey completed by telephone	485	358	2	125
Total interviews completed	2,212	808	775	629
Participation rate*	16%	14%	13%	23%

* Participation rate is calculated as the number of completed surveys divided by the number of invitations sent out.

Results based on the total sample of n=2,212 respondents are subject to a maximum (weighted) margin of error of ±3.2% (at the 95% confidence level). This implies that, for example, if 50% of respondents reported being affected by a noise source, there can be 95% confidence in obtaining a similar outcome, with a margin of error of approximately 3.2%, had all eligible households within the three study site areas been interviewed.

Higher margins of error apply to each of the three individual study site areas based on the achieved sub-sample sizes. Table 5.2 shows the number of interviews completed for each study site area along with the associated maximum margins of error.

Table 5.2 Maximum (weighted) margins of error (at the 95% confidence level)

	Total	Road	Railway	Aircraft
Total interviews completed	n=2,212	n=808	n=775	n=629
Maximum margin of error	±3.2%	±5.2%	±5.3%	±5.9%

5.5 Noise exposure bands

The percentage distribution of respondents within each noise exposure band is provided in Table 5.3. The predicted range of road-traffic, railway or aircraft noise levels is shown in Table 5.4. Modelled noise exposure levels were rounded up to the nearest whole dB. Although there will always be a degree of uncertainty associated with noise modelling, which can typically vary around 1–3 dB (increasing uncertainty at greater distances from the source of noise), no margins of error were applied to the dataset as it was considered that any uncertainty would apply equally across all calculated address points. Aircraft noise levels were derived from the 1 dB increment aircraft noise contours.

As dB is a logarithmic measure of sound pressure, a sound pressure level change in the order of 1–3 dB is often described by respondents in laboratory-based experiments as being imperceptible. Differences in the order of 5 dB or greater are judged by respondents as clearly perceptible, and a difference in sound level of 10 dB is typically classed as either a doubling or halving of the perceived loudness.

[14] 205,250 minus 13,854.

Table 5.3 Noise level grouping

	Total n=2,122 %	Road n=808 %	Railway n=775 %	Aircraft n=629 %
Low	32	46	10	39
Medium	39	35	51	28
High	16	7	17	26
Very high	14	11	22	8

Note: Total may not add to 100% exactly due to rounding and noise level groupings boundaries vary between road-traffic, railway and aircraft noise.

Table 5.4 Noise level ranges within study areas (dB)

	Road $L_{Aeq(24h)}$	Railway $L_{Aeq(24h)}$	Aircraft L_{dn}
Low	<45	<45	<50*
Medium	45–54	45–54	50–54
High	55–59	55–59	55–59
Very high	60+	60+	60+

* Noise levels below 45 dB L_{dn} were not determined due to the increased uncertainty extrapolating aircraft noise contours below 50 dB L_{dn}.

6 Data analysis

6.1 Demographic profile of respondents

Table 6.1 presents a demographic profile of the total sample of respondents. To ensure the data could be analysed on a representative population basis, the data was weighted by age and gender and used as the basis for all the analyses of the survey's results. Weighting parameters were sourced from the 2018 census.

Table 6.1 Unweighted and weighted demographic profile of respondents

	Unweighted n=2,212 %	Weighted n=2,212 %	Weighted road n=808 %	Weighted railway n=775 %	Weighted aircraft n=629 %
Age					
18–24	1	6	6	3	8
25–34	6	24	25	14	33
35–44	9	16	20	11	15
45–54	12	17	17	20	14
55–64	20	16	14	21	13
65–74	26	12	10	16	10
75+	25	8	7	12	7
Refused	1	1	1	3	0
Gender					
Male	38	48	45	47	54
Female	61	51	54	52	46
Another gender	0	0	0	0	0
Ethnicity					
European	77	67	77	83	42
Māori	11	15	15	12	16
Pasifika	6	10	4	3	24
Chinese	1	2	1	1	4
Indian	3	6	2	2	14
Another ethnic group	8	10	11	6	11
Refused/no response	2	3	1	3	4

Note: Total may not add to 100% exactly due to rounding.

6.2 Noise and annoyance levels

All survey respondents (the total sample irrespective of study area) were asked to rate the extent to which they were bothered, disturbed or annoyed by nine sources of environmental noise using the 11-point ISO/TS 15666:2021 annoyance question where 0 = not at all annoyed and 10 = extremely annoyed. A score of 8 or more is classified as being highly annoyed. Table 6.2 shows 20% of all respondents were highly annoyed by road-traffic noise. This result is at least twice as high as any other noise source. The next most commonly identified source of high annoyance was aircraft noise identified by 10% of all respondents. Relatively few respondents (4%) reported being highly annoyed by railway noise.

Table 6.2 Noise annoyance levels (total sample)

	Animals outside %	Aircraft %	Building and construction work %	Children outside %	Factories or machinery %	Other people outside %	Pubs and nightclubs %	Road traffic %	Trains %
0 – not at all	33	43	38	52	56	38	69	23	58
1	10	8	10	10	6	11	3	8	8
2	11	7	8	9	4	9	1	10	5
3	10	8	7	6	5	7	1	8	4
4	6	6	5	4	2	7	1	6	2
5	6	6	5	4	2	6	1	9	2
6	4	3	4	2	2	4	1	5	1
7	3	4	3	2	1	3	1	7	1
8	4	4	3	1	2	3	0	7	1
9	2	2	2	1	1	2	0	4	1
10 – extremely	3	4	3	1	3	3	1	9	2
Highly annoyed (8–10)	**9**	**10**	**8**	**3**	**6**	**8**	**1**	**20**	**4**
No response/DK/NA	8	6	10	9	17	8	21	4	16

Note: The totals in the above table may not add to 100% exactly due to rounding. This applies to all subsequent analysis tables.

Annoyance levels by the road-traffic, railway and aircraft samples are presented in Table 6.3.

Table 6.3 Noise annoyance levels (road-traffic, railway and aircraft samples)

	Road		Railway		Aircraft	
	Total n=2,212 %	Road-traffic sample n=808 %	Total n=2,212 %	Railway sample n=775 %	Total n=2,212 %	Aircraft sample n=629 %
0 – not at all	23	22	58	39	43	22
1	8	8	8	16	8	5
2	10	9	5	9	7	8
3	8	8	4	8	8	9
4	6	6	2	3	6	8
5	9	12	2	6	6	9
6	5	5	1	2	3	5
7	7	6	1	3	4	7
8	7	6	1	4	4	9
9	4	4	1	1	2	5
10 – extremely	9	10	2	2	4	10
Highly annoyed (8–10)	**20**	**20**	**4**	**7**	**10**	**24**
No response/DK/NA	4	2	16	6	6	3

While 10% of all respondents reported being highly annoyed by aircraft noise, this figure was much higher among the aircraft sample – 24% of respondents who live near Queenstown, Auckland or Rotorua Airports reported being highly annoyed by aircraft noise. 20% of the road-traffic traffic sample respondents reported being highly annoyed by road-traffic noise, which is the same result as for the total sample of respondents. Only 4% of all respondents reported being highly annoyed by railway noise. This was almost double among those from the railway sample, although it is still relatively low (7%).

Q17. Which one of these noises currently bothers you the most when you are at home?

As shown in Table 6.4, 28% of all respondents said road-traffic noise bothers them the most (as did 35% of the road-traffic sample respondents). Almost one-third of the aircraft sample respondents said they were bothered most by aircraft noise (30%), although a similar proportion of the aircraft sample said they were most bothered by road-traffic noise (28%). 9% of the railway sample respondents said they were most annoyed by railway noise although 20% said they were more annoyed by road-traffic noise.

Table 6.4 Most annoying noise

	Total sample n=2,212 %	Road-traffic sample n=808 %	Railway sample n=775 %	Aircraft sample n=629 %
Aircraft	14	5	5	30
Building and construction work	7	9	5	8
Factories or machinery	2	2	4	2
Pubs and nightclubs	0	1	0	0
Animals outside	13	15	16	8
Children outside	1	1	1	2
Other people outside	7	8	6	8
Road traffic	28	35	20	28
Trains	3	0	9	2
None of the above	20	21	29	11
Don't know/NA/no response	4	3	5	2

Q16. You said that the noise from [type of noise] bothers, disturbs or annoys you. Has this noise got worse, better or stayed the same in the last 12 months?

Respondents who reported being annoyed or bothered by noise at home were asked if they believed it had got worse, better or stayed the same in the last 12 months. Responses were analysed on the basis of those respondents who rated a 3 or more on the 0–10 annoyance scale (more than slightly annoyed). Based on further analysis, this was deemed to be the most appropriate basis even though it departs from the sections of the scale used for other analyses. As shown in Table 6.5, most of this sample group reported that noise issues where they live had stayed the same or become worse over the past 12 months. Relatively few noted any change for the better:

- 57% of road-traffic sample respondents who were more than slightly annoyed by road-traffic noise felt it had not changed in the past year, 38% thought it had got worse and 2% thought it had got better.
- 74% of railway sample respondents who were more than slightly annoyed by railway noise felt it had not changed in the past year, 18% thought it had got worse and 5% thought it had got better.
- 52% of aircraft sample respondents who were more than slightly annoyed by aircraft noise felt it had not changed in the past year, 33% thought it had got worse and 11% thought it had got better.

Table 6.5 Has the noise worsened, improved or stayed the same in the last year?

	Total sample %	Road-traffic sample %	Railway sample %	Aircraft sample %
Road-traffic noise	(n=1,062)	(n=416)		
Worse	49	38		
Better	2	2		
The same	46	57		
Railway noise	(n=262)		(n=178)	
Worse	14		18	
Better	4		5	
The same	73		74	
Aircraft noise	(n=658)			(n=361)
Worse	26			33
Better	8			11
The same	62			52

The bases for each noise source are for those respondents rating 3–10 on the annoyance scale. Those bases are derived from data used to generate Table 6.3, taking into account the weighting of the survey data.

Q18. Generally speaking, how sensitive would you say you are to noise?

All respondents were asked to rate how sensitive in general they were to noise using a scale of 0–10 where 0 = not at all sensitive and 10 = extremely sensitive. As shown in Table 6.6, most respondents did not consider themselves to be overly sensitive to noise in general, with 49% rating their sensitivity as 0–4 on the 11-point scale. In comparison, 14% rated themselves as an 8–10, indicating high sensitivity. Of the three samples, the aircraft sample respondents were the most likely to rate themselves as being highly sensitive to noise (20%), followed by 13% of the road-traffic respondents and 10% of the railway respondents.

Table 6.6 Sensitivity to noise

	Total sample n=2,212 %	Road-traffic sample n=808 %	Railway sample n=775 %	Aircraft sample n=629 %
0 – not at all	11	14	11	9
1	7	8	10	4
2	11	11	14	9
3	11	11	10	12
4	9	8	9	9
5	17	17	21	15
6	8	8	6	8
7	9	7	6	12
8	7	8	5	9
9	2	1	2	4
10 – extremely	5	4	3	7
Highly sensitive (8–10)	**14**	**13**	**10**	**20**
Don't know/not applicable	2	2	3	2

In the analysis that follows, while focus is generally on those highly annoyed (8–10 on the 0–10 scale), some results are also examined for those annoyed and those somewhat annoyed. Respectively, these two definitions include those rating their annoyance 1–10 (excluding not annoyed) and those rating their annoyance 1–7 on the 0–10 scale. While it could be tempting to think of this second group as those at least somewhat annoyed, that would suggest this includes the highly annoyed. The somewhat annoyed are only those with annoyance levels in the range 1–7 not including those highly annoyed.

6.3 Impact of road-traffic noise

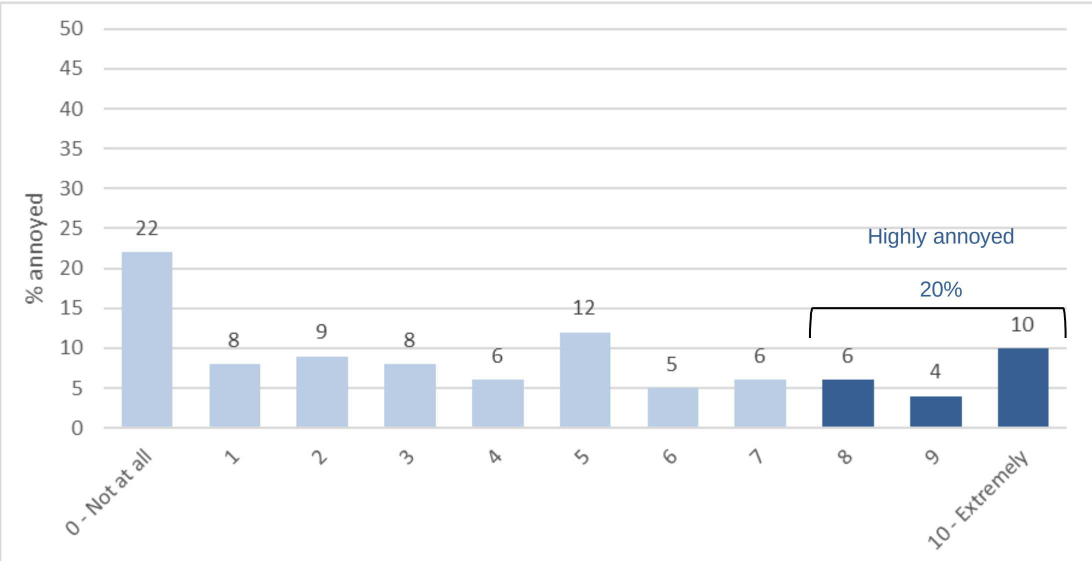
This section is based on the n=808 survey respondents who live in the road-traffic noise sample areas.

6.3.1 Level of annoyance with road-traffic noise

Q15. Thinking about the last 12 months or so, when you are at home, what number best shows how much you are bothered, disturbed or annoyed by road noise? This question uses a 0–10 opinion scale for how much road noise bothers, disturbs or annoys you when you are at home. If not at all annoyed, choose 0; if extremely annoyed, choose 10; if somewhere in between, choose a number between 0 and 10.

As illustrated in Figure 6.1, 20% of the sample's respondents reported being highly annoyed with road-traffic noise while at home (rating 8–10 on the 11-point annoyance scale). A further 29% were moderately annoyed (rating 4–7), 25% were slightly annoyed (rating 1–3), while 22% reported they were not annoyed at all.

Figure 6.1 Extent to which road-traffic sample annoyed by road-traffic noise (n=808)



Total will not sum to 100% because the graph shows the results for respondents who provided a response for this question and does not show not applicable responses.

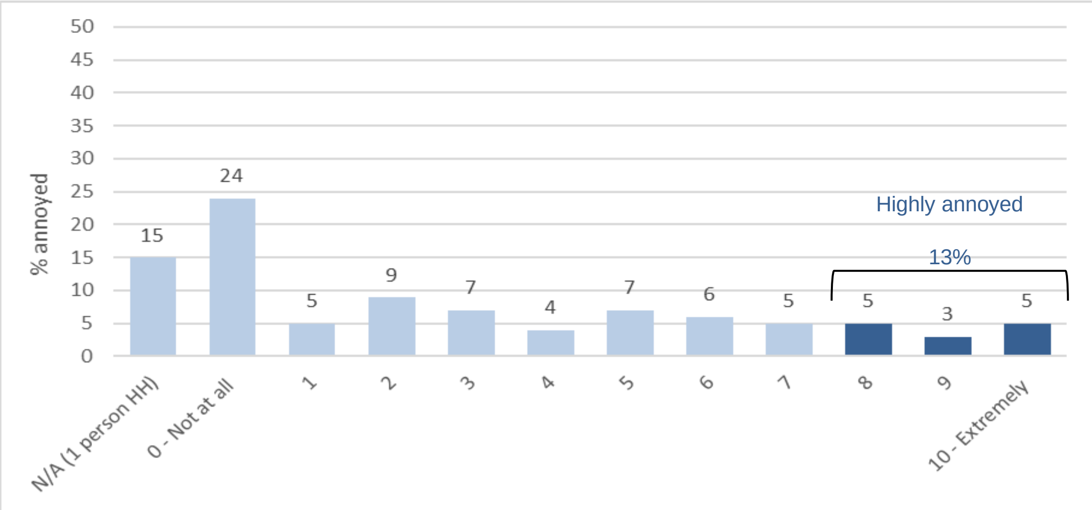
Although most of the road-traffic sample respondents were at least slightly annoyed by road-traffic noise when at home, others were more accepting if not pleased to hear the daily bustle of traffic going past.

> *I quite enjoy the sound of the traffic and watching them go past.*
>
> *I live in a busy street with logging trucks and other large vehicles. It never bothers me. I like to know life is busy and productive.*
>
> *Road noise is a part of living in society.*

Q19. Does road noise bother, disturb or annoy anyone else in your household?

Figure 6.2 shows that 13% of the road-traffic sample reported that someone else in their household is highly annoyed by road-traffic noise. Although 12% of those who identified as being highly annoyed with road-traffic noise live alone, 50% (of the highly annoyed road-traffic sample) reported that at least one other person in their household was also highly annoyed by road-traffic noise.

Figure 6.2 Extent to which other household members annoyed by road-traffic noise (n=808)



6.3.2 Annoyance when outside and inside the home

Q20–22. How much does road noise bother, disturb or annoy you when you are at home, inside, with the windows closed? … standing outside? ... inside, with the windows open?

As mentioned above, 20% of the road-traffic sample reported that, in the last 12 months or so, they had been highly annoyed with road-traffic noise while at home. Most (65%) were highly annoyed standing outside their home, slightly less (61%) were annoyed inside their home with the windows open and 51% were highly annoyed inside their home with the windows closed (Figure 6.3), Table 6.7 is a more detailed breakdown of the levels of annoyance within each of the three situations based on the total road-traffic traffic sample.

Figure 6.3 Road-traffic noise annoyance levels inside and outside the home (highly annoyed, n=148)

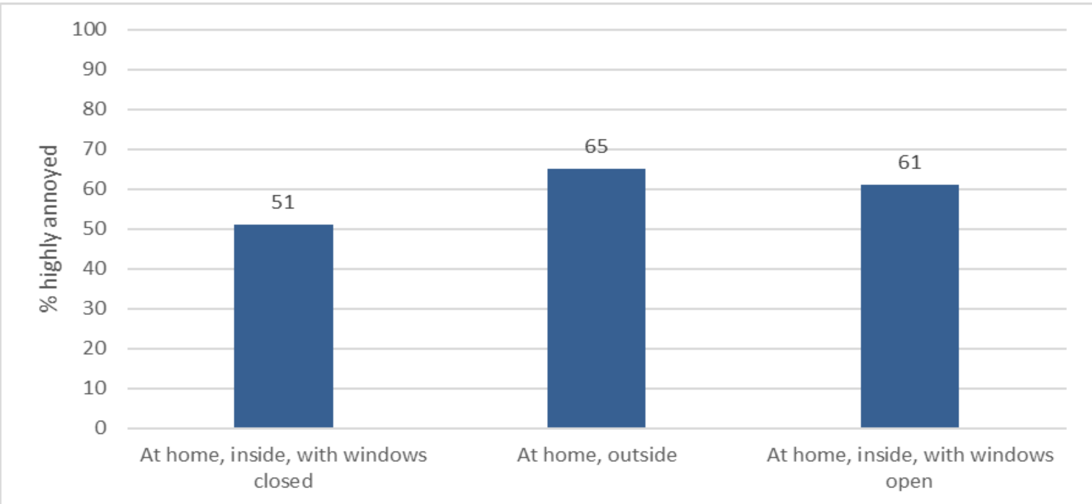


Table 6.7 Road-traffic noise annoyance levels when inside and outside of the home (n=808)

	At home, inside with the windows closed %	At home, inside with the windows open %	At home, standing outside %
0 – not at all	37	28	29
1	11	9	11
2	8	10	11
3	11	7	8
4	5	6	7
5	7	7	6
6	3	7	5
7	5	5	5
8	4	5	5
9	2	4	4
10 – extremely	5	9	8
Highly annoyed (8–10)	**11**	**18**	**17**
No response/NA	1	2	1

Q10. Which of the following apply to this house?

As shown in Table 6.8, compared to the total sample of road-traffic respondents, those highly annoyed with road-traffic noise were significantly more likely to report that their bedroom and living room faces the road.

Table 6.8 House layout and exposure to noise

	Total road-traffic sample n=808 %	Highly annoyed n=148 %
Bedroom faces the road	50	61
Living room/lounge faces the road	54	62
Has an outdoor area that faces the road	57	58
Bedroom windows are double (or triple) glazed	28	27
Windows in the living room/lounge are double (or triple) glazed	27	26
Has a heat pump in the house for heating/cooling	69	70
House has mechanical ventilation providing fresh air ducted from outside	19	15
House has been treated for road noise	3	2
None of the above	4	2

6.3.3 Specific factors relating to road-traffic noise that bother people

Q23. What is it about the road noise that bothers you?

Road-traffic sample respondents who reported being annoyed[15] about road-traffic noise while at home were asked to identify what it is about the road-traffic noise that bothers them. Table 6.9 shows respondents were

[15] Those respondents who used a rating of 1 or more on the 0–10 annoyance scale.

most annoyed with vehicles that have noisy engines, exhausts or horns (75% of all respondents and 77% of those who are highly annoyed) and 59% of the highly annoyed road-traffic sample were also bothered by vehicles driving past their home after 10pm (59%) while approximately one-half were annoyed by noisy cars, trucks and/or motorbikes (52%) and the number of vehicles that drive past their home (48%).

Table 6.9 Features of road-traffic noise that bother road-traffic sample respondents

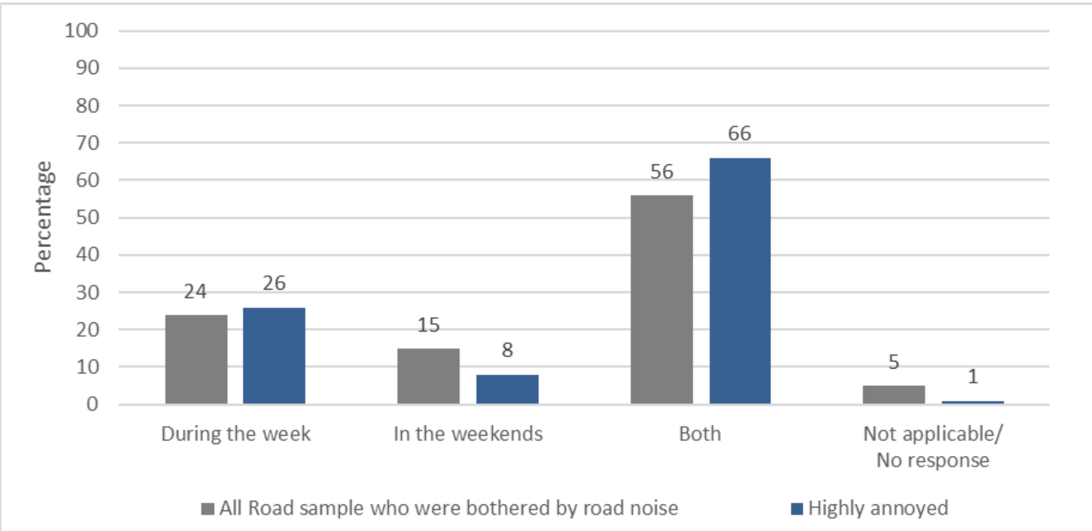
	Annoyed by road-traffic noise n=636 %	Highly annoyed n=148 %
Vehicles with noisy engines, exhausts or horns (including boy racers)	75	77
Particular types of vehicles (cars, trucks, motorbikes)	43	52
Vehicles at night (after 10pm)	42	59
Vehicles in the early morning (before 6am)	30	41
The number of vehicles	25	48
The way the noise makes the house vibrate	23	36
Noise caused by the road (road surface, potholes, manhole covers, rumble strip)	18	23
Something else	11	19
Don't know/no response	3	0

6.3.4 Times/days road-traffic noise is most annoying

Q24. And when is the road noise most annoying for you? Is it during the week, in the weekends or both?

Over one-half of the road-traffic sample respondents (56%) reported that road-traffic noise was annoying during both weekdays and weekends. This was particularly the case for those who reported being highly annoyed by road-traffic noise (66% of the highly annoyed road-traffic sample found that the noise is annoying every day). In addition, one-quarter of these respondents (24%) found road-traffic noise most annoying during weekdays, while 15% found the noise to be most annoying in the weekends.

Figure 6.4 Days of week road-traffic noise most annoying (all road-traffic sample versus highly annoyed)



Q25–26. Are there any particular times during the week (Monday–Friday) that the road noise is particularly annoying? … during the weekend?

Respondents who reported being bothered by road-traffic noise during the week were asked if there were any particular times the noise was particularly annoying (Table 6.10). While 13% said the noise was annoying all the time, evenings and late at night were the most annoying (7pm–3am). The most annoying times were the same for those who were bothered by road-traffic noise in the weekends (Table 6.11).

Table 6.10 Times during the week where road-traffic noise is particularly annoying

	Annoyed by road-traffic noise during weekdays n=532 %	Highly annoyed during weekdays n=133 %
Between 3am and 7am	24	22
Between 7am and 11am	17	22
Between 11am and 3pm	8	12
Between 3pm and 7pm	25	34
Between 7pm and 11pm	27	33
Between 11pm and 3am	32	34
Annoying all the time	13	34
Don't know	15	2
No response/not applicable	4	2

Table 6.11 Times during weekends where road-traffic noise is particularly annoying

	Annoyed by road-traffic noise during weekends n=479 %	Highly annoyed during weekends n=111 %
Between 3am and 7am	21	21
Between 7am and 11am	12	18
Between 11am and 3pm	10	15
Between 3pm and 7pm	14	21
Between 7pm and 11pm	29	39
Between 11pm and 3am	34	33
Annoying all the time	15	34
Don't know	22	5
Refused/no response/not applicable	6	2

6.3.5 Impact of road-traffic noise on respondents' everyday lives and their health and wellbeing

Q27. In the last 12 months, has road noise affected your …?

All road-traffic sample respondents were asked to rate the extent to which road-traffic noise had affected their ability to do everyday activities at home using an 11-point scale where 0 = not at all and 10 = extremely. Figure 6.5 presents the results by the total sample in comparison to those who were highly annoyed by road-traffic noise. Results are based on those who rated the impact on each activity as 8–10.

Around one-third of the highly annoyed road-traffic sample reported that road-traffic noise had affected their ability to relax outdoors (37%), their ability to read, work or study from home (33%) and their ability to get to sleep (31%). Other highly annoyed road-traffic sample respondents said the road-traffic noise affected how much sleep they get (26%), made it difficult to get children to sleep (25%) and affected their ability to listen to music or TV (24%). A more detailed breakdown of how (and to what extent) road-traffic noise had impacted day-to-day activities is presented in Table 6.12.

Figure 6.5 Ways in which road-traffic noise has affected respondents' day-to-day activities (all road-traffic sample versus highly annoyed)

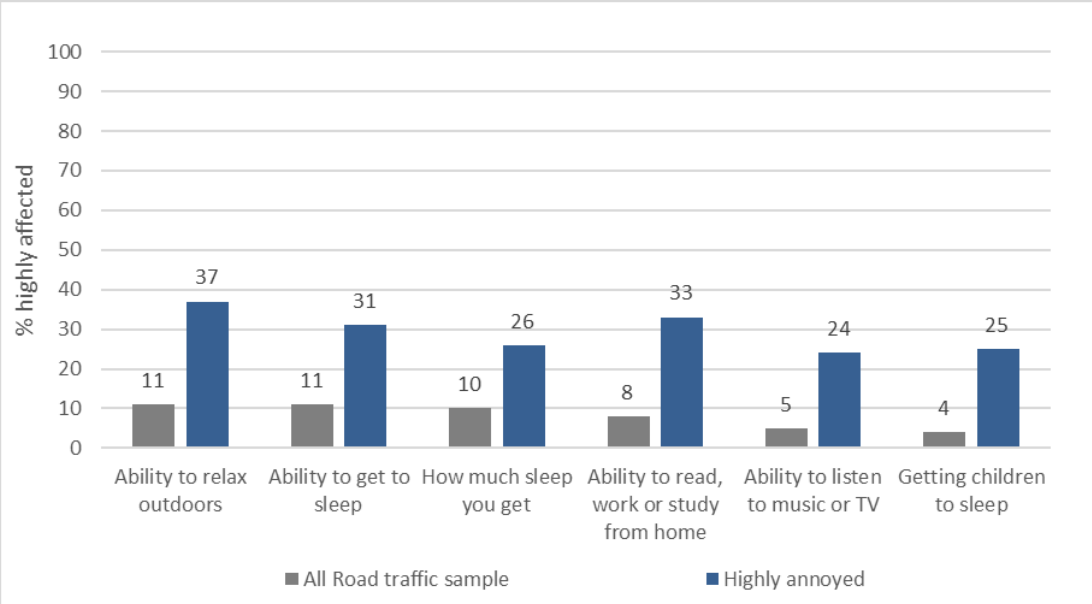


Table 6.12 Ways in which road-traffic noise has affected respondents' day-to-day activities (n=808)

	Ability to relax outdoors %	Ability to get to sleep %	How much sleep you get %	Ability to read, work or study from home %	Ability to listen to music or TV %	Ease of getting children to sleep %
0 – not at all	47	46	44	54	57	35
1	7	7	6	6	7	4
2	5	7	8	7	7	2
3	5	6	5	3	6	2
4	5	6	4	4	2	2
5	6	6	6	4	3	3
6	4	3	6	3	4	4
7	5	4	5	3	3	2
8	5	5	5	5	2	1
9	1	1	1	0	0	1
10 – extremely	5	5	4	3	3	2
Highly affected (8–10)	**11**	**11**	**10**	**8**	**5**	**4**
No response/DK/NA	5	4	6	8	5	42

Q28. And using the same scale, how much has the road noise specifically affected your health and general wellbeing? For example, has it affected …

All road-traffic sample respondents were asked to rate the extent to which road-traffic noise had affected factors relating to their health and wellbeing using an 11-point scale where 0 = not at all and 10 = extremely. Figure 6.6 presents the results by all road-traffic sample respondents in comparison to those who were highly annoyed by road-traffic noise. Results are based on those who rated the impact on each activity as 8–10. Approximately one-quarter of the highly annoyed road-traffic sample reported that the noise affected how easily they get irritated (26%), how stressful or anxious they feel (25%) and their energy levels (23%). A further 16% said road-traffic noise affected their health and wellbeing in general while 9% said their personal relationships with others at home were affected. A more detailed breakdown is presented in Table 6.13.

Figure 6.6 Ways in which road-traffic noise has affected respondents' health and wellbeing (all road-traffic sample versus highly annoyed)

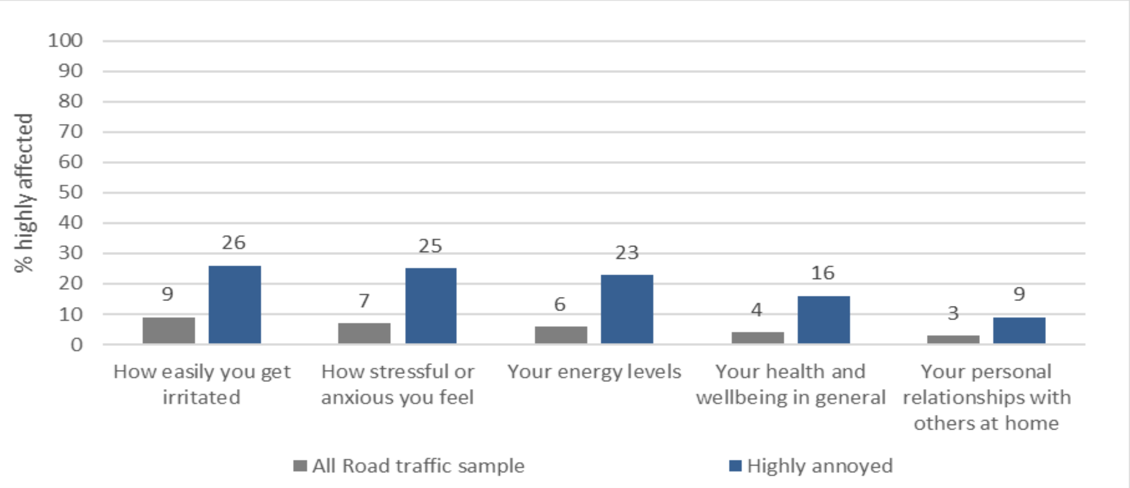


Table 6.13 Ways in which road-traffic noise has affected respondents' health and wellbeing

	How easily you get irritated %	How stressful or anxious you feel %	Your energy levels %	Your health and wellbeing in general %	Your personal relationship with others at home %
0 – not at all	48	53	57	56	62
1	9	7	6	8	7
2	8	7	6	8	5
3	4	6	3	4	3
4	4	2	2	3	3
5	7	8	7	7	3
6	4	3	3	2	1
7	3	2	3	3	1
8	4	3	2	2	1
9	1	1	1	1	0
10 – extremely	3	3	3	2	1
Highly affected (8–10)	**8**	**7**	**6**	**5**	**2**
No response/DK/NA	5	5	5	4	12

6.3.6 Interventions planned or taken to minimise annoyance of road-traffic noise

Q29. Which, if any, of the following have you done, are doing now or planning to do because of road noise?

Figure 6.7 shows 24% of all sample respondents reported that they keep their windows and doors closed when they are at home because of the road-traffic noise, 13% have done so in the past and 2% are planning to do so. Three-quarters of those who were highly annoyed with the noise reported that they (do/have done or plan to) keep their windows and doors closed when they are at home because of the noise (73%). Other actions planned or taken by the highly annoyed road-traffic sample are to spend less time outside and more time indoors (44% of the highly annoyed), make modifications to their homes (39%), complain to the local council or road authority (29%) or take medication (23%). A more detailed breakdown, including additional interventions, is presented in Table 6.14.

Figure 6.7 Actions planned or taken to minimise annoyance relating to road-traffic noise (all road-traffic sample versus highly annoyed)

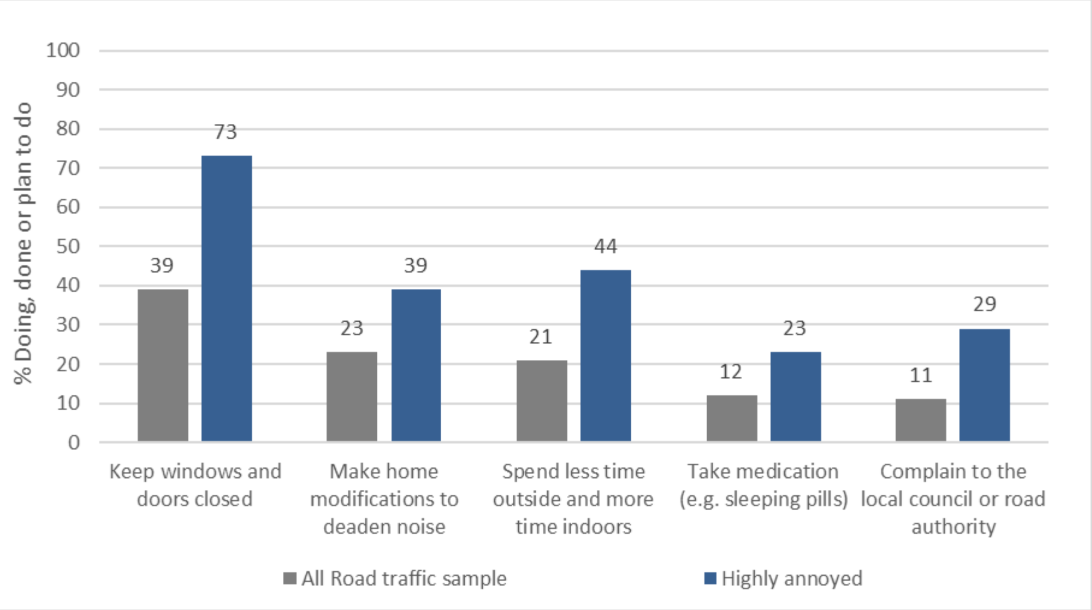


Table 6.14 Actions planned or taken to minimise annoyance relating to road-traffic noise (n=808)

	Keep windows and doors closed %	Make home modifications to deaden noise %	Spend less time outside and more indoors %	Take medication (e.g. sleeping pills) %	Complain to the local council or airport %	Spend less time at home %	Move from the area %	Changed the time you go to sleep %	Move the location of your bedroom %
Doing, done or plan to do	39	23	21	12	11	10	10	10	8
Currently do this	24	1	12	5	0	2	1	3	1
Have done this	13	12	8	5	7	5	0	5	5
Planning to do this	2	10	1	2	4	3	9	2	2
Haven't done it nor plan to	58	70	75	84	83	84	84	86	86
No response/DK/NA	3	6	5	4	5	6	5	4	6

6.3.7 Perceptions that local council and other key stakeholders are doing their best to help minimise the impact of road-traffic noise

Q30. On a scale of 0–10 where 0 = strongly disagree and 10 = strongly agree, how much do you agree or disagree your local council/freight operators or NZTA are doing their best to reduce road noise affecting your neighbourhood?

All road-traffic sample respondents were asked to rate their level of agreement that certain organisations are doing their best to reduce road-traffic noise affecting their neighbourhood using an 11-point scale where 0 = strongly disagree and 10 = strongly agree.

While groupings of survey ratings such as 8–10 (highly annoyed) and 1–10 (annoyed) have been used throughout most of this analysis and report, for this particular question, simply identifying those who strongly disagree (a rating of 0) was considered more relevant when it came to rating the perceived performance of organisations in reducing road-traffic noise.

While fewer than 10% of all road-traffic sample respondents agreed that the local council, freight operators or NZTA were doing their best to reduce road-traffic noise in their neighbourhood (rating of 8–10), approximately 20% strongly disagreed that this was the case. Figure 6.8 shows the extent to which all road-traffic sample respondents (and those who were highly annoyed by road-traffic noise) strongly disagreed that these organisations were doing their best. Around 40% of the highly annoyed road-traffic sample strongly disagreed that all three organisations are doing their best to reduce road-traffic noise in their neighbourhood:

- 40% strongly disagreed that local council is doing its best.
- 38% strongly disagreed that freight operators are doing their best.
- 37% strongly disagreed that NZTA is doing its best.

A more detailed breakdown of how much the road-traffic sample respondents agreed or disagreed that particular organisations are doing their best to reduce road-traffic noise is presented in Table 6.15.

Figure 6.8 Percentage of respondents who strongly disagreed particular organisations are doing their best to reduce road-traffic noise affecting their neighbourhood (all road-traffic sample versus highly annoyed)

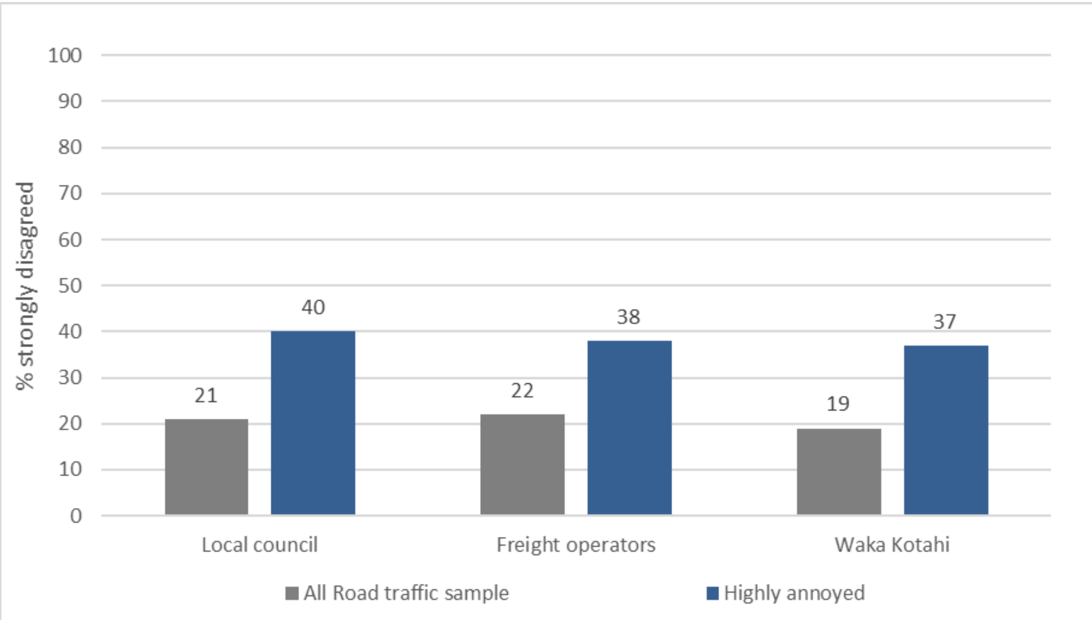


Table 6.15 Agreement that particular organisations are doing their best to reduce road-traffic noise affecting their neighbourhood (all road-traffic sample versus highly annoyed)

Base n=808	Local council %	Freight operators %	NZTA %
0 – strongly disagree	21	22	19
1	4	3	4
2	7	4	6
3	5	4	3
4	3	3	4
5	13	11	11
6	2	1	4
7	2	2	2
8	3	3	2
9	1	1	1
10 – strongly agree	4	3	6
No response/DK/NA	36	43	39

6.3.8 General views and perceptions about road vehicles

Q31. And using the same 0–10 scale, how much do you agree or disagree with each of the following statements about cars and other road vehicles in general?

Figure 6.9 presents the results by all road-traffic sample respondents in comparison to those who were highly annoyed by road-traffic noise. Results are based on those who highly agreed with each statement (rating of 8–10). The majority of respondents agreed that vehicles are an important form of freight transport (70% of all road-traffic sample respondents and 69% of those highly annoyed), vehicles are an important form of passenger transport (68% and 69%, respectively) and vehicles are important for the local and national economy (62% and 56%, respectively). Table 6.16 provides a more detailed breakdown.

Figure 6.9 Agreement with general statements about cars and road vehicles (all road-traffic sample versus highly annoyed)

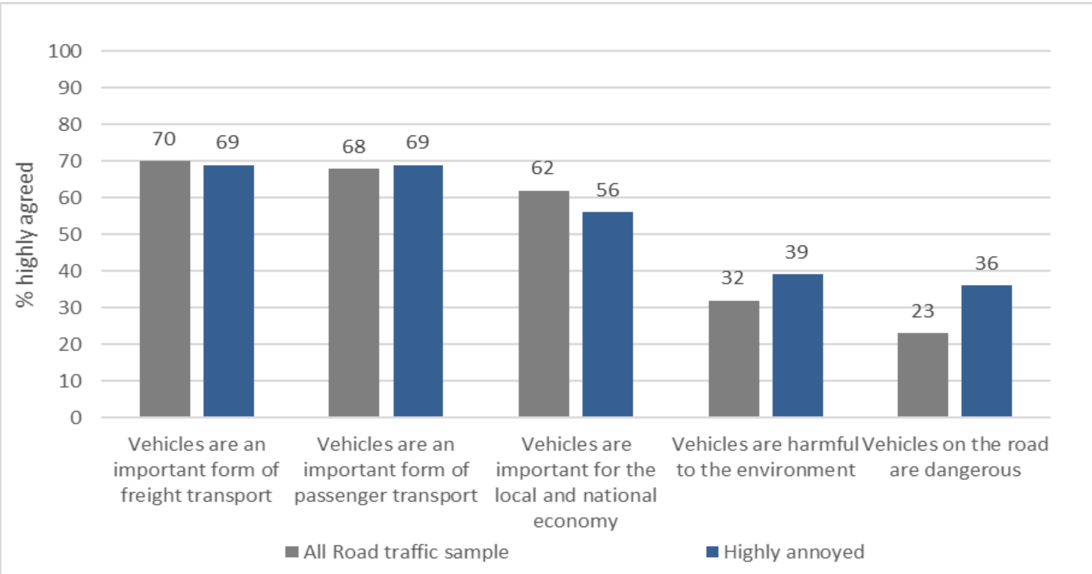


Table 6.16 Agreement with general statements about cars and road vehicles (n=808)

	Vehicles are an important form of passenger transport %	Vehicles and trucks are an important form of freight transport %	Vehicles are important for the local and national economy %	Vehicles are harmful to the environment %	Vehicles on the road are dangerous %
0 – strongly disagree	3	2	4	8	12
1	0	0	0	3	5
2	1	1	1	4	7
3	2	2	2	6	5
4	2	1	2	3	4
5	9	9	12	22	22
6	4	5	5	9	8
7	11	8	8	11	10
8	14	16	13	10	7
9	7	8	9	3	2
10 – strongly agree	47	46	40	19	14
Highly agree (8–10)	**68**	**70**	**62**	**32**	**23**
No response/DK/NA	1	1	3	2	2

6.4 Impact of railway noise

This section is based on the n=775 survey respondents who live near a railway.

6.4.1 Level of annoyance with railway noise

Q15. Thinking about the last 12 months or so, when you are at home, what number best shows how much you are bothered, disturbed or annoyed by train noise? This question uses a 0–10 opinion scale for how much noise bothers, disturbs or annoys you when you are at home. If not at all annoyed, choose 0; if extremely annoyed, choose 10; if somewhere in between, choose a number between 0 and 10.

As illustrated in Figure 6.10, just 7% of the railway sample reported being highly annoyed with railway (train) noise while at home (rating 8–10 on an 11-point annoyance scale). Another 14% were moderately annoyed (rating 4–7), while 33% were slightly annoyed (rating 1–3).

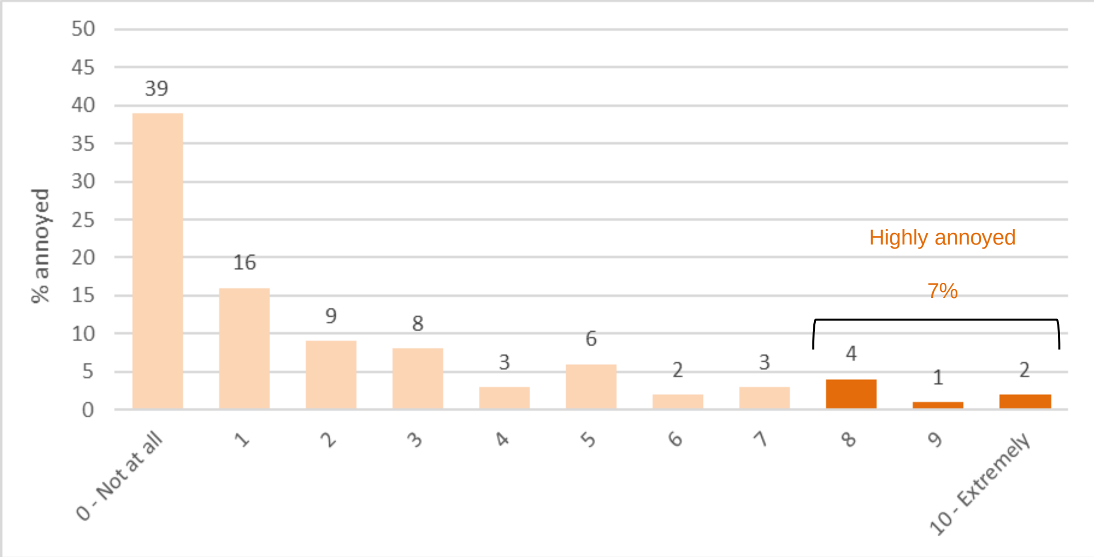
In response to this question, 39% reported that they were not annoyed at all despite living within close proximity to a railway. These are some examples of comments provided by respondents explaining the reasons for this:

> *The trains have run through [Town/City] for 150 years. We built a new house with the sound of train tracks, so I can't complain. If more trains were used, there would be less noise and pollution from trucks.*

> *I love the sound of all aspects of rail noise. Can be an eerie sound on a frosty night.*

> *Train noise is only for a short period of time as they are passing through or are stopping at the station and not a bother at all. Trains are only dangerous if not respected.*

Figure 6.10 Extent to which railway sample annoyed by railway noise (n=775)

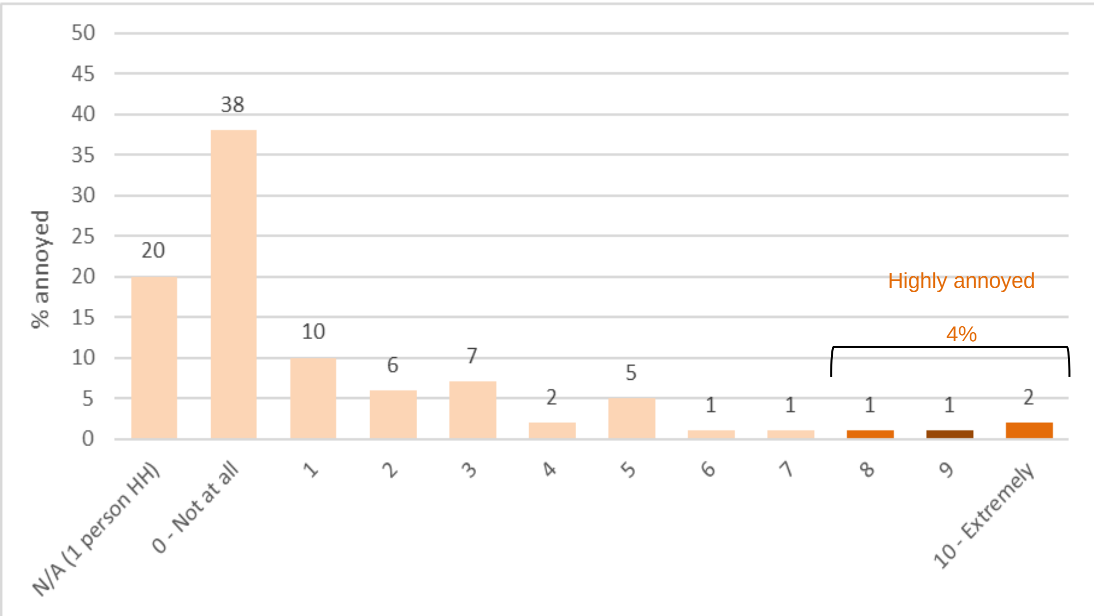


Total will not sum to 100% because the graph shows the results for respondents who provided a response for this question and does not show not applicable responses.

Q19. Does train noise bother, disturb or annoy anyone else in your household?

Respondents were also asked if railway noise bothers, disturbs or annoys anyone else in their household. In response, 4% of all the railway sample reported that someone else in their household is highly annoyed by railway noise (Figure 6.11).

Figure 6.11 Extent to which other household members were annoyed by railway noise (n=775)



Note: Graph does not show don't know, not applicable, would rather not say answers.

6.4.2 Annoyance when outside and inside the home

Q20–22. How much does train noise bother, disturb or annoy you when you are at home, inside, with the windows closed? … standing outside? … inside, with the windows open?

As stated above, 7% of the railway sample reported that, in the last 12 months or so, they had been highly annoyed with railway noise while at home. This equates to n=44 railway sample respondents. Most of these respondents (67%) were highly annoyed with railway noise when inside their home with their windows open. A similar proportion stated they were annoyed by railway noise standing outside their home, and 42% were also highly annoyed by railway noise at home even when they were inside with windows closed (Figure 6.12). Table 6.17 is a more detailed breakdown of the levels of annoyance within each of the three situations based on the total railway sample.

Figure 6.12 Railway noise annoyance levels inside and outside the home (highly annoyed, n=44)

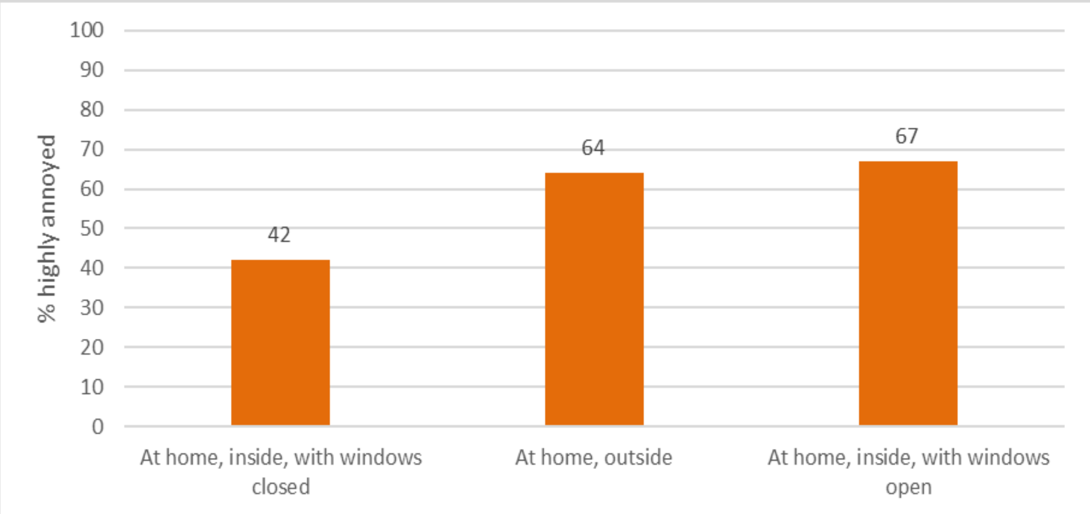


Table 6.17 Railway noise annoyance levels when inside and outside of the home

	At home, inside with the windows closed %	At home, standing outside %	At home, inside with the windows open %
0 – not at all	56	51	49
1	12	15	14
2	8	7	10
3	5	6	6
4	4	4	4
5	3	5	4
6	2	2	3
7	2	1	1
8	1	2	2
9	0	1	1
10 – extremely	2	2	2
Highly annoyed (8–10)	**3**	**5**	**5**
No response/NA	5	4	4

Q10. Which of the following apply to this house?

As shown in Table 6.18, compared to the total sample of railway respondents, those highly annoyed with railway noise were significantly more likely to report that their bedroom faces the railway.

Table 6.18 House layout and exposure to noise

	Total railway sample n=775 %	Highly annoyed n=44 %
Bedroom faces the train tracks	40	81
Living room/lounge faces train tracks	38	50
Has an outdoor area that faces train tracks	52	72
Bedroom windows are double (or triple) glazed	32	37
Windows in the living room/lounge are double (or triple) glazed	29	30
Has a heat pump in the house for heating/cooling	64	70
House has mechanical ventilation providing fresh air ducted from outside	16	17
House has been treated for train noise	1	1
None of the above	7	3

6.4.3 Specific factors relating to railway noise that bother people

Q23. What is it about the train noise that bothers you?

Railway sample respondents who reported being bothered about railway noise while at home were asked to identify what it is specifically about the railway noise that bothers them. As shown in Table 6.19, respondents were most annoyed by trains going past their home after 10pm (33% of all respondents bothered by railway noise and 64% of the highly annoyed railway sample). Almost two-thirds (63%) of those who are highly annoyed by railway noise said they were annoyed by the particular noises that railways make (engines, carriages, squealing wheels, train horns), while others were bothered by particular types of trains (61%), trains in the morning before 6am (59%) and the way the noise makes their house vibrate (59%).

Table 6.19 Features of railway noise that bother respondents

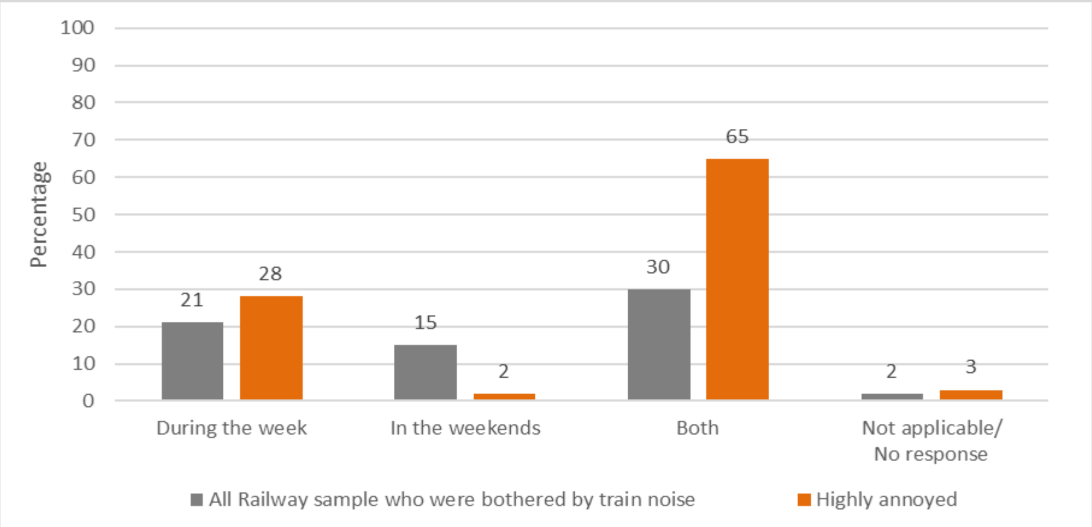
	Annoyed by railway noise n=394 %	Highly annoyed n=44 %
Trains at night (after 10pm)	33	64
Particular noises that trains make (engines, carriages, squealing wheels, train horns)	31	63
Trains in the early morning (before 6am)	27	59
The way the noise makes the house vibrate	24	59
Particular types of trains (electric, diesel or freight trains)	21	61
The number of trains	6	38
Something else	15	13
Don't know/refused/no response	22	3

6.4.4 Times/days that railway noise is most annoying

Q24. And when is the train noise most annoying for you? Is it during the week, in the weekends or both?

Almost one-third of the railway sample respondents (30%) reported that railway noise was annoying during both weekdays and weekends. This was particularly the case for those who reported being highly annoyed by railway noise (65% of whom found the noise annoying every day). A further 21% found it most annoying during weekdays, while 15% found the noise to be most annoying in the weekends.

Figure 6.13 Days of week railway noise is most annoying (all railway sample versus highly annoyed)



Q25–26. Are there any particular times during the week (Monday–Friday) that the train noise is particularly annoying? … during the weekend?

Respondents who reported being bothered by railway noise during the week were asked if there were any particular times that the noise was especially annoying (Table 6.20). As with the road-traffic sample, respondents who were bothered by railway noise during the week were most annoyed by trains passing late at night or early in the morning. Although the sub-sample size is small (n=42), approximately one-half of the highly annoyed railway sample found the noise to be particularly annoying between 11pm and 3am (48%) and between 3am and 7am (54%). A similar pattern was noted for noise in the weekends (Table 6.21).

Table 6.20 Times during the week when railway noise is particularly annoying

	Annoyed by railway noise during weekdays n=356 %	Highly annoyed during weekdays n=42 %
Between 3am and 7am	29	54
Between 7am and 11am	5	16
Between 11am and 3pm	3	10
Between 3pm and 7pm	8	24
Between 7pm and 11pm	13	34
Between 11pm and 3am	24	48
Annoying all the time	4	19
Don’t know	14	10
No response/not applicable	37	4

Table 6.21 Times during weekends when railway noise is particularly annoying

	Annoyed by railway noise during weekends n=329 %	Highly annoyed during weekends n=36 %
Between 3am and 7am	20	44
Between 7am and 11am	4	16
Between 11am and 3pm	5	13
Between 3pm and 7pm	4	12
Between 7pm and 11pm	10	30
Between 11pm and 3am	19	43
Annoying all the time	'	27
Don't know	17	14
No response/not applicable	43	5

6.4.5 Impact of railway noise on respondents' everyday lives and their health and wellbeing

Q27. In the last 12 months, has train noise affected your … ?

All railway sample respondents were asked to rate the extent to which railway noise had affected their ability to do everyday activities at home using an 11-point scale where 0 = not at all and 10 = extremely. Figure 6.14 presents the results to this line of questioning by the total sample in comparison to those who were highly annoyed by railway noise. Results are based on those who rated the impact on each activity as 8–10. One-third of those who were highly annoyed with railway noise (33%) reported that the noise affected how much sleep they get. In descending order, railway noise also affected their ability to get to sleep (26%), to listen to music or TV (22%), to read, work or study from home (22%), to relax outdoors (19%) and to get their children to sleep (10%). A more detailed breakdown is presented in Table 6.22.

Figure 6.14 Ways in which railway noise has affected the railway sample respondents' day-to-day activities (all railway sample versus highly annoyed)

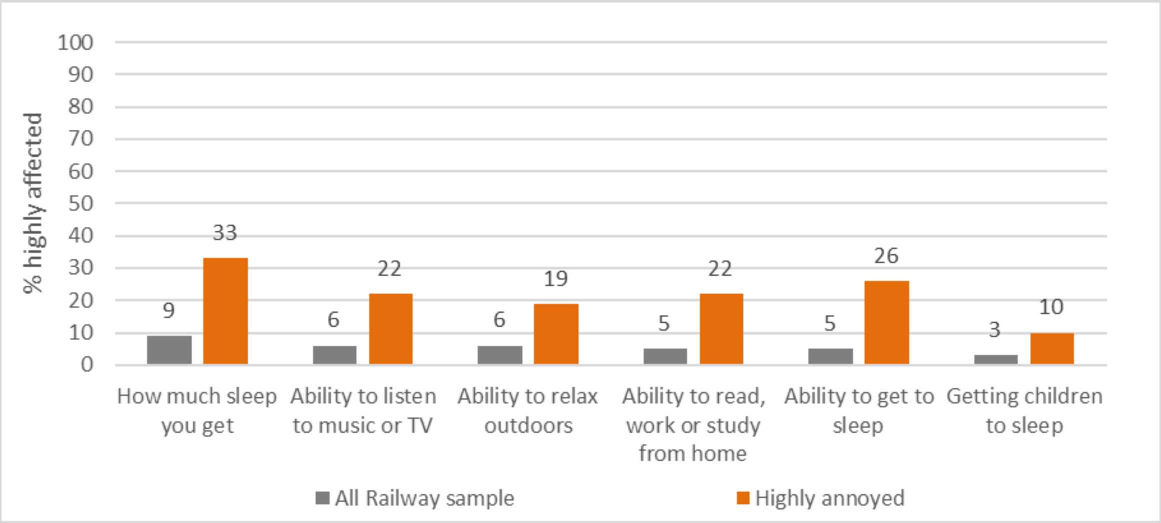


Table 6.22 Ways in which railway noise has affected railway sample respondents' day-to-day activities (n=775)

	How much sleep you get %	Ability to listen to music or TV %	Ability to relax outdoors %	Ability to read, work or study from home %	Ability to get to sleep %	Ease of getting children to sleep %
0 – not at all	52	58	56	59	58	44
1	7	6	8	6	7	4
2	3	2	4	4	2	2
3	2	2	1	1	2	1
4	1	2	2	1	1	1
5	3	3	4	2	5	2
6	4	1	1	1	1	0
7	2	1	0	0	1	0
8	4	2	3	2	2	1
9	1	0	0	0	1	0
10 – extremely	4	4	3	3	2	2
Highly affected (8–10)	**9**	**6**	**6**	**5**	**5**	**3**
No response/DK/NA	17	17	17	20	17	42

Q28. And using the same scale, how much has the train noise specifically affected your health and general wellbeing? For example, has it affected …

All railway sample respondents were asked to rate the extent to which railway noise had affected factors relating to their health and wellbeing using an 11-point scale where 0 = not at all and 10 = extremely. Figure 6.15 shows the results by the total sample in comparison to the n=44 who were highly annoyed. Results are based on those who rated the impact on each factor as 8–10. More than one-quarter (28%) of those highly annoyed with railway noise reported the noise had affected how stressful or anxious they feel. Another 25% said it affected how easily irritated they get, while 19% said the noise affected their energy levels and 18% their health and wellbeing in general (35%). 15% of those highly annoyed said the noise had affected their personal relationships with others at home. A more detailed breakdown is presented in Table 6.23.

Figure 6.15 Ways in which railway noise has affected respondents' health and wellbeing (all railway sample versus highly annoyed)

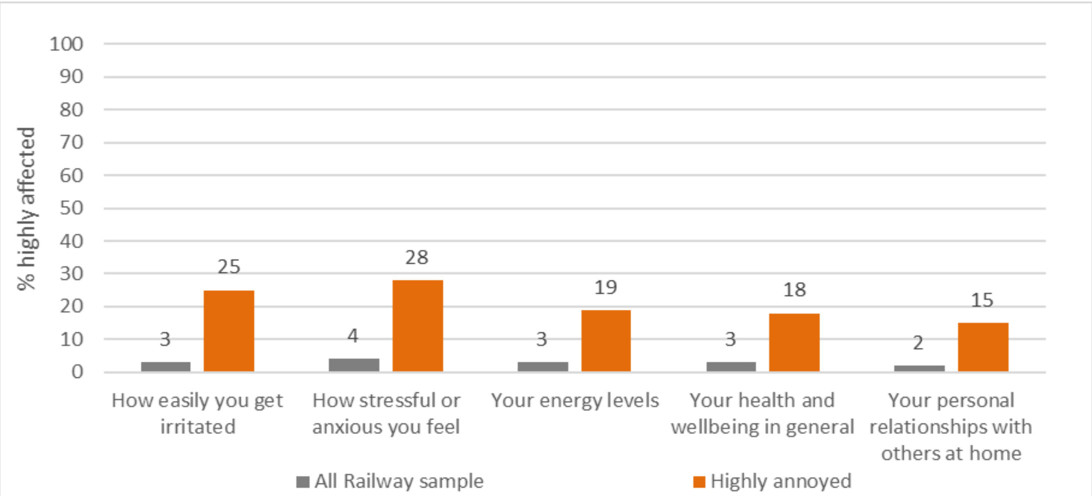


Table 6.23 Ways in which railway noise has affected respondents' health and wellbeing

	How easily you get irritated %	How stressful or anxious you feel %	Your energy levels %	Your personal relationship with others at home %	Your health and wellbeing in general %
0 – not at all	66	68	68	69	67
1	6	5	5	4	6
2	2	2	2	2	2
3	1	1	1	1	1
4	1	0	1	0	1
5	2	2	2	1	2
6	1	0	0	1	1
7	1	1	0	0	0
8	0	2	1	0	1
9	0	0	1	1	0
10 – extremely	2	2	1	1	1
Highly affected (8–10)	**2**	**4**	**3**	**2**	**2**
No response/DK/NA	16	16	17	19	17

6.4.6 Interventions planned or taken to minimise annoyance of railway noise

Q29. Which, if any, of the following have you done, are doing now or planning to do because of train noise?

Figure 6.16 shows 56% of those who were highly annoyed with railway noise reported that they are currently, have done or plan to keep their windows and doors closed when they are at home because of the noise. Another 44% are currently making modifications to their homes to minimise the noise, have done so already or are planning to. One-quarter (23%) of the highly annoyed take, have taken or plan to take medication to reduce the annoyance of railway noise, while 21% spend, have spent or plan to spend less time at home to avoid the noise. A more detailed breakdown, including additional interventions, is presented in Table 6.24.

Figure 6.16 Actions planned or taken to minimise annoyance relating to railway noise (all railway sample versus highly annoyed)

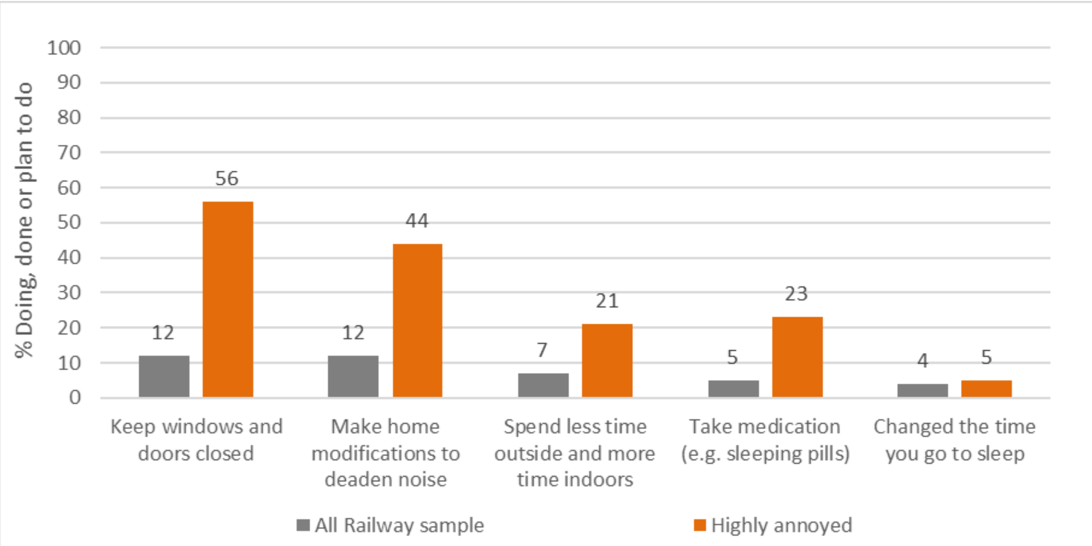


Table 6.24 Actions planned or taken to minimise annoyance relating to railway noise

	Keep windows and doors closed %	Make home modifications to deaden noise %	Spend less time outside and more indoors %	Take medication (e.g. sleeping pills) %	Changed the time you go to sleep %	Move from the area %	Move the location of your bedroom %	Complain to the local council or airport %	Spend less time at home %
Doing, done or plan to do	12	12	7	5	5	4	4	3	3
Currently do this	6	2	3	2	1	1	1	1	1
Have done this	4	5	2	2	2	0	2	0	1
Planning to do this	2	5	2	1	1	3	1	2	1
Haven't done it nor plan to	77	75	82	84	83	83	85	85	84
No response/DK/NA	11	13	12	11	11	13	11	13	12

6.4.7 Perceptions that local council and other key stakeholders are doing their best to help minimise the impact of railway noise

Q30. On a scale of 0–10 where 0 = strongly disagree and 10 = strongly agree, how much do you agree or disagree your local council/KiwiRail are doing their best to reduce train noise affecting your neighbourhood?

All railway sample respondents were asked to rate their level of agreement that certain organisations are doing their best to reduce railway noise that affects their neighbourhood. Figure 6.17 presents the results from the total railway sample in comparison to those who were highly annoyed by railway noise. Results are based on those who strongly disagreed (rating of 0). Just over one-third of those who were highly annoyed strongly disagreed that the two organisations are doing their best to reduce railway noise:

- 38% strongly disagreed that KiwiRail is doing its best.
- 34% strongly disagreed that local council is doing its best.

A more detailed breakdown is presented in Table 6.25.

Figure 6.17 Percentage of respondents who strongly disagreed particular organisations are doing their best to reduce railway noise affecting their neighbourhood (all railway sample versus highly annoyed)

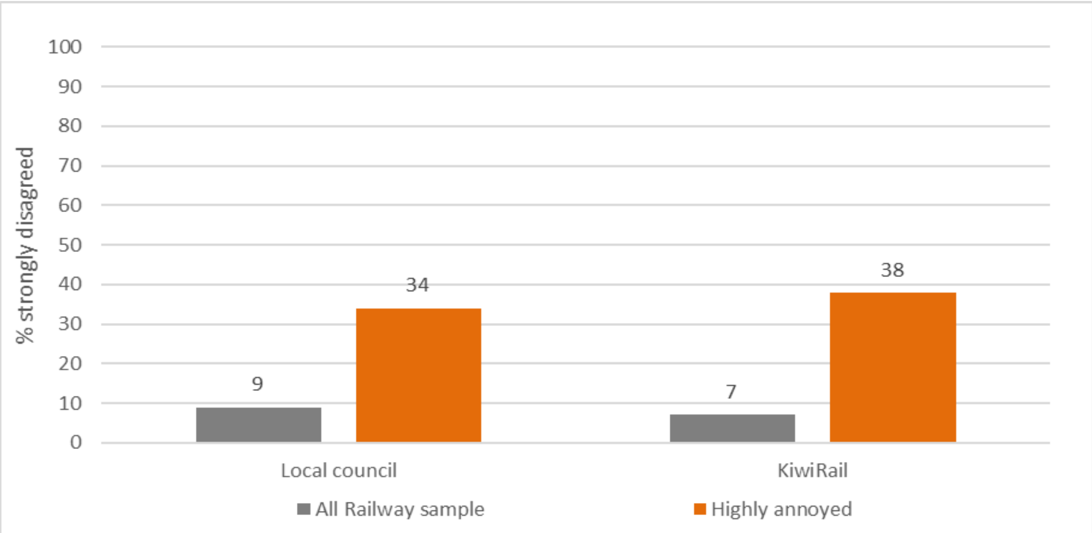


Table 6.25 Agreement that particular organisations are doing their best to reduce railway noise affecting their neighbourhood

Base n=775	Local council %	KiwiRail %
0 – strongly disagree	9	7
1	3	2
2	2	1
3	3	2
4	1	2
5	8	7
6	1	3
7	2	1
8	3	4
9	1	2
10 – strongly agree	4	6
No response/DK/NA	64	63

6.4.8 General views and perceptions about railways

Q31. And using the same 0–10 scale, how much do you agree or disagree with each of the following statements about trains in general?

Figure 6.18 presents the results based on those who highly agreed with each statement (rated as 8–10). The majority of respondents highly agreed that railways are an important form of freight transport (82% of all respondents in the railway sample and 88% of those who are highly annoyed), railways are important for the local and national economy (75% and 78%, respectively) and railways are an important form of passenger transport (69% and 67%, respectively). A more detailed breakdown is presented in Table 6.26.

Figure 6.18 Agreement with general statements about trains (all railway sample versus highly annoyed)

Table 6.26 Agreement with general statements about railways

	Trains are an important form of freight transport %	Trains are important for the local and national economy %	Trains are an important form of passenger transport %	Trains are dangerous %	Trains are harmful to the environment %
0 – strongly disagree	1	2	2	25	27
1	1	1	1	12	9
2	0	1	1	11	11
3	0	0	3	8	11
4	0	0	3	2	4
5	3	5	6	11	12
6	3	2	3	4	2
7	6	8	7	4	3
8	8	9	7	3	2
9	10	8	7	3	1
10– strongly agree	64	58	55	11	4
Highly agree (8–10)	**82**	**75**	**69**	**17**	**7**
No response/DK/NA	3	6	5	6	13

6.5 Impact of aircraft noise

This section is based on the n=629 survey respondents who live within close proximity to Auckland, Rotorua or Queenstown Airports.

6.5.1 Level of annoyance with aircraft noise

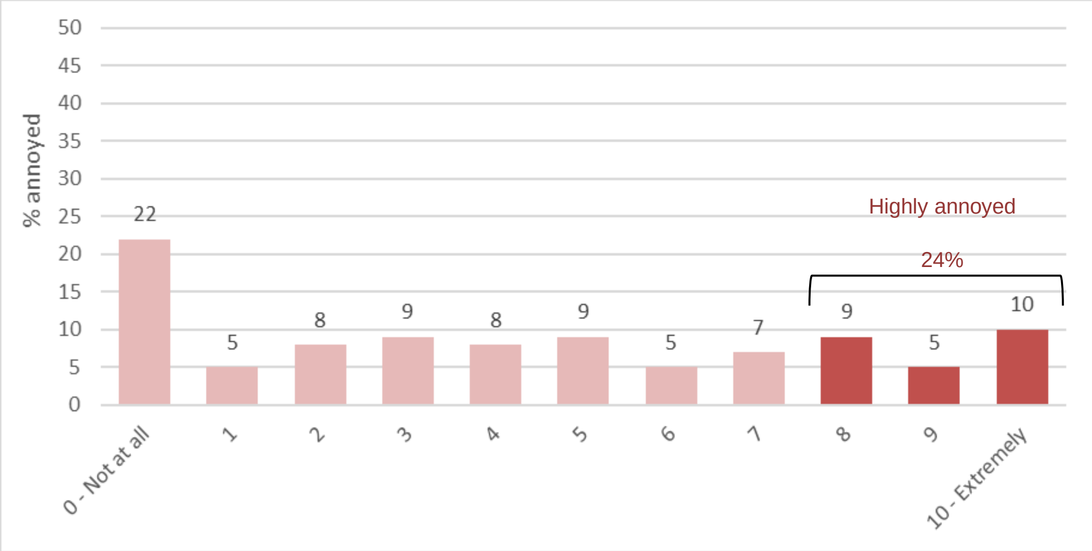
Q15. Thinking about the last 12 months or so, when you are at home, what number best shows how much you are bothered, disturbed or annoyed by aircraft noise? This question uses a 0–10 opinion scale for how much noise bothers, disturbs or annoys you when you are at home. If not at all annoyed, choose 0; if extremely annoyed, choose 10; if somewhere in between, choose a number between 0 and 10.

As illustrated in Figure 6.19, one-in-four (24%) of the aircraft sample reported being highly annoyed with aircraft noise while at home (rating 8–10 on an 11-point annoyance scale). A further 29% were moderately annoyed (rating 4–7), while 22% were slightly annoyed (rating 1–3).

In response to this question, 22% reported that they were not annoyed by aircraft noise at all, despite living within close proximity to an airport. This appeared to be either because they liked aircraft or they had become accustomed to the sound.

> *Love airplanes. We are on the flight path, so we watch them fly over our house.*
>
> *I was aware that my property was in the flight air pathway, when I purchased in 1983, so have not been bothered by the noise when planes fly overhead. It has been a highlight at times, as I saw the concord, the All-Blacks' plane and air force planes.*
>
> *We do hear lots of planes coming into land at Auckland airport, but you get used to the noise and hardly notice unless visitors point it out.*

Figure 6.19 Extent to which the aircraft sample were annoyed by aircraft noise (n=629)

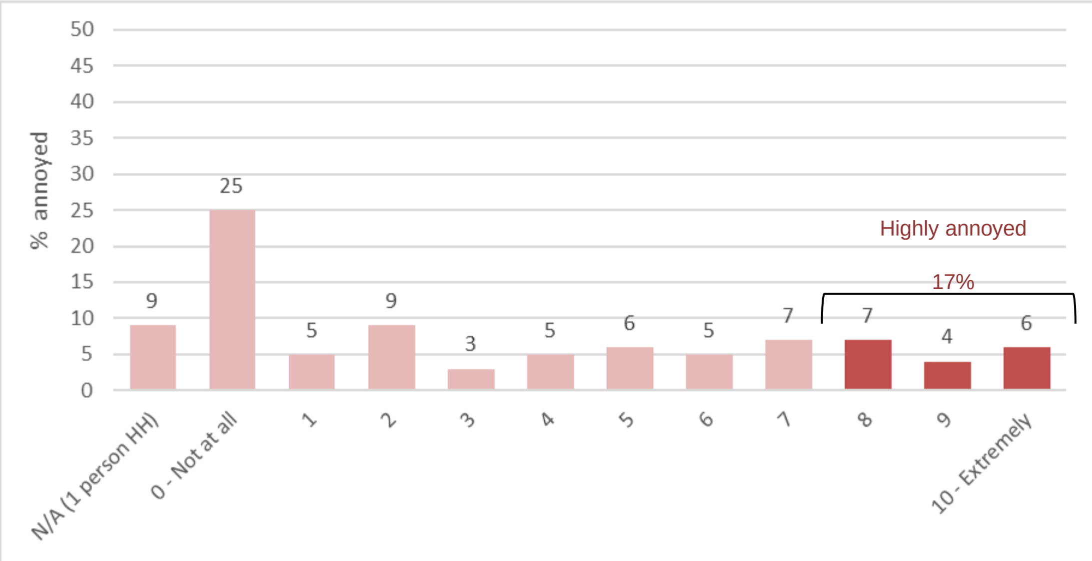


Q19. Does aircraft noise bother, disturb or annoy anyone else in your household?

Respondents were also asked if aircraft noise bothers, disturbs or annoys anyone else in their household. In response, 17% of the aircraft sample reported that someone else in their household is highly annoyed by aircraft noise (Figure 6.20).

Although 7% of those who identified as being highly annoyed with aircraft noise live alone, 60% of those highly annoyed reported that at least one other person in their household was also highly annoyed with aircraft noise. This implies that, in multi-person households, if one person is highly annoyed by the sound of aircraft from a nearby airport, it is more than likely that other people in their household will be highly annoyed by the sound of aircraft too.

Figure 6.20 Extent to which other household members were annoyed by aircraft noise (n=629)



6.5.2 Annoyance when outside and inside the home

Q20–22. How much does noise from aircraft bother, disturb or annoy you when you are at home, inside, with the windows closed? … standing outside? … inside, with the windows open?

As mentioned above, 24% of the aircraft sample reported that, in the last 12 months or so, they had been highly annoyed with aircraft noise while at home. Most of these highly annoyed respondents were highly annoyed with the sound of aircraft when at home standing outside (78%), although a very similar proportion (81%) were just as annoyed by the sound of aircraft when inside their home with the windows open (Figure 6.21). A sizable proportion (63%) were also highly annoyed by the sound of aircraft at home even when they were inside with windows closed. Table 6.27 provides a more detailed breakdown of the levels of annoyance within each of the three situations based on the total aircraft sample.

Figure 6.21 Aircraft annoyance levels when inside and outside of the home (highly annoyed, n=140)

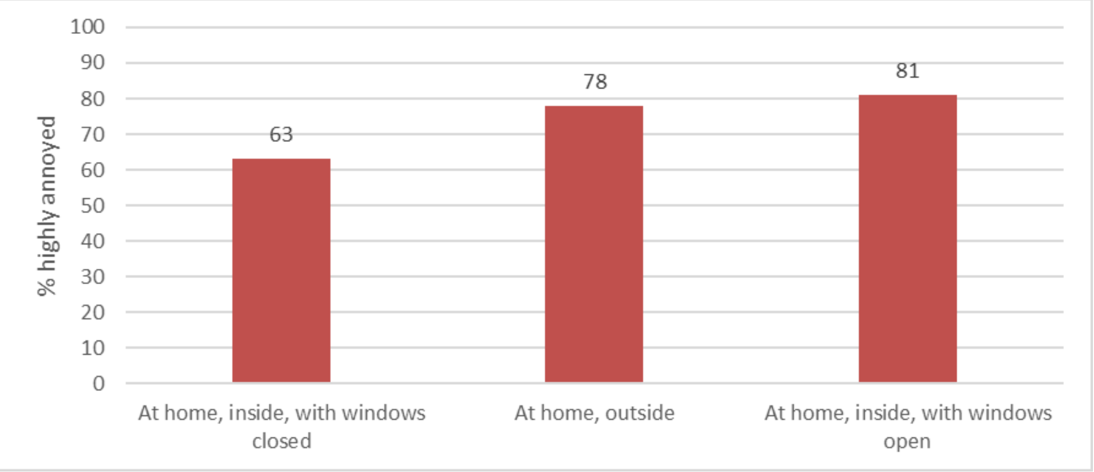


Table 6.27 Aircraft noise annoyance levels when inside and outside of the home (n=629)

	At home, inside with the windows closed %	At home, standing outside %	At home, inside, with the windows open %
0 – not at all	31	29	27
1	8	3	5
2	10	9	7
3	7	7	7
4	6	5	4
5	5	7	9
6	4	5	6
7	7	7	5
8	9	7	8
9	3	7	6
10 – extremely	7	13	12
Highly annoyed (8–10)	**19**	**27**	**26**
No response/DK/NA	2	2	2

Q10. Which of the following apply to this house?

As shown in Table 6.28, those respondents highly annoyed with aircraft noise at home were significantly more likely to report that their bedroom, living room and/or outdoor area faces the airport.

Table 6.28 House layout and exposure to noise

	Total aircraft sample n=629 %	Highly annoyed n=140 %
Bedroom faces the airport	45	61
Living room/lounge faces the airport	42	59
Has an outdoor area that faces the airport	55	66
Bedroom windows are double (or triple) glazed	28	22
Windows in the living room/lounge are double (or triple) glazed	26	20
Has a heat pump in the house for heating/cooling	68	73
House has mechanical ventilation providing fresh air ducted from outside	31	33
House has been treated for aircraft noise	5	8
None of the above	10	3

6.5.3 Specific factors relating to aircraft noise that bother people

Q23. What is it about the aircraft noise that bothers you?

Aircraft sample respondents who reported being annoyed by aircraft noise were asked to identify what it is about the aircraft noise that bothers them. As illustrated in Table 6.29, respondents were most annoyed when aircraft fly directly over their house (53% of all respondents bothered by aircraft noise and 71% of the highly annoyed aircraft sample). Around one-half of those who are highly annoyed by aircraft noise also stated they are bothered by flights after 10pm at night (53%), aircraft that fly low over their house (51%), early morning flights (54%) and the number of flights in general (48%).

Table 6.29 Features of aircraft noise that bother respondents

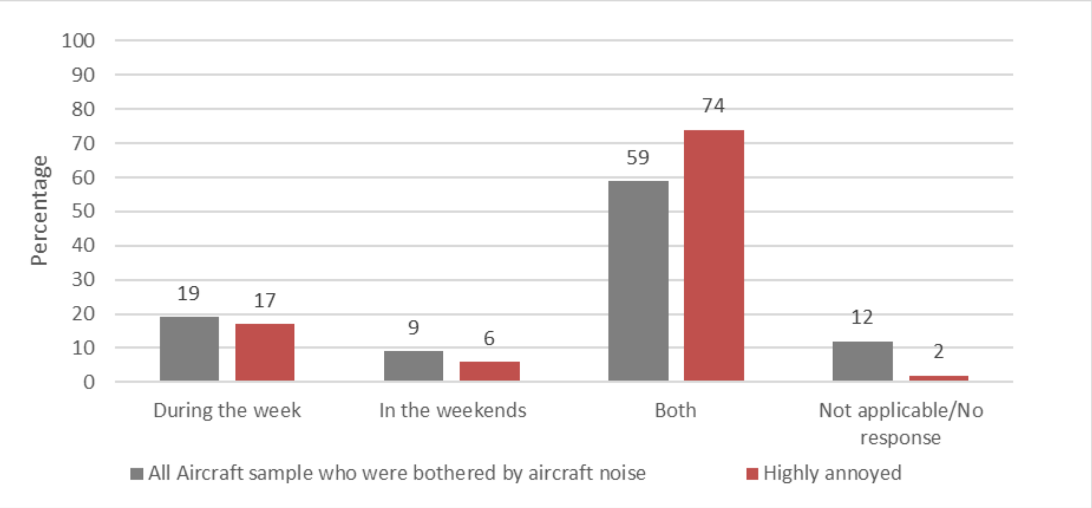
	Annoyed by aircraft noise n=492 %	Highly annoyed n=140 %
When they fly directly over your house	53	71
Flights late at night (after 10pm)	37	53
Particular types of planes or aircraft	36	41
How low they fly over your house	34	51
Early morning flights (before 6am)	29	54
The number of flights	24	48
During take off	12	7
When on the ground (taxiing, engines running)	4	6
Something else	4	9
Don’t know	7	1

6.5.4 Times/days that aircraft noise is most annoying

Q24. And when is the aircraft noise most annoying for you? Is it during the week, in the weekends or both?

Most of the aircraft sample who were annoyed by aircraft noise (59%) reported that aircraft noise was annoying during both weekdays and weekends. This was particularly the case for those who reported being highly annoyed by aircraft noise (74% of whom found the noise annoying every day), 19% found the noise to be most annoying during weekdays while 9% found it most annoying in the weekends (Figure 6.22).

Figure 6.22 Days of week aircraft noise is most annoying (at least somewhat annoyed versus highly annoyed)



Q25–26. Are there any particular times during the week (Monday-Friday) that the aircraft noise is particularly annoying? … during the weekend?

Respondents who reported being bothered by aircraft noise during the week were then asked if there were any particular times that the noise was especially annoying (Table 6.30). While 22% said the aircraft noise was annoying all the time, evenings and early mornings were generally the most annoying times (between 7pm and 7am). A similar pattern was found with regard to noise at weekends, although 46% of those who were highly annoyed by aircraft noise at weekends said it is annoying all of the time (Table 6.31).

Table 6.30 Times during the week where aircraft noise is particularly annoying

	Annoyed by aircraft noise during weekdays n=375 %	Highly annoyed during weekdays n=131 %
Between 3am and 7am	26	29
Between 7am and 11am	11	16
Between 11am and 3pm	11	16
Between 3pm and 7pm	15	20
Between 7pm and 11pm	24	28
Between 11pm and 3am	24	25
Annoying all the time	22	37
Don't know	14	5
Not applicable	0	0

Table 6.31 Times during weekends where aircraft noise is particularly annoying

	Annoyed by aircraft noise during weekends n=343 %	Highly annoyed during weekends n=118 %
Between 3am and 7am	23	22
Between 7am and 11am	16	17
Between 11am and 3pm	10	11
Between 3pm and 7pm	15	17
Between 7pm and 11pm	22	25
Between 11pm and 3am	23	23
Annoying all the time	25	46
Don't know	18	7
Not applicable	1	0

6.5.5 Impact of aircraft noise on respondents' everyday lives and their health and wellbeing

Q27. In the last 12 months, has aircraft noise affected your … ?

All aircraft sample respondents were asked to rate the extent to which aircraft noise had affected their ability to do everyday activities at home using an 11-point scale where 0 = not at all and 10 = extremely. Figure 6.23 presents the results to this line of questioning by all aircraft sample respondents in comparison to those who were highly annoyed by aircraft noise. Results are based on those who rated the impact on each activity as 8–10. Just under one-half of those who were highly annoyed with aircraft noise reported that the noise had affected their ability to relax outdoors (47%) and listen to music or TV (46%). 42% of those highly annoyed reported that aircraft noise had affected their ability to get to sleep, while one-third said it affected how much sleep they get (33%) as well as their ability to read, work or study from home (33%). A more detailed breakdown of how (and to what extent) aircraft noise has impacted the day-to-day activities of those who live near airports is presented in Table 6.32.

Figure 6.23 Ways in which aircraft noise has affected aircraft sample respondents' day-to-day activities (all aircraft sample versus highly annoyed)

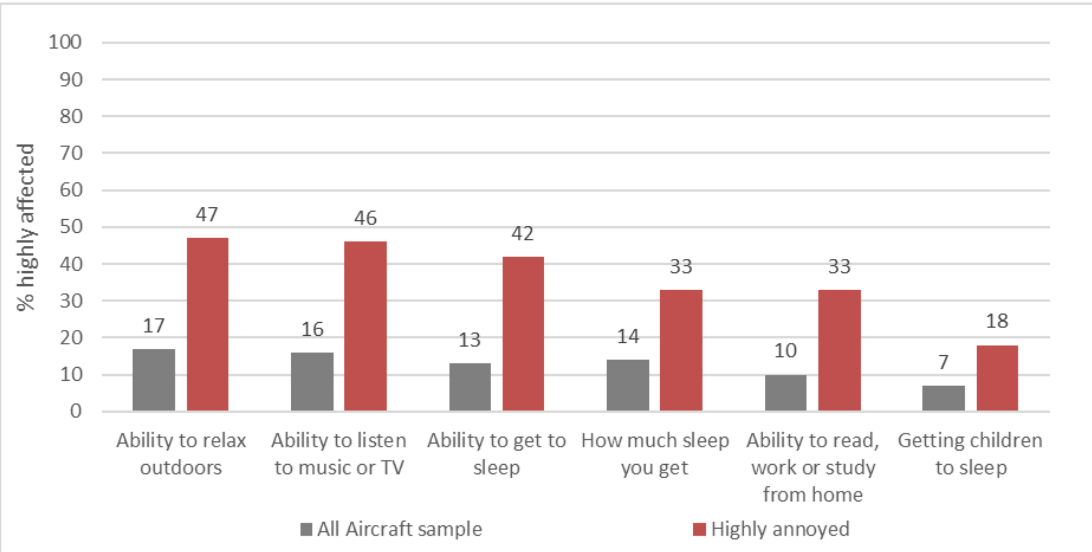


Table 6.32 Ways in which aircraft noise has affected respondents' day-to-day activities (n=629)

	Ability to get to sleep %	How much sleep you get %	Ability to listen to music/TV %	Ease of getting children to sleep %	Ability to relax outdoors %	Ability to read, work or study from home %
0 – not at all	38	35	32	29	33	39
1	6	5	4	2	4	4
2	5	7	10	3	6	4
3	8	5	5	4	9	8
4	4	6	4	2	4	6
5	6	7	7	6	7	5
6	6	4	4	2	3	3
7	4	6	6	3	5	6
8	5	6	4	3	4	2
9	1	1	1	1	5	3
10 – extremely	8	7	11	3	8	5
Highly affected (8–10)	**14**	**14**	**16**	**7**	**17**	**10**
No response/DK/NA	10	11	11	43	13	13

Q28. And using the same scale, how much has the noise from aircraft specifically affected your health and general wellbeing? For example, has it affected …

Figure 6.24 presents the results to this line of questioning by the total aircraft sample in comparison to those who were highly annoyed by aircraft noise. Results are based on those who rated the impact on each factor as 8–10. 44% of the highly annoyed reported that the noise had affected how easily they get irritated. Approximately one-third said it affected how stressful or anxious they feel (35%), their energy levels (32%) and their health and wellbeing in general (35%). More than one-quarter (27%) of the highly annoyed said the noise had affected their personal relationships with others at home. On a total sample basis, approximately one in 10 of the aircraft sample reported that their health and wellbeing had been affected in some way by aircraft noise. A more detailed breakdown of how (and to what extent) aircraft noise had impacted the health and wellbeing of the aircraft sample is presented in Table 6.33.

Figure 6.24 Ways in which aircraft noise has affected respondents' health and wellbeing (all aircraft sample versus highly annoyed)

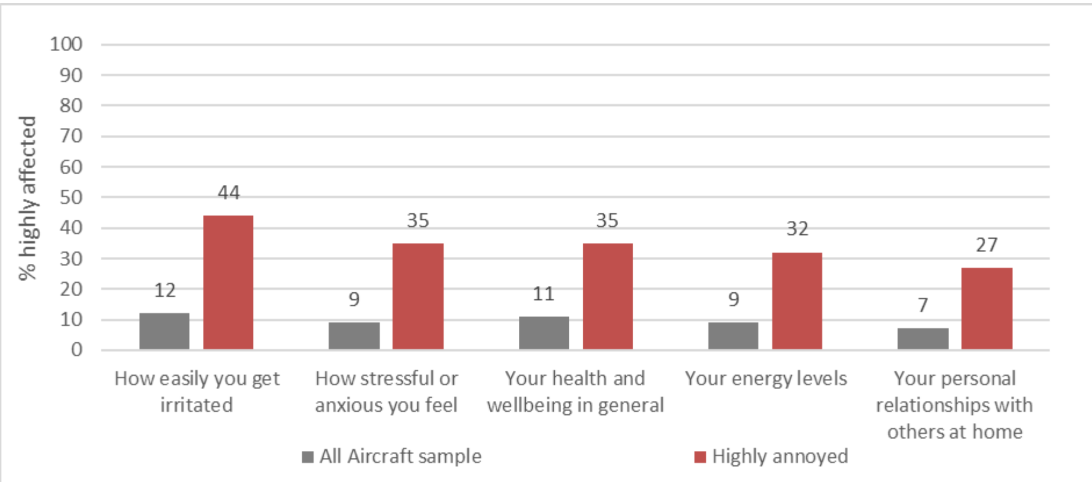


Table 6.33 Ways in which aircraft noise has affected respondents' health and wellbeing (n=629)

	How easily you get irritated %	How stressful or anxious you feel %	Your energy levels %	Your personal relationship with others at home %	Your health and wellbeing in general %
0 – not at all	41	47	49	54	48
1	9	8	7	7	7
2	4	5	4	4	3
3	6	3	5	2	5
4	4	4	3	2	3
5	4	4	4	4	4
6	4	5	5	3	2
7	4	4	2	2	5
8	5	3	5	3	4
9	1	2	0	1	3
10 – extremely	6	4	4	3	4
Highly affected (8–10)	**12**	**9**	**9**	**7**	**11**
No response/DK/NA	11	12	12	16	12

6.5.6 Interventions planned or taken to minimise annoyance of aircraft noise

Q29. Which, if any, of the following have you done, are doing now or planning to do because of aircraft noise?

Figure 6.25 shows 23% of all respondents reported that they currently keep their windows and doors closed when they are at home because of aircraft noise, another 13% have done so in the past and 5% plan to do so. As illustrated in Table 6.34, which includes additional interventions, those highly annoyed were significantly more likely to report this (73%). Other actions identified by respondents who were highly annoyed by aircraft noise were to spend less time outside and more time indoors (43% are/have done or plan to do this because of aircraft noise), spend less time at home (32%), make modifications to their home (23%) or take medication such as sleeping pills because of the noise (21%).

Figure 6.25 Interventions planned or taken to minimise annoyance relating to aircraft noise (all aircraft sample versus highly annoyed)

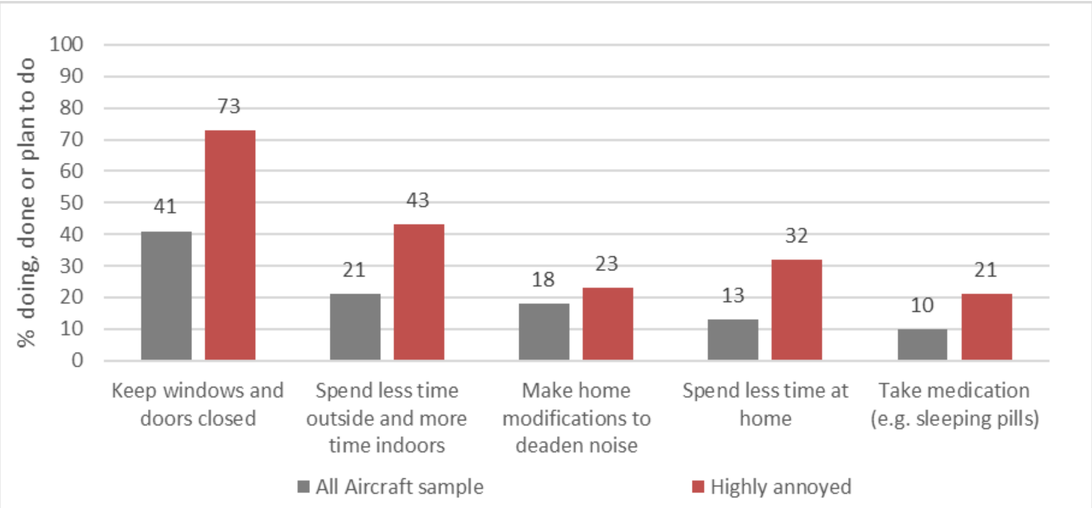


Table 6.34 Interventions planned or taken to minimise annoyance relating to aircraft noise (n=629)

	Keep windows and doors closed %	Spend less time outside and more indoors %	Make home modifications to deaden noise %	Spend less time at home %	Take medication (e.g. sleeping pills) %	Complain to the local council or airport %	Move from the area %	Move the location of your bedroom %	Changed the time you go to sleep %
Doing, done or plan to do	41	21	18	13	10	10	10	6	6
Currently do this	23	9	2	6	3	1	0	0	1
Have done this	13	8	8	4	5	3	1	4	4
Planning to do this	5	4	8	3	2	6	9	2	1
Haven't done it nor plan to	53	71	70	78	80	79	79	82	83
No response/DK/NA	6	9	13	9	10	12	11	11	11

6.5.7 Perceptions that local council and other key stakeholders are doing their best to help minimise the impact of aircraft noise

Q30. On a scale of 0–10 where 0 = strongly disagree and 10 = strongly agree, how much do you agree or disagree that your local council/airport company/airline or aircraft operators are doing their best to reduce the noise from aircraft affecting your neighbourhood?

All aircraft sample respondents were asked to rate their level of agreement that certain organisations are doing their best to reduce the noise from aircraft in their neighbourhood. While 10% of all aircraft sample respondents strongly agreed (rating of 10) that the local council, airline/aircraft operators and airport companies were doing their best to reduce aircraft noise in their neighbourhood, around 25% strongly disagreed that this was the case (rating of 0) (A more detailed breakdown is presented in Table 6.35.

Figure 6.26). Almost one-half of those who were highly annoyed with aircraft noise strongly disagreed that the organisations are doing their best to reduce the noise from aircraft that affects their neighbourhood – 49% strongly disagreed that airline/aircraft operators are doing their best, 47% strongly disagreed that local council is doing its best and 45% strongly disagreed that the airport company is doing its best. A more detailed breakdown is presented in Table 6.35.

Figure 6.26 Percentage of respondents who strongly disagreed particular organisations are doing their best to reduce aircraft noise affecting their neighbourhood (all aircraft sample versus highly annoyed)

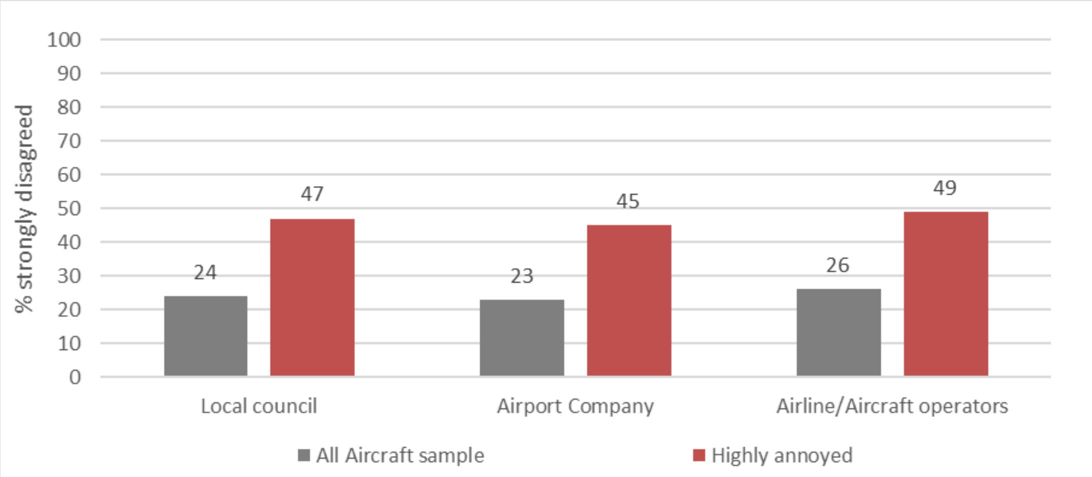


Table 6.35 Agreement/disagreement that particular organisations are doing their best to reduce the noise from aircraft affecting their neighbourhood (n=629)

	Local council %	Airport company %	Airline/aircraft operators %
0 – strongly disagree	24	23	26
1	3	5	4
2	5	5	5
3	3	4	3
4	2	1	1
5	10	10	9
6	2	3	2
7	2	2	1
8	3	1	3
9	1	2	2
10 – strongly agree	11	10	10
Agree (8–10)	**15**	**13**	**15**
No response/DK/NA	35	34	36

6.5.8 General views and perceptions about aircraft

Q31. And using the same 0–10 scale, how much do you agree or disagree with each of the following statements about aircraft in general?

Figure 6.27 presents the results by all aircraft sample respondents in comparison to those who were highly annoyed by aircraft noise. Results are based on those who rated their agreement as 8–10. On this basis, the majority of respondents agreed that aircraft are an important form of passenger transport (82% of all respondents in the aircraft sample and 77% of those who are highly annoyed with aircraft noise), aircraft are an important form of freight transport (80% and 74%, respectively) and aircraft are important for the local and national economy (80% and 82%, respectively). A more detailed breakdown is presented in Table 6.36.

Figure 6.27 Agreement with general statements about aircraft (all aircraft sample versus highly annoyed)

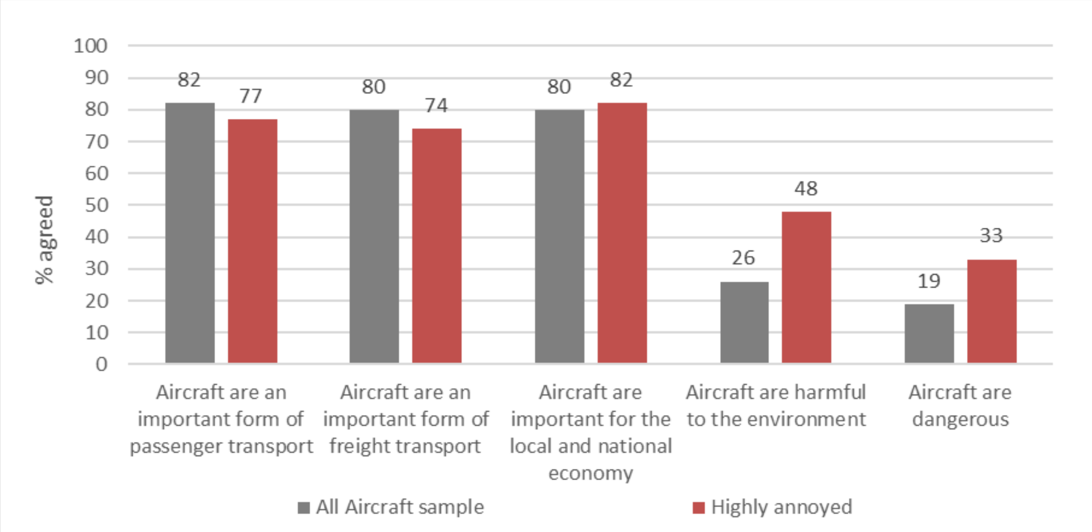


Table 6.36 Agreement with general statements about aircraft (n=629)

	Aircraft are an important form of passenger transport %	Aircraft are an important form of freight transport %	Aircraft are important for the local and national economy %	Aircraft are harmful to the environment %	Aircraft are dangerous %
0 – strongly disagree	1	1	2	10	23
1	0	0	1	2	11
2	1	1	1	5	10
3	0	1	1	4	7
4	1	1	0	2	3
5	5	4	5	23	13
6	2	2	1	6	1
7	5	6	5	10	3
8	14	15	17	6	4
9	7	7	8	5	1
10 – strongly agree	61	58	55	15	14
Agree (8–10)	**82**	**80**	**80**	**26**	**19**
No response/DK/NA	3	4	5	11	9

7 Response to noise

7.1 Exposure response functions

An objective of the research was to quantify New Zealand community response to short-term increases in transportation noise exposure. At the scoping stage of the research, it was recognised that only road-traffic noise could be assessed for the short-term component of this study as there were no new railways or changes to aviation (new or altered runways and/or airports).

This research study commenced in April 2021 during the COVID-19 pandemic. Due to limitations in the integrity of conducting a socio-acoustic survey during a pandemic, the survey element of this study was delayed until COVID-19 restrictions in New Zealand had lifted and society and transport movements had started to return to pre-pandemic levels of activity. The period while people habituate or adjust to the opening of a new or altered road is typically 12–18 months. Traffic movement numbers during 2021 and early 2022 remained reduced due to ongoing restrictions from the COVID-19 response. Therefore, there was a delay of more than 18 months between selecting study areas and conducting the surveys. It was agreed with NZTA and the steering group that short-term increases in transportation noise exposure would be omitted from the analysis. ERFs were only generated for long-term noise exposure from the three transportation modes.

7.1.1 Uncertainty

Uncertainty is present both in the estimation of the noise exposure levels at individual properties and the derivation of the percentage highly annoyed (%HA).

Noise exposure levels at properties were calculated using established methods. As with any modelling exercise, the accuracy of the outputs is also dependent on the input data and assumptions. For example, road-traffic noise modelling in New Zealand may have an uncertainty of 5–8 dB depending on the surface conditions and distance from the road (Jackett, 2023), and the Federal Aviation Administration’s Integrated Noise Model for aircraft noise has an accepted uncertainty of ±2 dB, before accounting for flight track accuracy, flight profiles and so on. This research has assumed that each transportation mode has been modelled using best practice and in accordance with the relevant procedures. Best practice would include the use of relevant input data – for example, numbers and types of road-traffic vehicles, passenger and freight trains and aircraft. However the intended purpose of the models may affect the overall level of uncertainty – for example, a strategic noise model will generally be based on more high-level assumptions than a more geographically constrained model. Any uncertainty associated with these inputs is within the uncertainty range of the methodologies – from ±2 dB to ±8 dB.

There is also uncertainty associated with the data used to develop the noise exposure levels and whether it is representative of the conditions when the social surveys were conducted in late 2022. As road-traffic and railway noise exposure levels were based on 2021 input data and aircraft noise exposure levels were based on 2019 data, there will be an uncertainty associated with the derived ERFs. In the case of road-traffic and railway noise exposure data, this uncertainty is unknown as comparing traffic flow data between 2021 and 2022 across all roads and railways would be arduous and impractical, noting that increasing road-traffic flows by 25% would only increase the noise exposure level by 1 dB. However, the airport noise exposure data was derived from pre-COVID-19 conditions, and in the case of Auckland Airport, the reduced number of aircraft movements likely results in a 1–2 dB change in the noise exposure level. The exact change can only be determined by remodelling the contours as international flights (which generate more noise than domestic flights) are still recovering post pandemic. Applying a movement adjustment factor would not be appropriate. Therefore, an additional 1 dB uncertainty has been applied to the aircraft noise exposure dataset.

While section 5.4 discusses margins of error associated with the sample sizes, there is also uncertainty associated with expanding the survey results to the wider New Zealand population. The extent to which the study represents the entire population has been discussed in section 4.3. The entire population is not as relevant to this study as the exposed population (those exposed to transportation noise).

A total of 13,854 potential respondents were invited to take part in the study, and by the closing date, the participation rate was 16%. This raises a number of questions such as the representativeness of the 2,122 responses within the invited pool of potential respondents and their representativeness against the wider population. For this type of study design, there is no information as to why 11,732 potential participants did not take part in the study. As there is no means to question these people, it can only be assumed that they have the same opinions (on average) as those who completed the questionnaires and that the respondents also have the same opinions (on average) as the exposed population. The converse would be that the 2,122 respondents are interested in transportation noise and are motivated to respond to these types of studies, therefore biasing their responses (noting that a wide range of annoyance responses were received). As there is no way of knowing their opinions, it has to be assumed that the sample is reflective of the exposed population subject to levels of uncertainty identified in Table 5.2. These levels of uncertainty also apply to the derived %HA for each mode of transport.

ERFs have therefore been prepared for comparison with other study findings with and without the above uncertainties.

7.1.2 Derived ERF curves

For each transportation mode, an ERF has been developed using the relevant noise exposure data and annoyance response of those respondents reporting an annoyance rating of 8 or more (highly annoyed). The %HA against noise exposure level for each sample has been generated. For comparison with the WHO guidelines (WHO, 2018), the L_{den} metric has been used.

The determined ERFs are shown in Figures 7.1 to 7.3. The bounds of these curves relate to the range of noise exposure levels. Second-order polynomial regression lines were used to derive the ERFs as these regressions result in the best fit across each transport mode. The equations for these relationships are shown in Table 7.1 together with the R-squared value for the bounds of the data.

Figure 7.1 Road-traffic ERF curve

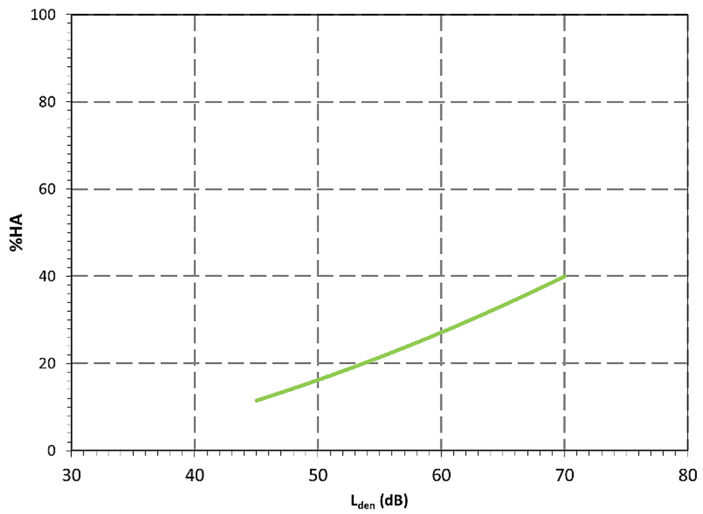


Figure 7.2 Railway ERF curve

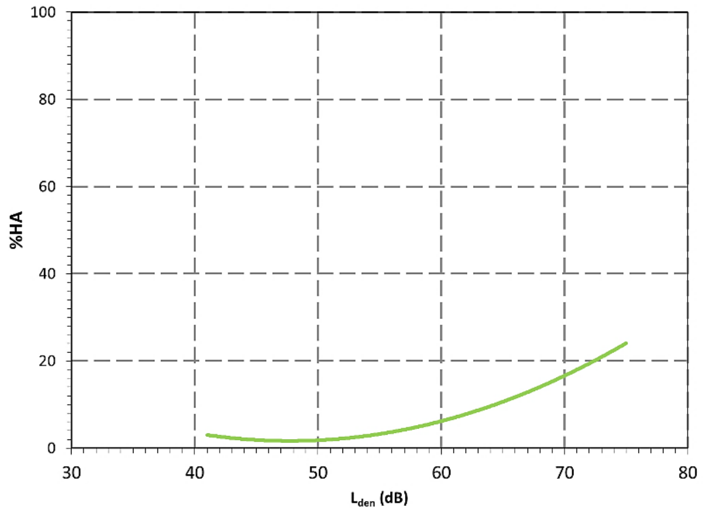


Figure 7.3 Aircraft ERF curve

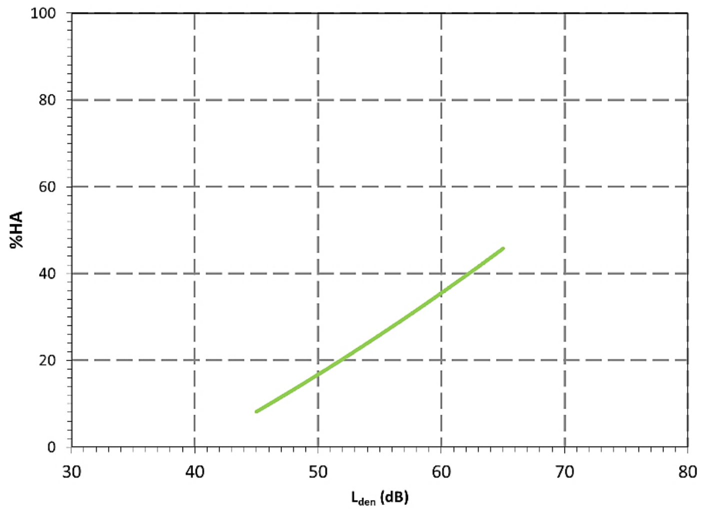


Table 7.1 ERF relationships

Transport mode	ERF relationship	R-squared
Road traffic	$\%HA = 0.0098\ L_{den}^2 + 0.016\ L_{den} - 9.0107$	0.7584
Railway	$\%HA = 0.0302\ L_{den}^2 - 2.8805\ L_{den} + 70.387$	0.9580
Aircraft	$\%HA = 0.0113\ L_{den}^2 + 0.6398\ L_{den} - 43.38$	0.9969

Appendix D includes the data points used to determine the three ERFs. The %HA data points are shown for each 5 dB L_{den} sound class grouping.

The associations between exposure to transportation noise (L_{den}) and annoyance (%HA) are shown in Table 7.2. The L_{den} range is based on the exposure range of 40–80 dB, extending outside the exposure data of each dataset (see section 7.1.3 for an explanation).

Table 7.2 Exposure level and annoyance by each mode

L_{den} dB	%HA		
	Road traffic	Railway	Aircraft
40	7.3	3.5	0.3
45	11.6	1.9	8.3
50	16.3	1.9	16.9
55	21.5	3.3	26.0
60	27.2	6.3	35.7
65	33.4	10.7	45.9
70	40.1	16.7	56.8
75	47.3	24.2	68.2
80	55.0	33.2	80.1

7.1.3 Projected ERF curves

Uncertainty bands have been used to reflect the uncertainty in modelled noise exposure levels and the uncertainty in %HA based on the sample population. Maximum margins of error at the 95% confidence interval were calculated for each sample group (see Table 5.2). This means that, if the surveys were repeated with many different sample groups, the responses in 95% of samples would be within the margin of error. These uncertainties have been used to define the %HA margin of error for each derived ERF curve.

As populations exposed to different noise exposure levels may have significantly different opinions of the noise source in question, an alternative approach would have been to calculate the maximum margin of error in each noise exposure band based on the total population exposed to that level of noise from the given transport source.

In practice, information on the number of people exposed to each level of noise was not readily available, and variations in sampling numbers may unduly influence a polynomial regression line (as would modelling uncertainties when deriving reliable noise levels in the lower noise exposure bands).

Shaded areas have been added to the derived ERFs (Figures 7.4 to 7.6) to highlight the 95% confidence interval margin of error. The response relationships are polynomial regression lines based on data points at each noise exposure level where sensible data existed. Each data point was adjusted to a best-case and worst-case dose-response based on the maximum uncertainty in noise exposure level and reported annoyance. Polynomial trend lines were calculated in the same manner as the response relationship but projected (extrapolated) outside each sample's noise exposure range. A lower limit of 40 dB L_{den} and an upper limit of 80 dB L_{den} was used for each sample group to be consistent with the WHO 2018 presentation of L_{den} and %HA, noting that the WHO only presents aircraft L_{den} data to 70 dB.

Figure 7.4 Road-traffic projected ERF curve

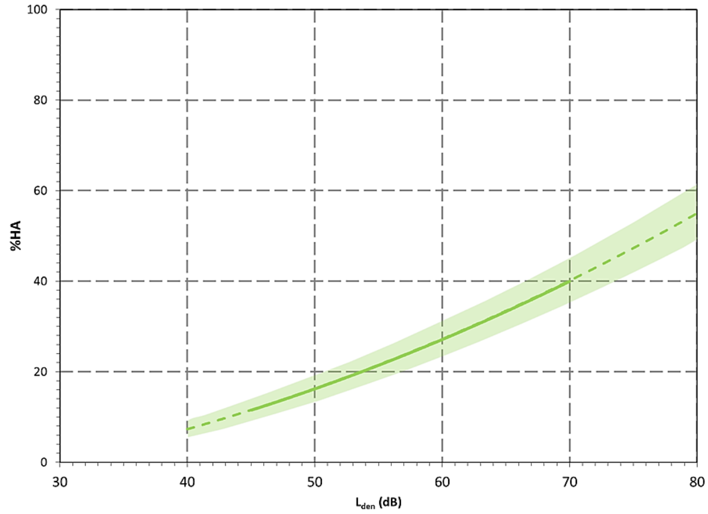


Figure 7.5 Railway projected ERF curve

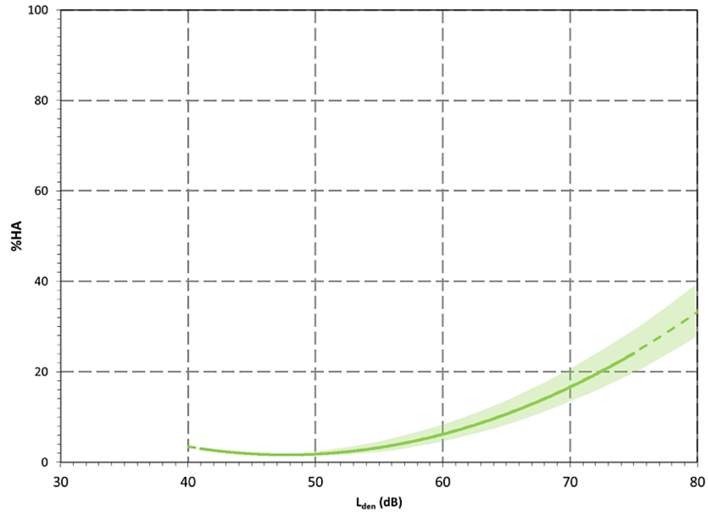
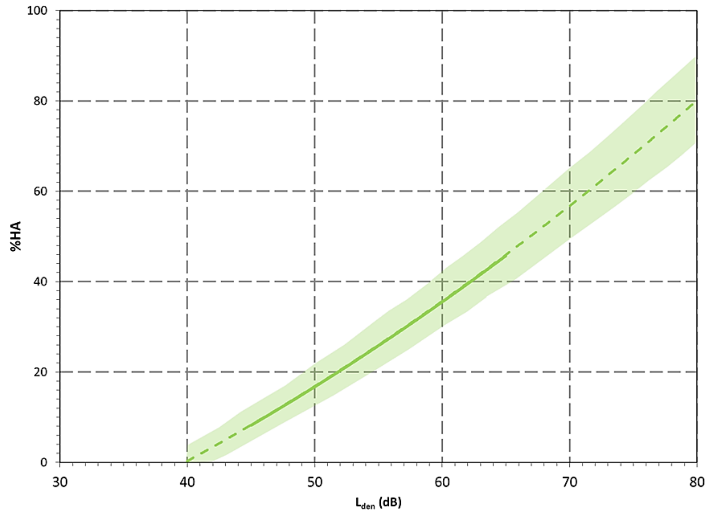


Figure 7.6 Aircraft projected ERF curve



7.2 Comparison with other studies

The derived ERFs (labelled 2022 Survey) have been compared to the WHO 2018 guidelines (Guski et al., 2017) and the last New Zealand response curves presented by Humpheson and Wareing (2019) (labelled RR656). Prior to 2018, the standardised ERFs were determined by a meta-analysis of socio-acoustic studies by Miedema and Oudshoorn (2001). Figures 7.7 to 7.9 show the ERF curves for each study.

Figure 7.7 Road-traffic ERF comparison

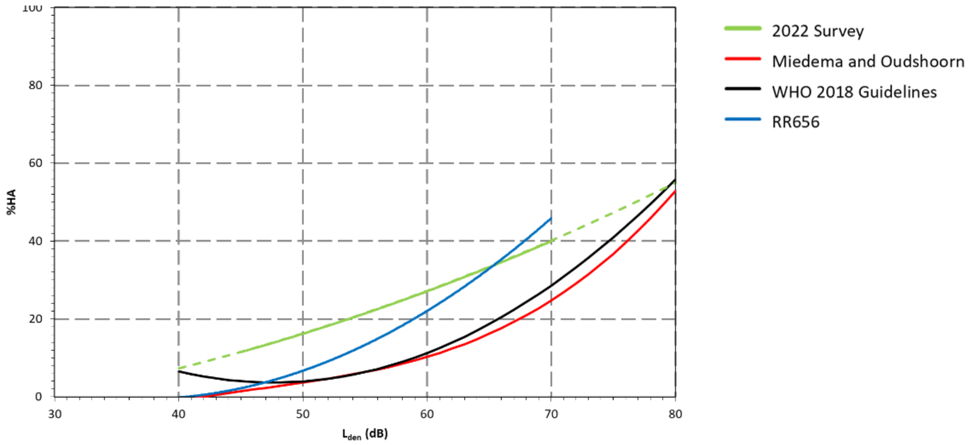


Figure 7.8 Railway ERF comparison

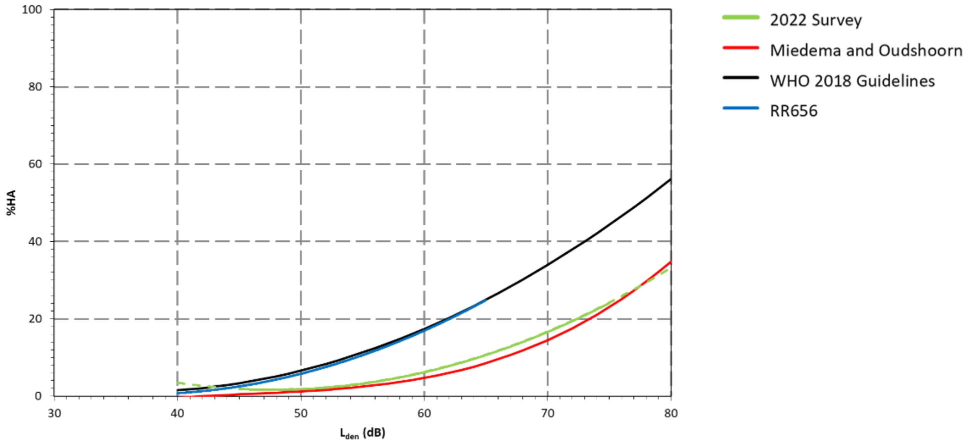
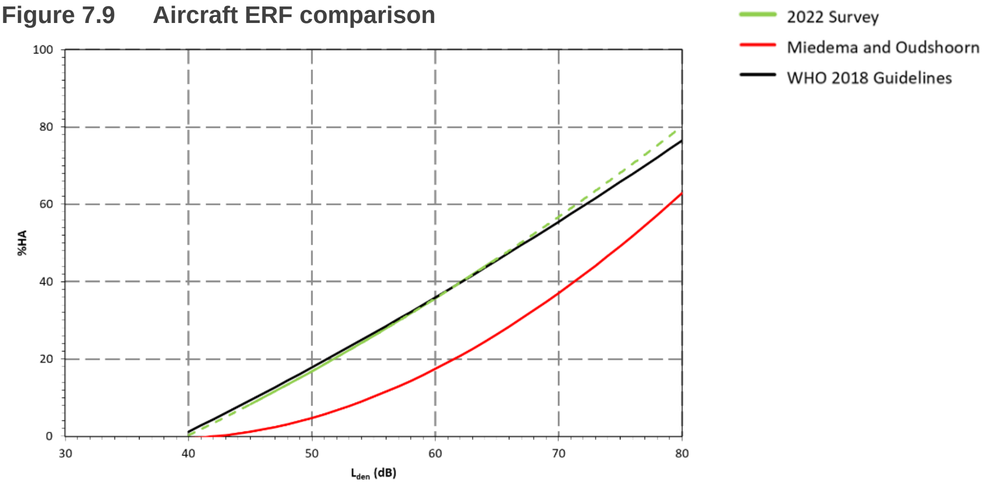


Figure 7.9 Aircraft ERF comparison



The levels at which 10%HA and 50%HA occur are useful metrics (see Table 7.3). 10%HA is referenced in the WHO 2018 guidelines based on the level at which the authors were confident there is an increased risk of adverse health effects, and 50%HA is the basis for defining the CTL. While the 50%HA point on a polynomial regression line is not equivalent to the CTL, it is the best point of correspondence and can be used as a proxy for comparison.

Table 7.3 10%HA and 50%HA values

Transportation mode	10%HA	50%HA
Road traffic	43 dB	77 dB
Railway	64 dB	88 dB
Aircraft	46 dB	67 dB

When compared to the other studies, the key observations are that:

- the road-traffic noise sample showed a greater annoyance sensitivity than the WHO 2018 guidelines (black ERF curves) and the Miedema and Oudshoorn (red ERF curves) analysis
- the railway ERF relationship closely matches the Miedema and Oudshoorn analysis although it was lacking in the number of highly annoyed subjects
- the aircraft ERF relationship is nearly identical to the WHO 2018 guidelines.

The WHO 2018 guidelines demonstrated a higher exposure response than Miedema and Oudshoorn, which implies a general increase in sensitivity to transportation noise over the last 20 years. While this study showed a greater exposure response than that found by Humpheson and Wareing (2019), it was also significantly greater in scope than that study, covering both a larger geographic area and greater number of respondents. Given the known influences of factors unrelated to noise exposure level, it would not be possible to identify if any differences were a factor of a change in noise sensitivity of the New Zealand population or opinions local to the area surveyed by Humpheson and Wareing.

The road-traffic sample results indicate that people are much more sensitive to road-traffic noise in New Zealand than in Europe (WHO, 2018; Miedema & Oudshoorn, 2001). It is hypothesised that this may be due to individual events as respondents were asked ‘What is it about the road noise that bothers you?’ – 59% of the highly annoyed road-traffic sample were bothered by vehicles driving past their home after 10pm and approximately one-half were annoyed by noisy cars, trucks and/or motorbikes. Other factors may also contribute such as differences in noise character arising from factors such as road surface type and age of vehicles in New Zealand.

The shape of the ERF regression lines also influences the outcome, displaying a much greater difference in annoyance in the central noise exposure bands of 50–60 dB L_{den} than in the lower and upper bands. This is likely an artifact of fitting a polynomial relationship to variable data.

All sample groups had greater numbers of subjects in lower noise exposure ranges. This is to be expected as land-use planning controls are well established in New Zealand to restrict noise-sensitive development at high noise levels (greater than 60–65 dB L_{den}). Unlike other studies, the relationships at some higher noise levels could not be derived (extrapolation of the relationships outside the range of noise exposure data was undertaken). A particular limitation was in the railway noise sample. Relatively few people registered high levels of annoyance from railway noise in the higher noise exposure ranges. The combination of a small sample exposed to high levels of railway noise and a low exposure response meant the total number of people highly annoyed was very small thereby reducing the statistical robustness of the ERFs at high noise exposure levels.

Unlike the findings of Humpheson and Wareing (2019), this study investigated response to transport noise at different times of the day and differences between weekdays and weekends. A common theme across all three modes was that transport noise was more annoying at night. The railway sample had a higher proportion of respondents being annoyed between 11pm and 7am than the other two modes. Between two-thirds and three-quarters of highly annoyed respondents considered that the noise was annoying regardless of the day of the week, and the remaining respondents considered that the noise was more annoying on weekdays than at weekends. ERFs have not been prepared to determine the time-of-day effects of annoyance and noise exposure level as the number of respondents reporting annoyance in the different time periods is relatively small – for example, the time of day analysis for the railway sample would be based on approximately 20 responses.

8 Conclusions

A second socio-acoustic study has been conducted to further explore the New Zealand response to transportation noise. Unlike the previous research, aircraft noise was included as a mode of transport and survey areas were extended to include roads and railways outside Auckland. Aircraft study areas were defined around Auckland, Rotorua and Queenstown Airports.

The objectives of the study were to define and quantify the responses to short-term and long-term transportation noise exposure from road traffic, railways and aircraft. It was identified that there were no new or altered rail or airport projects to qualify as short-term study areas. Therefore, only road-traffic noise was selected for short-term study areas.

The timing of the research study coincided with COVID-19 restrictions within New Zealand and the subsequent reduction in transportation activity. Socio-acoustic surveys were delayed until movement levels for all three modes had returned more or less to pre-COVID levels. Due to the intervening period between selecting short-term road-traffic study areas and conducting the surveys (greater than 18 months), it was considered unreliable to assess short-term response to road-traffic noise. Therefore, ultimately only long-term response to transportation noise for each mode of transport was assessed.

A study objective of surveying at least 500 people for each mode of transport was met. A total sample of 2,212 respondents completed the survey. This was mostly on paper although some completed the survey online and by telephone. A sub-sample of n=808 respondents completed the road-traffic survey, n=775 for the railway element and n=629 aircraft respondents.

Overall, a participation rate of 16% was achieved (13,854 survey invitations were sent out). In the absence of the reasons why 84% of people did not participate before the cut-off date, the study has had to assume that the exposed population in the surveyed areas have the same opinions (on average) as the sample group. On the basis of that assumption, extrapolation of the results to the wider relevant New Zealand population (all those exposed to transportation noise) and comparison with comparable studies in other countries is justifiable.

The survey questionnaire used the ISO/TS 15666:2021 11-point annoyance question and sought responses on time-of-day annoyance, health and general wellbeing, interventions used to reduce annoyance and respondents' views of the noise source and those responsible for the relevant transportation infrastructure.

Exposure response relationships were derived for each transportation mode. When compared to the WHO 2018 guidelines, this study shows that the sampled New Zealand population is more sensitive to road-traffic noise, is less sensitive to railway noise and has similar sensitivities to aircraft noise. The findings for road-traffic and railway noise are comparable to the findings of the previous New Zealand community noise study.

Socio-acoustic studies have consistently shown that a person's sensitivity to environmental noise varies considerably, that exposure response functions differ depending on the source and that attitudes are also related to non-acoustic factors. Differences could be due to changes in attitudes towards the source of noise, changes in noise exposure, differences in the cultures of those being surveyed, differences in study design, implementation or measurement or a combination of these factors. The WHO 2018 guidelines identify that, of the three sources of transportation noise, aircraft noise invokes the highest exposure response followed by road-traffic noise then railway noise. The studies used to inform the WHO 2018 guidelines also show that there are geographic variations in ERFs for the same source of noise, which include country/cultural differences.

8.1 Future work

The study design relied on respondents completing questionnaires via telephone or online or by sending back a paper copy. A 16% participation rate was achieved from those individuals invited to participate and is typical for this type of study. To increase the participation rate would require a change to the survey design. A possible option would be to conduct face-to-face interviews rather than using self-completion questionnaires. The resources required to administer face-to-face interviews on the same scale as this study (minimum of n=400 per mode) would be impractical. However, on a small scale, face-to-face interviews can be more flexible to tease out key issues such as responses to short-term noise and possible adaptation after changes in noise exposure. These researcher-led interviews do require the interviewer to maintain consistency and independence – otherwise the respondent may be 'led', resulting in a biased response. A combination of research techniques may be appropriate for future studies such as large-scale self-reported questionnaires supplemented with face-to-face interviews.

Short-term response to noise requires suitable study areas with sufficient population. As new road projects will generally be in rural areas with low numbers of people, a survey would have to include multiple projects to obtain sufficient responses or to survey everyone subject to the noise change (assuming that there are at least n=400 respondents). It is unlikely that there will be any new rail or airport projects that would result in a significant change in noise within the next 5 years.

It is recommended that any future study that investigates short-term response to noise should be planned to coincide with the opening of a major project and that the sampling methodology should be designed to maximise the response rate.

Although the study investigated annoyance by time of day and the difference between weekdays and weekends, only aircraft noise exposure levels were derived from a time-of-day weighted level (L_{dn}). Road-traffic and railway noise exposure levels were based on the $L_{Aeq(24h)}$ with a standardised numerical adjustment to derive the L_{den}. Road-traffic flows are based on the average daily traffic flow and not a breakdown of traffic flows in specific time periods or individual hours. This 24-hour average daily traffic flow does not provide sufficient detail for a time-of-day exposure response analysis. A similar approach was adopted for the railway modelling. The survey responses suggest that night-time noise should be weighted to account for the increased sensitivity of respondents to noise between 11pm and 7am. Ideally, a comparison between noise exposure levels calculated using $L_{Aeq(24h)}$ and a time-of-day noise exposure metric such as L_{dn} or L_{den} should be conducted. However, this comparison relies on traffic movement data being available at a sufficient resolution to determine the noise contribution in different time periods.

The study was designed to investigate the exposure response to individual modes of transport. Accordingly, the sample areas were selected to minimise the contribution of multiple sources by establishing buffers between roads and railways and selecting aircraft-affected areas away from other modes with a high noise environment. Despite the participants being exposed to one dominant form of transportation noise, many respondents reported being annoyed by more than one mode of transport. The study did not investigate the exposure response to multiple modes. Future work could consider the cumulative noise exposure from more than one mode and the overall annoyance rating.

Community response surveys are known to have a large range of responses based on a combination of so-called non-acoustic attributes not related to the average level of noise experienced. Although non-acoustic influences were investigated, it is unknown whether individuals were basing their response on their experience of the noise in general or due to specific incidents. For example, the road-traffic sample group highlighted that the noise of individual vehicles was annoying. A future study could investigate whether respondents are basing their opinion on an aggregated noise exposure or from specific events.

As discussed in the road-traffic study selection section, road surface type was considered when selecting areas to ensure the overall sample group included a range of road surfaces. The influence of road surface on exposure response could be investigated in further detail.

The railway dataset could be investigated to determine the proportion of responses to freight traffic versus passenger traffic. However, the number of respondents reporting to be highly annoyed is very low compared to the road-traffic sample, which would severely affect the statistical significance of the results. Therefore, reassessment of the railway sample is not recommended but a future study could be designed to increase the railway sample.

The community tolerance level is being reported more frequently and is included within ISO 1996-1:2016 with appropriate level adjustment factors for comparison to other forms of transportation. It would be beneficial to assess this metric for benchmarking with other studies.

The study investigated various aspects of the respondent's home – for example, whether the bedroom/living room/lounge/outdoor area faces the source of the noise and whether this had been acoustically treated. Analysis of these influencing factors only considered the number of respondents who agreed with the statement. A further analysis could be undertaken by assessing noise level and reported annoyance for each factor to investigate whether reported annoyance is less for those respondents who agreed with the statements.

The study questioned respondents on whether they have or are planning to undertake measures to avoid, remedy or mitigate the effects of transportation noise. Future analysis could determine if there is a link between noise exposure level and reported annoyance for those who intend to do something either now or in the future.

References

Abbott, P. G., & Nelson, P. M. (2002). *Converting the UK traffic noise index $L_{A10,18h}$ to EU noise indices for noise mapping*. Department for Environment, Food and Rural Affairs.

Babisch. W., & van Kamp, I. (2009). Exposure-response relationship of the association between aircraft noise and the risk of hypertension. *Noise Health*, *11*(44), 161–168.

Bowyer, B. T., & Rogowski, J. C. (2017). Mode matters: Evaluating response comparability in a mixed-mode survey. *Political Science Research and Methods*, *5*(2), 295–313.

Brink, M., Schäffer, B., Pieren, R., & Wunderli, J. M. (2018). Conversion between noise exposure indicators L_{eq24h}, L_{Day}, $L_{Evening}$, L_{Night}, L_{dn} and L_{den}: Principles and practical guidance. *International Journal of Hygiene and Environmental Health*, *221*(1), 54–63.

Brink, M., Schreckenberg, D., Vienneau, D., Cajochen, C., Wunderli, J.-M., Probst-Hensch, N., & Röösli, M. (2016). Effects of scale, question location, order of response alternatives, and season on self-reported noise annoyance using ICBEN scales: A field experiment. *International Journal of Environmental Research and Public Health*, *13*(11), 1163.

CAA. (2021). *Survey of noise attitudes 2014: Aircraft noise and annoyance* (2nd ed.). Civil Aviation Authority.

Christensen, A. I., Ekholm, O., Glümer, C., & Juel, K. (2014). Effect of survey mode on response patterns: Comparison of face-to-face and self-administered modes in health surveys. *European Journal of Public Health, 24*(2), 327–332*.*

Corbetta, P. (2003). *Social research: Theory, methods and techniques*. SAGE Publications.

Department of Transport. (1988). *Calculation of road traffic noise*. HMSO.

Department of Transport. (1995). *Calculation of railway noise*. HMSO.

Evans, L., Wright, J., Rowcroft, P., Jakhu, S., Wagner, L., Hong, T., & Klap, D. (2023). *Social cost (health) of land transport noise exposure in New Zealand.* (Research Report 715). NZ Transport Agency, Wellington: New Zealand.

FICON. (1992). *Federal agency review of selected airport noise analysis issues*. Federal Interagency Committee on Noise.

Fidell, S., Barber, D. S., & Schultz, T. J. (1991). Updating a dosage-effect relationship for the prevalence of annoyance due to general transportation noise. *The Journal of the Acoustical Society of America*, *89*(1), 221–233.

Fidell, S., Mestre, V., Gjestland, T., & Tabachnick, B. (2022). An alternate approach to regulatory analyses of the findings of a 20-airport social survey. *The Journal of the Acoustical Society of America, 152*, 3681–3694.

Fields, J. M. (1993). Effect of personal and situational variables on noise annoyance in residential areas. *The Journal of the Acoustical Society of America*, *93*(1), 2753–2763.

Flindell, I., Le Masurier, P., & Le Masurier, H. (2021). Resolving uncertainties in understanding community attitudes to aircraft noise. *Applied Acoustics*, *178*, 108032.

Fryd, J., Michelsen, L. N., Bendtsen, H., Iversen, L. M., & Petersen, T. H. (2016). *Noise annoyance from urban roads and motorways* (Research report 565). Danish Road Directorate.

Gjestland, T. (2018). A systematic review of the basis for WHO's new recommendation for limiting aircraft noise annoyance. *International Journal of Environmental Research and Public Health*, *15*(12), 2717.

Gjestland, T. (2019). Reply to Guski, Schreckenberg, Schuemer, Brink and Stansfeld: Comment on Gjestland, T. A systematic review of the basis for WHO's new recommendation for limiting aircraft noise annoyance. Int. J. Env. Res. Pub. Health 2018, 15, 2717. *International Journal of Environmental Research and Public Health*, *16*(7), 1105.

Groves, R. M., & Couper, M. P. (1998). *Nonresponse in household interview surveys*. Wiley and Sons.

Guski, R. (1999). Personal and social variable as co-determinants of noise annoyance. *Noise and Health*, *1*(3), 45–56.

Guski, R., Schreckenberg, D., & Schuemer, R. (2017). WHO environmental noise guidelines for the European region: A systematic review on environmental noise and annoyance. *International Journal of Environmental Research and Public Health*, *14(*12), 1539.

Guski, R., Schreckenberg, D., Schuemer, R., Brink, M., & Stansfeld, S. (2019). Comment on Gjestland, T. A systematic review of the basis for WHO's new recommendation for limiting aircraft noise annoyance. *International Journal of Environmental Research and Public Health*, *16*(7), 1088.

Hong, J., Lee, S., Lim, C., Kim, J., Kim, K., & Kim, G. (2018). Community annoyance toward transportation noise: Review of a 4-year comprehensive survey in Korea. *Applied Acoustics*, *139*(4), 229–234.

Humpheson, D., & Wareing, R. (2019). *Evidential basis for community response to land transport noise* (Research report 656). NZ Transport Agency. https://www.nzta.govt.nz/assets/resources/research/reports/656/656-Evidential-basis-for-community-response-to-noise.pdf

Jackett, R. (2023). Uncertainty of road-traffic noise prediction in New Zealand. *New Zealand Acoustics*, *36*(2), 40–47. https://www.acoustics.org.nz/sites/www.acoustics.org.nz/files/journal/pdfs/ASNZ_2023_V362_Opt.pdf#page=40

Lechner, C., Schnaiter, D., & Bose-O'Reilly, S. (2019). Combined effects of aircraft, rail, and road traffic noise on total noise annoyance – a cross-sectional study in Innsbruck*. International Journal of Environmental Research and Public Health, 16*(18), 3504*.*

Lefèvre, M., Chaumond, A., Champelovier, P., Allemand, L., Lambert, J., Laumon, B., & Evrard, A-S. (2020). Understanding the relationship between air traffic noise exposure and annoyance in populations living near airports in France. *Environment International*, *144*, 106058.

Marquis-Favre, C., Gille, L.-A., & Breton, L. (2021). Combined road traffic, railway and aircraft noise sources: Total noise annoyance model appraisal from field data*. Applied Acoustics, 180*, 108127.

Miedema, H., & Vos, H. (1998). Exposure-response relationships for transportation noise. *Journal of the Acoustical Society of America, 104*(6), 3432–3445*.*

Miedema, H., & Oudshoorn, C. (2001). Annoyance from transportation noise: Relationships with exposure metrics DNL and DENL and their confidence intervals. *Environmental Health Perspectives*, *109*(4), 409–416.

Miller, N., Czech, J., Hellauer, K., Nicholas, B., Lohr, S., Jodts, E., Broene, P., Morganstein, D., Kali, J., Zhu, X., Cantor, D., Hudnall, J., & Melia, K. (2021). *Analysis of the Neighborhood Environmental Survey.* Federal Aviation Administration.

Morinaga, M., Nguyen, T. L., Shimoyama, K., Yokoshima, S., & Yano, T. (2020). Effects of step change in aircraft noise exposure on activity disturbances: Socio-acoustic surveys around Hanoi Noi Bai International Airport. *Acoustical Science and Technology*, *41*(3), 590–597.

Morinaga, M., Nguyen, T. L., Yokoshima, S., Shimoyama, K., Morihara, T., & Yano, T. (2021). The effect of an alternative definition of "percent highly annoyed" on the exposure–response relationship: Comparison of noise annoyance responses measured by ICBEN 5-point verbal and 11-point numerical scales. *International Journal of Environmental Research and Public Health*, *18*(12), 6258.

National Research Council. (2002). *Studies of welfare populations: Data collection and research issues*. National Academies Press.

Noise Advisory Council. (1978). *A guide to measurement and prediction of the equivalent continuous sound level* L_{eq}. HMSO.

Schultz, T. J. (1978). Synthesis of social surveys on noise annoyance. *The Journal of the Acoustical Society of America*, *64*(2), 377–405.

Stats NZ. (2019). *A guide to good survey design* (5th ed.). https://www.stats.govt.nz/assets/Uploads/Methods/A-guide-to-good-survey-design-fifth-edition/a-guide-to-good-survey-design-fifth-edition.pdf

WHO. (1999). *Guidelines for community noise*. World Health Organization. https://iris.who.int/bitstream/handle/10665/66217/a68672.pdf?sequence=1

WHO. (2018). *Environmental noise guidelines for the European region*. World Health Organization. https://iris.who.int/bitstream/handle/10665/279952/9789289053563-eng.pdf?sequence=1

Appendix A: Pilot report

research
NEW ZEALAND
Rangahau Aotearoa

MEMORANDUM | 15 August 2022

TO	Darran Humpheson and Chris Soutar, Tonkin & Taylor
FROM	Katrina Magill & Sarah Buchanan, Research New Zealand
SUBJECT	Community response to noise (#5216) – cognitive pre-testing

Introduction and purpose

The Community Response to Noise Survey will assess the effects of transport-related noise on people's health and wellbeing. This includes noise from a range of different sources, but with a particular focus on the noise from aircraft, trains and road traffic.

Prior to surveys being launched, it is important to cognitively test them to ensure they are working as well as they should be (i.e. respondents are understanding the questions, the questions aren't difficult to answer, the survey isn't arduous and taking too long).

This memorandum reports the findings from the cognitive testing exercise undertaken with a small sample of the general public who live near to an airport, railway line or main highway.

Between 9 and 18 August 2022, a total of n=7 people, from a range of demographic profiles, completed the cognitive testing process.

Sample and methodology

Sample

Participants were recruited via networking and snowballing off the back of those who had agreed to participate. To qualify for the survey, all respondents had to live in very close proximity to an airport, railway line or main highway.

All participants received a $50 electronic gift card through GiftPay.co.nz.

Of the 7 people who took part in the cognitive testing, n=3 live next to an airport, n=2 live next to a main railway line and n=2 live next to a main highway. Table 1 shows the demographic profile of these respondents.

Table 1: Respondent demographics for cognitive testing

	No. of respondents n=7
Live next to:	
An airport	3
A railway line	2
A highway	2
Age group	
18-24	2
25-34	2
35-44	0
45-54	2
55-64	1
Gender	
Male	2
Female	5
Other	0

Approach

Cognitive testing of the survey was carried out using Belson's double-back methodology, in which participants completed the online survey independently and were then followed-up with a telephone interview to discuss the following:

- How long the survey took to complete
- Any questions or wording they didn't understand
- Any questions they felt they couldn't answer in the way they wanted
- Any technical/wording issues
- Any other feedback

Once they had completed the survey, follow-up interviews were between 9 and 18 August 2022.

Feedback interviews were quite short because, overall, all participants found the survey easy to do and had few if any suggestions for improvement.

Key findings

Overall, respondents found the questionnaire to be straightforward, easy and quick to complete, and relevant to their living situations.

"Survey was user-friendly, very easy."

"Really easy survey to do and covered more than I expected so made me think a lot about my answers."

"[The survey was} quick and easy, well-structured and the questions were well worded."

"I completed it on my cellphone – easy as."

"The question order was good as it asked about my situation and then progressed to how the noise is impacting me."

All respondents felt that they had been given ample opportunity to talk about their situation and how the air/railway/highway noise impacts them.

On average, the survey took 10 minutes to complete, with respondents taking between 10 and 15 minutes to complete the survey (self-reported).

Recommended change

As a result of the feedback received, we suggest only one change is made to the questionnaire, although this relates to both Q11 and Q12. Although there are other time-related questions later on in the questionnaire, this was only an issue in relation to Q11 and Q12.

A few respondents weren't sure if they should select a response option if they weren't home for the full portion of a particular timeframe. Adding the following sentence for clarification is recommended (assuming that our assumption in this regard is correct): 'Even if you are only home for half an hour of a particular timeframe, please select that option.'

Q11. I'm now going to ask you some questions about different sources of noise, which might or might not annoy you when you are at home.

First of all, can you tell me if you are usually at home during the week (Monday to Friday) at the following times? If necessary: Please don't count the odd time you might pop out to the shops or to meet someone for lunch or dinner, etc. **Read Code many**

Even if you are only home for half an hour of a particular timeframe, please select that option.

1 .....between 3am and 7am in the morning
2 .....between 7am and 11am in the morning
3 .....between 11am and 3pm
4 .....between 3pm in the afternoon and 7pm at night
5 .....between 7pm and 11pm
6 .....between 11pm at night and 3am in the morning

97 ...Not usually at home during the week ****Do not read****
98 ...Don't know ****Do not read****
99 ...Refused ****Do not read****

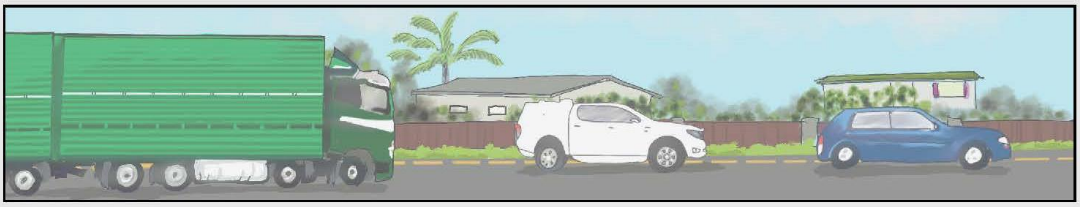
Appendix B: Questionnaires

B.1 Road traffic

WAKA KOTAHI NZ TRANSPORT AGENCY

research NEW ZEALAND Rangahau Aotearoa

SURVEY ABOUT THE EFFECTS OF NOISE IN YOUR NEIGHBOURHOOD



This confidential survey is being conducted on behalf of Tonkin & Taylor for Waka Kotahi NZ Transport Agency.

The survey should take no more than about 10-15 minutes to complete and will help Waka Kotahi to better understand the impacts of noise on people's health and wellbeing, which they can then take into account in their planning for future projects.

Please complete and return this questionnaire in the Freepost envelope provided. Even if you are not bothered by any noise at all where you live, your feedback is still important. Thank you!

The first few questions are about you and your household.

1 Which one of the following age groups are you in?

- ☐ 18-24 years
- ☐ 25-34 years
- ☐ 35-44 years
- ☐ 45-54 years
- ☐ 55-64 years
- ☐ 65-74 years
- ☐ 75 and over
- ☐ Would rather not say

2 What gender do you identify as?
Please tick as many options as apply.

- ○ Male
- ○ Female
- ○ Another gender
  Please specify ________________
- ○ Would prefer not to say

1

3 **Which ethnic groups do you belong to?**
Please tick as many options as apply.

- ◯ NZ European (or Pākehā)
- ◯ Māori
- ◯ Samoan
- ◯ Cook Island Māori
- ◯ Another Pacific nation (Tongan, Niuean, Tokelauan, Fijian)
- ◯ Chinese
- ◯ Indian
- ◯ Another ethnic group such as Dutch, Japanese or South African?

  Please specify ______
- ◯ Don't know
- ◯ Would prefer not to say

4 **Are you currently..?**
Please tick as many options as apply to you.

- ◯ An employer
- ◯ Self employed
- ◯ A salary or wage earner
- ◯ Retired
- ◯ A full time home-maker
- ◯ A student
- ◯ Unemployed
- ◯ A beneficiary
- ◯ Would rather not say

5 **Which of these best describes your personal income from all sources, before tax for the last year? Please include any child support, benefits or other income support you may receive.**
Please tick one answer.

- ☐ Under $40,000
- ☐ At least $40,000 but less than $80,000
- ☐ $80,000 but less than $100,000
- ☐ $100,000 but less than $120,000
- ☐ $120,000 or more
- ☐ Don't know
- ☐ Would rather not say

6 **What is your highest completed qualification?**
Please tick one answer.

- ☐ Secondary school qualification (NCEA, School certificate etc.)
- ☐ Polytechnic/trade certificate or diploma
- ☐ University degree
- ☐ Other *Please specify* ______
- ☐ No qualifications
- ☐ Would rather not say

2

7 **Including yourself, how many people normally live in your household?**
Please tick one answer.

- ☐ One
- ☐ Two
- ☐ Three or more
- ☐ Don't know
- ☐ Would rather not say

8 **And are any of the people that live with you…**
Please tick as many options as apply to you.

- ◯ Under 5 years old
- ◯ 5-12 years old
- ◯ 13-17 years old
- ◯ Don't know
- ◯ No, everyone in the house is 18 years or over
- ◯ Would rather not say

9 **Do you own or rent the house that you live in?**
Please tick one answer.

- ☐ Own (with/without mortgage)
- ☐ Rent
- ☐ Board
- ☐ Other (e.g. live with parents)
- ☐ Don't know
- ☐ Would rather not say

10 **Which of the following apply to this house?**
Please tick as many options as apply to you.

- ◯ Your bedroom faces the road
- ◯ The living room/lounge faces the road
- ◯ It has an outdoor area (lawn, garden, deck, balcony etc) that faces the road
- ◯ Your bedroom windows are double (or triple) glazed
- ◯ The windows in the living room/lounge are double (or triple) glazed
- ◯ There is a heat pump in the house for heating/cooling
- ◯ The house has mechanical ventilation that provides fresh air ducted from outside
- ◯ Your house has been treated for road noise (Council requirement or provided by the road operator)
- ◯ None of the above

3

Sources of annoying noise

The following questions are about different sources of noise, which might or might not annoy you **when you are at home.**

11 **First of all, are you <u>usually</u> at home <u>during the week</u> (Monday – Friday) at the following times? Please don't count the odd time you might pop out to the shops or to meet someone for lunch or dinner, etc.**

Please tick as many options as apply to you. Even if you are only home for half an hour of a particular timeframe, please select that option.

- ◯ Between 3am and 7am in the morning
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Not usually at home during the week
- ◯ Don't know
- ◯ Would rather not say

12 **And are you <u>usually</u> home during the weekend (Saturdays and Sunday)...**

Please tick as many options as apply to you. Even if you are only home for half an hour of a particular timeframe, please select that option.

- ◯ Between 3am and 7am in the morning
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Not usually at home in the weekends
- ◯ Don't know
- ◯ Would rather not say

4

13 **About what time do you usually go to bed to sleep?**

- ☐ Please specify ______ pm ______ am
- ☐ Don't know
- ☐ Would prefer not to say

14 **About what time do you usually get up?**

- ☐ Please specify ______ pm ______ am
- ☐ Don't know
- ☐ Would prefer not to say

15 **Thinking about the last 12 months or so, when you are at home, what number best shows how much you are bothered, disturbed or annoyed by each of the following noises?**

If you are not at all annoyed choose 0; if you are extremely annoyed choose 10; if you are somewhere in between, choose a number between 0 and 10.

		0	1	2	3	4	5	6	7	8	9	10	Not applicable
a.	Aircraft	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b.	Building and construction work	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c.	Factories or machinery	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d.	Pubs and nightclubs	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e.	Animals outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
f.	Children outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
g.	Other people outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
h.	Road traffic	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
i.	Trains	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

15a **Are there any other noises (from outside of your house) that bother, disturb or annoy you when you're at home?**

- ○ Yes
  Please specify ______
- ○ No
- ○ Would rather not say

16 **Have any of the following noises got worse, better or stayed the same in the last 12 months?**

		Worse	*Better*	*The same*	*Don't know*	*Not applicable*
a.	Aircraft	☐	☐	☐	☐	☐
b.	Building and construction work	☐	☐	☐	☐	☐
c.	Factories or machinery	☐	☐	☐	☐	☐
d.	Pubs and nightclubs	☐	☐	☐	☐	☐
e.	Animals outside	☐	☐	☐	☐	☐
f.	Children outside	☐	☐	☐	☐	☐
g.	Other people outside	☐	☐	☐	☐	☐
h.	Road traffic	☐	☐	☐	☐	☐
i.	Trains	☐	☐	☐	☐	☐

17 **Which one of these noises currently bothers you the most when you are at home?**

Please tick one answer.

- ☐ Aircraft
- ☐ Building and construction work
- ☐ Factories or machinery
- ☐ Pubs and nightclubs
- ☐ Animals outside
- ☐ Children outside
- ☐ Other people outside
- ☐ Road traffic
- ☐ Trains
- ☐ Don't know
- ☐ Would rather not say

18 **Generally speaking, how sensitive would you say you are to noise?**

Please tick one answer.

Not at all sensitive										*Extremely sensitive*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

6

Impact of noise from road traffic

We understand you live near a main road or highway. These next few questions are about road traffic noise.

19 **Earlier we asked if road noise bothered you when you were at home. Does road noise bother, disturb or annoy anyone else in your household?**

Not at all bothered										*Extremely bothered*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

20 **How much does noise from road bother, disturb or annoy you when you are at home, inside, with the windows closed?**

Not at all bothered										*Extremely bothered*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

21 **How much does noise from road bother, disturb or annoy you when you are at home, inside, with the windows open?**

Not at all bothered										*Extremely bothered*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

22 **How much does noise from road bother, disturb or annoy you when you are at home, but standing outside?**

Not at all bothered										*Extremely bothered*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

23 **What is it about the road noise that bothers you? Is it...**

Please tick as many options as apply to you.

- ◯ Vehicles in the early morning (before 6am)
- ◯ Vehicles at night (after 10pm)
- ◯ The number of vehicles
- ◯ Vehicles with noisy engines, exhausts or horns (including 'boy racers')
- ◯ Particular types of vehicles (e.g. cars, trucks, motorbikes)

  Please specify ______________________
- ◯ Noise caused by the road (the road surface, potholes, manhole covers, rumble strip)
- ◯ The way the noise makes the house vibrate
- ◯ Or something else

  Please specify ______________________
- ◯ Don't know
- ◯ Would rather not say

24 **When is the road noise most annoying for you?**

Please tick one answer.

- ☐ During the week
- ☐ In the weekends
- ☐ Both
- ☐ Not applicable (am not bothered by road noise)

8

25 **Are there any particular times during the week (Monday – Friday) that the road noise is particularly annoying?**

Please tick as many options as apply to you.

- ◯ Between 3am and 7am
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Annoying all the time
- ◯ Don't know
- ◯ Would rather not say
- ◯ Not applicable (the noise is not annoying during the week)

26 **Are there any particular times that you find road noise particularly annoying in the weekends (Saturday or Sunday)?**

Please tick as many options as apply to you.

- ◯ Between 3am and 7am
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Annoying all the time
- ◯ Don't know
- ◯ Would rather not say
- ◯ Not applicable (the noise is not annoying during the weekend)

27 **How much has the road noise <u>specifically affected</u> you in each of the following ways?**

In the last 12 months, has road noise affected…

Please tick one answer for each statement.

	0 *Not at all*	1	2	3	4	5	6	7	8	9	10 *A lot*	*Don't know*	*Not applicable*
a. your ability to **get to** sleep?													
b. **how much** sleep you get?													
c. your ability to **listen to music, the radio or television**?													
d. how easy it is to get the **children to sleep**?													
e. your ability to **relax outdoors**?													
f. your ability to **read, work or study** from home?													

28 **How much has the road noise <u>specifically affected</u> your <u>health and general wellbeing</u>? For example, has it affected...**

Please tick one answer for each statement.

	0 *Not at all*	1	2	3	4	5	6	7	8	9	10 *A lot*	*Don't know*	*Not applicable*
a. how easily you get **irritated**?													
b. how **stressful** or **anxious** you feel?													
c. your **energy** levels?													
d. your **personal relationships** with others in your home?													
e. your **health** and **wellbeing** in general?													

10

29 **Which, if any, of the following have you done, are doing now or planning to do, because of road noise?**

Please tick one answer for each statement.

	Planning to do this	*Have done this*	*Currently do this*	*No (haven't done it nor plan to)*	*Don't know*
a. Spend less time at home	☐	☐	☐	☐	☐
b. Spend less time outside and more indoors	☐	☐	☐	☐	☐
c. Keep windows and doors closed	☐	☐	☐	☐	☐
d. Move the location of your bedroom	☐	☐	☐	☐	☐
e. Take medication (e.g. sleeping pills)	☐	☐	☐	☐	☐
f. Make modifications to your property (e.g. double-glazing / planted trees to deaden noise)	☐	☐	☐	☐	☐
g. Move from the area	☐	☐	☐	☐	☐
h. Complain to the local council or airport	☐	☐	☐	☐	☐
i. Changed the time I go to sleep	☐	☐	☐	☐	☐

30 **How much do you agree or disagree that each of the following are doing their best to reduce the noise from road traffic affecting your neighbourhood?**

Please tick one answer for each statement.

	0 *strongly disagree*	1	2	3	4	5	6	7	8	9	10 *strongly agree*	*Don't know*
Your local council	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Waka Kotahi (NZTA)	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Freight operators	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

11

31 **How much do you agree or disagree with each of the following statements about cars and other road vehicles in general?**

Please tick one answer for each statement.

	0 *strongly disagree*	1	2	3	4	5	6	7	8	9	10 *strongly agree*	*Don't know*
Vehicles are an important form of **passenger transport**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Vehicles and trucks are an important form of **freight transport**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Vehicles on the road are **dangerous**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Vehicles are harmful to the **environment**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Vehicles are important for the local and national **economy**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Closing questions

32 **Do you have any final comments you'd like to make about about road noise?**

☐ Yes

Please comment here

☐ No

Thank you very much for your help. If you have enquiries about this survey, please ring the Project Manager, Katrina Magill, on our toll-free number: 0800 500 168. (Wellington respondents 499-3088).

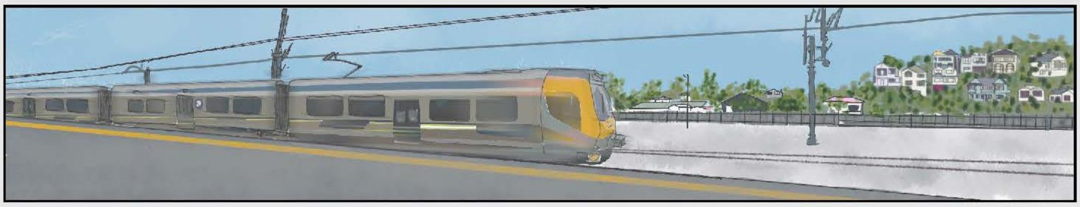
12

B.2 Railway

WAKA KOTAHI NZ TRANSPORT AGENCY

research NEW ZEALAND Rangahau Aotearoa

SURVEY ABOUT THE EFFECTS OF NOISE IN YOUR NEIGHBOURHOOD



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Please complete and return this questionnaire in the Freepost envelope provided. Even if you are not bothered by any noise at all where you live, your feedback is still important. Thank you!

The first few questions are about you and your household.

1 **Which one of the following age groups are you in?**

- ☐ 18-24 years
- ☐ 25-34 years
- ☐ 35-44 years
- ☐ 45-54 years
- ☐ 55-64 years
- ☐ 65-74 years
- ☐ 75 and over
- ☐ Would rather not say

2 **What gender do you identify as?**

Please tick as many options as apply.

- ◯ Male
- ◯ Female
- ◯ Another gender

  Please specify ________________
- ◯ Would prefer not to say

1

3 **Which <u>ethnic</u> groups do you belong to?**

Please tick as many options as apply.

- ◯ NZ European (or Pākehā)
- ◯ Māori
- ◯ Samoan
- ◯ Cook Island Māori
- ◯ Another Pacific nation (Tongan, Niuean, Tokelauan, Fijian)
- ◯ Chinese
- ◯ Indian
- ◯ Another ethnic group such as Dutch, Japanese or South African?

Please specify ____________________

- ◯ Don't know
- ◯ Would prefer not to say

4 **Are you currently..?**

Please tick as many options as apply to you.

- ◯ An employer
- ◯ Self employed
- ◯ A salary or wage earner
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- ◯ A full time home-maker
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5 **Which of these best describes your personal income from all sources, before tax for the last year? Please include any child support, benefits or other income support you may receive.**

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- ☐ $100,000 but less than $120,000
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6 **What is your highest completed qualification?**

Please tick one answer.

- ☐ Secondary school qualification (NCEA, School certificate etc.)
- ☐ Polytechnic/trade certificate or diploma
- ☐ University degree
- ☐ Other *Please specify* ____________________
- ☐ No qualifications
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2

7 **Including yourself, how many people normally live in your household?**
Please tick one answer.

- ☐ One
- ☐ Two
- ☐ Three or more
- ☐ Don't know
- ☐ Would rather not say

8 **And are any of the people that live with you…**
Please tick as many options as apply to you.

- ◯ Under 5 years old
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9 **Do you own or rent the house that you live in?**
Please tick one answer.

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- ☐ Board
- ☐ Other (e.g. live with parents)
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10 **Which of the following apply to this house?**
Please tick as many options as apply to you.

- ◯ Your bedroom faces the train tracks
- ◯ The living room/lounge faces the train tracks
- ◯ It has an outdoor area (lawn, garden, deck, balcony etc) that faces the train tracks
- ◯ Your bedroom windows are double (or triple) glazed
- ◯ The windows in the living room/lounge are double (or triple) glazed
- ◯ There is a heat pump in the house for heating/cooling
- ◯ The house has mechanical ventilation that provides fresh air ducted from outside
- ◯ Your house has been treated for train noise (Council requirement or provided by the train operator)
- ◯ None of the above

3

Sources of annoying noise

The following questions are about different sources of noise, which might or might not annoy you **when you are at home.**

11 **First of all, are you <u>usually</u> at home <u>during the week</u> (Monday – Friday) at the following times? Please don't count the odd time you might pop out to the shops or to meet someone for lunch or dinner, etc.**

Please tick <u>as many options as</u> apply to you. Even if you are only home for half an hour of a particular timeframe, please select that option.

- ◯ Between 3am and 7am in the morning
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Not usually at home during the week
- ◯ Don't know
- ◯ Would rather not say

12 **And are you <u>usually</u> home during the weekend (Saturdays and Sunday)...**

Please tick <u>as many options as</u> apply to you. Even if you are only home for half an hour of a particular timeframe, please select that option.

- ◯ Between 3am and 7am in the morning
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Not usually at home in the weekends
- ◯ Don't know
- ◯ Would rather not say

4

13 **About what time do you usually go to bed to sleep?**

- ☐ Please specify ______ pm ______ am
- ☐ Don't know
- ☐ Would prefer not to say

14 **About what time do you usually get up?**

- ☐ Please specify ______ pm ______ am
- ☐ Don't know
- ☐ Would prefer not to say

15 **Thinking about the last 12 months or so, when you are at home, what number best shows how much you are bothered, disturbed or annoyed by each of the following noises?**

If you are not at all annoyed choose 0; if you are extremely annoyed choose 10; if you are somewhere in between, choose a number between 0 and 10.

		0	1	2	3	4	5	6	7	8	9	10	Not applicable
a.	Aircraft	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b.	Building and construction work	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c.	Factories or machinery	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d.	Pubs and nightclubs	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e.	Animals outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
f.	Children outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
g.	Other people outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
h.	Road traffic	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
i.	Trains	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

15a **Are there any other noises (from outside of your house) that bother, disturb or annoy you when you're at home?**

- ◯ Yes
  - *Please specify* ______
- ◯ No
- ◯ Would rather not say

16 **Have any of the following noises got worse, better or stayed the same in the last 12 months?**

		Worse	*Better*	*The same*	*Don't know*	*Not applicable*
a.	Aircraft	☐	☐	☐	☐	☐
b.	Building and construction work	☐	☐	☐	☐	☐
c.	Factories or machinery	☐	☐	☐	☐	☐
d.	Pubs and nightclubs	☐	☐	☐	☐	☐
e.	Animals outside	☐	☐	☐	☐	☐
f.	Children outside	☐	☐	☐	☐	☐
g.	Other people outside	☐	☐	☐	☐	☐
h.	Road traffic	☐	☐	☐	☐	☐
i.	Trains	☐	☐	☐	☐	☐

17 **Which one of these noises currently bothers you the most when you are at home?**

Please tick one answer.

- ☐ Aircraft
- ☐ Building and construction work
- ☐ Factories or machinery
- ☐ Pubs and nightclubs
- ☐ Animals outside
- ☐ Children outside
- ☐ Other people outside
- ☐ Road traffic
- ☐ Trains
- ☐ Don't know
- ☐ Would rather not say

18 **Generally speaking, how sensitive would you say you are to noise?**

Please tick one answer.

Not at all sensitive										*Extremely sensitive*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

6

Impact of noise from trains

We understand you live near railway lines. These next few questions are about train noise.

19 **Earlier we asked if train noise bothered you when you were at home. Does train noise bother, disturb or annoy anyone else in your household?**

Not at all bothered 0	1	2	3	4	5	6	7	8	9	*Extremely bothered* 10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

20 **How much does train noise bother, disturb or annoy you when you are at home, inside, with the windows closed?**

Not at all bothered 0	1	2	3	4	5	6	7	8	9	*Extremely bothered* 10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

21 **How much does train noise bother, disturb or annoy you when you are at home, inside, with the windows open?**

Not at all bothered 0	1	2	3	4	5	6	7	8	9	*Extremely bothered* 10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

22 **How much does train noise bother, disturb or annoy you when you are at home, but standing outside?**

Not at all bothered 0	1	2	3	4	5	6	7	8	9	*Extremely bothered* 10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

23 **What is it about the train noise that bothers you? Is it…**

Please tick as many options as apply to you.

- ◯ Trains in the early morning (before 6am)
- ◯ Trains at night (after 10pm)
- ◯ The number of trains
- ◯ Particular types of trains (e.g. electric, diesel or freight trains)

  Please specify __________
- ◯ Particular noises that trains make (e.g. engines, carriages, squealing wheels, train horns)
- ◯ The way the noise makes the house vibrate
- ◯ Or something else

  Please specify __________
- ◯ Don't know
- ◯ Would rather not say

24 **When is the train noise most annoying for you?**

Please tick one answer.

- ☐ During the week
- ☐ In the weekends
- ☐ Both
- ☐ Not applicable (am not bothered by train noise)

25 **Are there any particular times during the week (Monday – Friday) that the train noise is particularly annoying?**

Please tick as many options as apply to you.

- ◯ Between 3am and 7am
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Annoying all the time
- ◯ Don't know
- ◯ Would rather not say
- ◯ Not applicable (the noise is not annoying during the week)

26 **Are there any particular times that you find train noise particularly annoying in the weekends (Saturday or Sunday)?**

Please tick as many options as apply to you.

- ◯ Between 3am and 7am
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Annoying all the time
- ◯ Don't know
- ◯ Would rather not say
- ◯ Not applicable (the noise is not annoying during the weekend)

27 **How much has the train noise <u>specifically affected</u> you in each of the following ways?**

In the last 12 months, has train noise affected...

Please tick one answer for each statement.

	Not at all 0	1	2	3	4	5	6	7	8	9	*A lot* 10	*Don't know*	*Not applicable*
a. your ability to **get to** sleep?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b. **how much** sleep you get?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c. your ability to **listen to music, the radio or television**?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d. how easy it is to get the **children to sleep**?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e. your ability to **relax outdoors**?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
f. your ability to **read, work or study** from home?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

28 **How much has the train noise <u>specifically affected</u> your <u>health and general wellbeing</u>? For example, has it affected...**

Please tick one answer for each statement.

	Not at all 0	1	2	3	4	5	6	7	8	9	*A lot* 10	*Don't know*	*Not applicable*
a. how easily you get **irritated**?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b. how **stressful** or **anxious** you feel?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c. your **energy** levels?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d. your **personal relationships** with others in your home?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e. your **health** and **wellbeing** in general?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

10

29 **Which, if any, of the following have you done, are doing now or planning to do, because of train noise?**

Please tick one answer for each statement.

	Planning to do this	*Have done this*	*Currently do this*	*No (haven't done it nor plan to)*	*Don't know*
a. Spend less time at home	☐	☐	☐	☐	☐
b. Spend less time outside and more indoors	☐	☐	☐	☐	☐
c. Keep windows and doors closed	☐	☐	☐	☐	☐
d. Move the location of your bedroom	☐	☐	☐	☐	☐
e. Take medication (e.g. sleeping pills)	☐	☐	☐	☐	☐
f. Make modifications to your property (e.g. double-glazing / planted trees to deaden noise)	☐	☐	☐	☐	☐
g. Move from the area	☐	☐	☐	☐	☐
h. Complain to the local council or airport	☐	☐	☐	☐	☐
i. Changed the time I go to sleep	☐	☐	☐	☐	☐

30 **How much do you agree or disagree that each of the following are doing their best to reduce the noise from trains affecting your neighbourhood?**

Please tick one answer for each statement.

	strongly disagree 0	1	2	3	4	5	6	7	8	9	*strongly agree* 10	*Don't know*
Your local council	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
KiwiRail	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

31 **How much do you agree or disagree with each of the following statements about trains in general?**

Please tick one answer for each statement.

	0 *strongly disagree*	1	2	3	4	5	6	7	8	9	10 *strongly agree*	*Don't know*
Trains are an important form of **passenger transport**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Trains are an important form of **freight transport**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Trains are **dangerous**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Trains are harmful to the **environment**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Trains are important for the local and national **economy**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Closing questions

32 **Do you have any final comments you'd like to make about about rail noise?**

☐ Yes

Please comment here

☐ No

Thank you very much for your help. If you have enquiries about this survey, please ring the Project Manager, Katrina Magill, on our toll-free number: 0800 500 168. (Wellington respondents 499-3088).

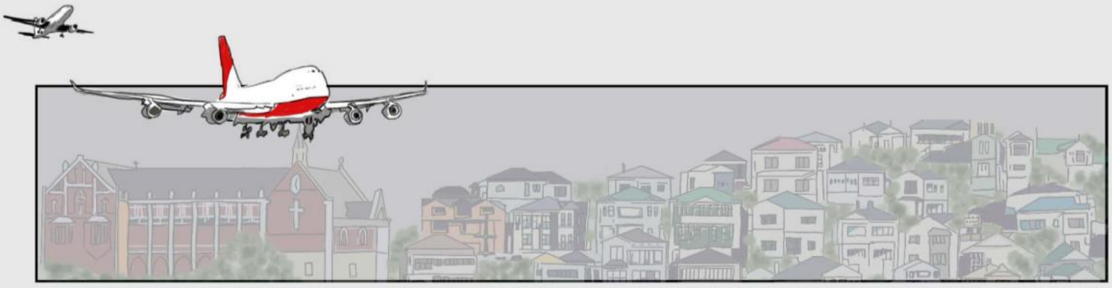
12

B.3 Aircraft

WAKA KOTAHI NZ TRANSPORT AGENCY

research NEW ZEALAND Rangahau Aotearoa

SURVEY ABOUT THE EFFECTS OF NOISE IN YOUR NEIGHBOURHOOD



This confidential survey is being conducted on behalf of Tonkin & Taylor for Waka Kotahi NZ Transport Agency.

The survey should take no more than about 10-15 minutes to complete and will help Waka Kotahi to better understand the impacts of noise on people's health and wellbeing, which they can then take into account in their planning for future projects.

Please complete and return this questionnaire in the Freepost envelope provided. Even if you are not bothered by any noise at all where you live, your feedback is still important. Thank you!

The first few questions are about you and your household.

1 **Which one of the following age groups are you in?**

☐ 18-24 years	☐ 25-34 years
☐ 35-44 years	☐ 45-54 years
☐ 55-64 years	☐ 65-74 years
☐ 75 and over	☐ Would rather not say

2 **What gender do you identify as?**

Please tick as many options as apply.

○ Male	○ Female
○ Another gender	

Please specify ______________________

○ Would prefer not to say

1

3 **Which ethnic groups do you belong to?**
Please tick as many options as apply.

- ◯ NZ European (or Pākehā)
- ◯ Māori
- ◯ Samoan
- ◯ Cook Island Māori
- ◯ Another Pacific nation (Tongan, Niuean, Tokelauan, Fijian)
- ◯ Chinese
- ◯ Indian
- ◯ Another ethnic group such as Dutch, Japanese or South African?

Please specify ______

- ◯ Don't know
- ◯ Would prefer not to say

4 **Are you currently..?**
Please tick as many options as apply to you.

- ◯ An employer
- ◯ Self employed
- ◯ A salary or wage earner
- ◯ Retired
- ◯ A full time home-maker
- ◯ A student
- ◯ Unemployed
- ◯ A beneficiary
- ◯ Would rather not say

5 **Which of these best describes your personal income from all sources, before tax for the last year? Please include any child support, benefits or other income support you may receive.**
Please tick one answer.

- ☐ Under $40,000
- ☐ At least $40,000 but less than $80,000
- ☐ $80,000 but less than $100,000
- ☐ $100,000 but less than $120,000
- ☐ $120,000 or more
- ☐ Don't know
- ☐ Would rather not say

6 **What is your highest completed qualification?**
Please tick one answer.

- ☐ Secondary school qualification (NCEA, School certificate etc.)
- ☐ Polytechnic/trade certificate or diploma
- ☐ University degree
- ☐ Other *Please specify* ______
- ☐ No qualifications
- ☐ Would rather not say

2

7 **Including yourself, how many people normally live in your household?**
Please tick one answer.

- ☐ One
- ☐ Two
- ☐ Three or more
- ☐ Don't know
- ☐ Would rather not say

8 **And are any of the people that live with you…**
Please tick as many options as apply to you.

- ◯ Under 5 years old
- ◯ 5-12 years old
- ◯ 13-17 years old
- ◯ Don't know
- ◯ No, everyone in the house is 18 years or over
- ◯ Would rather not say

9 **Do you own or rent the house that you live in?**
Please tick one answer.

- ☐ Own (with/without mortgage)
- ☐ Rent
- ☐ Board
- ☐ Other (e.g. live with parents)
- ☐ Don't know
- ☐ Would rather not say

10 **Which of the following apply to this house?**
Please tick <u>as many options as</u> apply to you.

- ◯ Your bedroom faces the airport
- ◯ The living room/lounge faces the airport
- ◯ It has an outdoor area (lawn, garden, deck, balcony etc) that faces the airport
- ◯ Your bedroom windows are double (or triple) glazed
- ◯ The windows in the living room/lounge are double (or triple) glazed
- ◯ There is a heat pump in the house for heating/cooling
- ◯ The house has mechanical ventilation that provides fresh air ducted from outside
- ◯ Your house has been treated for airport noise (Council requirement or provided by the airport operator)
- ◯ None of the above

3

Sources of annoying noise

The following questions are about different sources of noise, which might or might not annoy you **when you are at home.**

11

First of all, are you usually at home during the week (Monday – Friday) at the following times? Please don't count the odd time you might pop out to the shops or to meet someone for lunch or dinner, etc.

Please tick as many options as apply to you. Even if you are only home for half an hour of a particular timeframe, please select that option.

- ◯ Between 3am and 7am in the morning
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Not usually at home during the week
- ◯ Don't know
- ◯ Would rather not say

12

And are you usually home during the weekend (Saturdays and Sunday)...

Please tick as many options as apply to you. Even if you are only home for half an hour of a particular timeframe, please select that option.

- ◯ Between 3am and 7am in the morning
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Not usually at home in the weekends
- ◯ Don't know
- ◯ Would rather not say

4

13 **About what time do you usually go to bed to sleep?**

☐ Please specify [____] pm [____] am

☐ Don't know

☐ Would prefer not to say

14 **About what time do you usually get up?**

☐ Please specify [____] pm [____] am

☐ Don't know

☐ Would prefer not to say

15 **Thinking about the last 12 months or so, when you are at home, what number best shows how much you are bothered, disturbed or annoyed by each of the following noises?**

If you are not at all annoyed choose 0; if you are extremely annoyed choose 10; if you are somewhere in between, choose a number between 0 and 10.

		0	1	2	3	4	5	6	7	8	9	10	Not applicable
a.	Aircraft	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b.	Building and construction work	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c.	Factories or machinery	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d.	Pubs and nightclubs	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e.	Animals outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
f.	Children outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
g.	Other people outside	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
h.	Road traffic	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
i.	Trains	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

15a **Are there any other noises (from outside of your house) that bother, disturb or annoy you when you're at home?**

○ Yes

Please specify [____]

○ No

○ Would rather not say

5

16 **Have any of the following noises got worse, better or stayed the same in the last 12 months?**

		Worse	*Better*	*The same*	*Don't know*	*Not applicable*
a.	Aircraft	☐	☐	☐	☐	☐
b.	Building and construction work	☐	☐	☐	☐	☐
c.	Factories or machinery	☐	☐	☐	☐	☐
d.	Pubs and nightclubs	☐	☐	☐	☐	☐
e.	Animals outside	☐	☐	☐	☐	☐
f.	Children outside	☐	☐	☐	☐	☐
g.	Other people outside	☐	☐	☐	☐	☐
h.	Road traffic	☐	☐	☐	☐	☐
i.	Trains	☐	☐	☐	☐	☐

17 **Which one of these noises currently bothers you the most when you are at home?**

Please tick one answer.

- ☐ Aircraft
- ☐ Building and construction work
- ☐ Factories or machinery
- ☐ Pubs and nightclubs
- ☐ Animals outside
- ☐ Children outside
- ☐ Other people outside
- ☐ Road traffic
- ☐ Trains
- ☐ Don't know
- ☐ Would rather not say

18 **Generally speaking, how sensitive would you say you are to noise?**

Please tick one answer.

Not at all sensitive										*Extremely sensitive*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

6

Impact of noise from aircraft

We understand you live near an airport. These next few questions are about aircraft noise.

19 **Earlier we asked if aircraft noise bothered you when you were at home. Does aircraft noise bother, disturb or annoy anyone else in your household?**

Not at all bothered										*Extremely bothered*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

20 **How much does noise from aircraft bother, disturb or annoy you when you are at home, inside, with the windows closed?**

Not at all bothered										*Extremely bothered*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

21 **How much does noise from aircraft bother, disturb or annoy you when you are at home, inside, with the windows open?**

Not at all bothered										*Extremely bothered*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

22 **How much does noise from aircraft bother, disturb or annoy you when you are at home, but standing outside?**

Not at all bothered										*Extremely bothered*	
0	1	2	3	4	5	6	7	8	9	10	Not applicable
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

23 **What is it about the aircraft noise that bothers you? Is it...**

Please tick as many options as apply to you.

- ◯ The early morning flights (before 6am)
- ◯ Flights late at night (after 10pm)
- ◯ Particular types of planes or aircraft (e.g. jets, propellor, helicopters, small leisure planes)

  Please specify ______
- ◯ The number of flights
- ◯ When they fly directly over the top of your house
- ◯ How low they fly over your house
- ◯ The noise when the planes are on the ground taxiing, or just sitting with their engines running
- ◯ Or something else

  Please specify ______
- ◯ Not applicable (am not bothered by aircraft noise)
- ◯ Don't know
- ◯ Would rather not say

24 **When is the aircraft noise most annoying for you?**

Please tick one answer.

- ☐ During the week
- ☐ In the weekends
- ☐ Both
- ☐ Not applicable (am not bothered by aircraft noise)

25 **Are there any particular times during the week (Monday – Friday) that the aircraft noise is particularly annoying?**

Please tick as many options as apply to you.

- ◯ Between 3am and 7am
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Annoying all the time
- ◯ Don't know
- ◯ Would rather not say
- ◯ Not applicable (the noise is not annoying during the week)

26 **Are there any particular times that you find aircraft noise particularly annoying in the weekends (Saturday or Sunday)?**

Please tick as many options as apply to you.

- ◯ Between 3am and 7am
- ◯ Between 7am and 11am in the morning
- ◯ Between 11am and 3pm
- ◯ Between 3pm in the afternoon and 7pm at night
- ◯ Between 7pm and 11pm
- ◯ Between 11pm at night and 3am in the morning
- ◯ Annoying all the time
- ◯ Don't know
- ◯ Would rather not say
- ◯ Not applicable (the noise is not annoying during the weekend)

27 **How much has the noise from aircraft <u>specifically affected</u> you in each of the following ways?**

In the last 12 months, has aircraft noise affected...

Please tick one answer for each statement.

	Not at all 0	1	2	3	4	5	6	7	8	9	A lot 10	*Don't know*	*Not applicable*
a. your ability to **get to** sleep?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b. **how much** sleep you get?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c. your ability to **listen to music, the radio or television**?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d. how easy it is to get the **children to sleep**?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e. your ability to **relax outdoors**?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
f. your ability to **read, work or study** from home?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

28 **How much has the noise from aircraft <u>specifically affected</u> your <u>health and general wellbeing</u>? For example, has it affected...**

Please tick one answer for each statement.

	Not at all 0	1	2	3	4	5	6	7	8	9	A lot 10	*Don't know*	*Not applicable*
a. how easily you get **irritated**?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
b. how **stressful** or **anxious** you feel?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
c. your **energy** levels?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
d. your **personal relationships** with others in your home?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
e. your **health** and **wellbeing** in general?	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

10

29 **Which, if any, of the following have you done, are doing now or planning to do, because of aircraft noise?**

Please tick one answer for each statement.

	Planning to do this	*Have done this*	*Currently do this*	*No (haven't done it nor plan to)*	*Don't know*
a. Spend less time at home	☐	☐	☐	☐	☐
b. Spend less time outside and more indoors	☐	☐	☐	☐	☐
c. Keep windows and doors closed	☐	☐	☐	☐	☐
d. Move the location of your bedroom	☐	☐	☐	☐	☐
e. Take medication (e.g. sleeping pills)	☐	☐	☐	☐	☐
f. Make modifications to your property (e.g. double-glazing / planted trees to deaden noise)	☐	☐	☐	☐	☐
g. Move from the area	☐	☐	☐	☐	☐
h. Complain to the local council or airport	☐	☐	☐	☐	☐
i. Changed the time I go to sleep	☐	☐	☐	☐	☐

30 **How much do you agree or disagree that each of the following are doing their best to reduce the noise from aircraft affecting your neighbourhood?**

Please tick one answer for each statement.

	0 *strongly disagree*	1	2	3	4	5	6	7	8	9	10 *strongly agree*	*Don't know*
Your local council	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
The airport company	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
The airline/aircraft operators	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

31 **How much do you agree or disagree with each of the following statements about aircraft in general?**

Please tick one answer for each statement.

	0 *strongly disagree*	1	2	3	4	5	6	7	8	9	10 *strongly agree*	*Don't know*
Aircraft are an important form of **passenger transport**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Aircraft are an important form of **freight transport**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Aircraft are **dangerous**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Aircraft are harmful to the **environment**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐
Aircraft are important for the local and national **economy**	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Closing questions

32 **Do you have any final comments you'd like to make about about aircraft noise?**

☐ Yes

Please comment here

☐ No

Thank you very much for your help. If you have enquiries about this survey, please ring the Project Manager, Katrina Magill, on our toll-free number: 0800 500 168. (Wellington respondents 499-3088).

Appendix C: Questionnaire invitation letter

Tonkin+Taylor

research NEW ZEALAND Rangahau Aotearoa

21 September 2022

Name
Address 1
Address 2
Address 3

Kia ora [Name]

A survey about the effects of noise in your neighbourhood

Waka Kotahi NZ Transport Agency (**Waka Kotahi**) has appointed engineering consultants Tonkin & Taylor to define and quantify the effects of noise on New Zealand communities. Tonkin & Taylor have in turn, commissioned Research New Zealand to conduct the fieldwork for this research study.

This study involves a survey with people who live in your neighbourhood about **the effects of noise**. This could be the noise from a range of different sources, including nearby roads, businesses or factories, parks and recreational grounds, or railroads and airports.

Information from this survey will help Waka Kotahi better understand the impacts of noise on people's health and wellbeing, which can then be taken into account in planning for future projects.

Everyone who completes the survey will go into a draw for one of three $250 petrol or supermarket vouchers. Winners will be notified by telephone in December 2022.

It's your choice whether you take part in this research, but as it is important that we interview a cross-section of people in your area, we would appreciate someone in your household taking part.

What does taking part involve?

You can complete the survey, in under 10 minutes:

On paper
Complete the paper questionnaire and post it back to Research NZ using the freepost envelope provided.

By telephone
One of Research New Zealand's interviewers may give you a call to see if you would like to complete the survey by phone, or you can call Research NZ directly on 0800 500 168 to arrange a time that suits you.

Online
Step 1: Go to www.researchnz.com
Step 2: Click on **Current Surveys**
Step 3: Choose **Noise Survey**
Step 4: Enter your **Access Code:** «PIN»

OR scan the **QR code** to go straight to the start of the survey and enter your **Access Code:** «PIN»

Yours sincerely

Katrina Magill
Research Director
Research New Zealand

Tonkin+Taylor

research NEW ZEALAND Rangahau Aotearoa

FREQUENTLY ASKED QUESTIONS

What's the purpose of the survey?	To gather information from people in your neighbourhood about the effects of noise. This information will be used in future planning.
Who will be conducting this research?	Research New Zealand is conducting the survey on behalf of Tonkin & Taylor for **Waka Kotahi** NZ Transport Agency.
Who is Tonkin & Taylor?	Tonkin & Taylor is one of New Zealand's leading environmental and engineering consultancy firms. You can find out more about them by visiting their website www.tonkintaylor.co.nz
Who is Research New Zealand?	Research New Zealand is a privately owned research company based in Wellington who specialise in research for the public sector. You can find out more about them by visiting their website www.researchnz.com
How did they get my name and address?	Your name and address was randomly selected along with many others from your neighbourhood through the Electoral Rolls.
When does the survey have to be completed by?	We are aiming to complete the survey by mid-December 2022 and, therefore, your household may get a call from one of Research New Zealand's interviewers during this time.
Is the survey confidential?	Yes, it is confidential. Your household's answers to the survey will be depersonalised as soon as the survey is completed, which means the person in your household who is interviewed, as well as your household, will not be identifiable in any report that is prepared. Research New Zealand is bound by the Professional Code of Practice of the European Society for Marketing and Opinion Research Inc., which prohibits them from identifying any person who takes part in a survey unless they have explicit consent from that person to do so.
Do I have to take part in the survey?	No, your household doesn't have to do the survey. Participation in this survey is completely voluntary, but it is important that as many people as possible do so we can have a representative picture of the effects of noise in your neighbourhood. If you do not want to take part in this research, please contact Research New Zealand on 0800 500 168 and let them know. Or you can simply tell the interviewer if they call.
What if I want to find out more about it?	If you have any questions about the survey, you can email sarah.m.buchanan@researchnz.com or call Research New Zealand on 0800 500 168. If you would like to get in touch with Tonkin & Taylor, please email research@tonkintaylor.co.nz.

Appendix D: ERFs with data points

Figure D.1 Road-traffic ERF curve

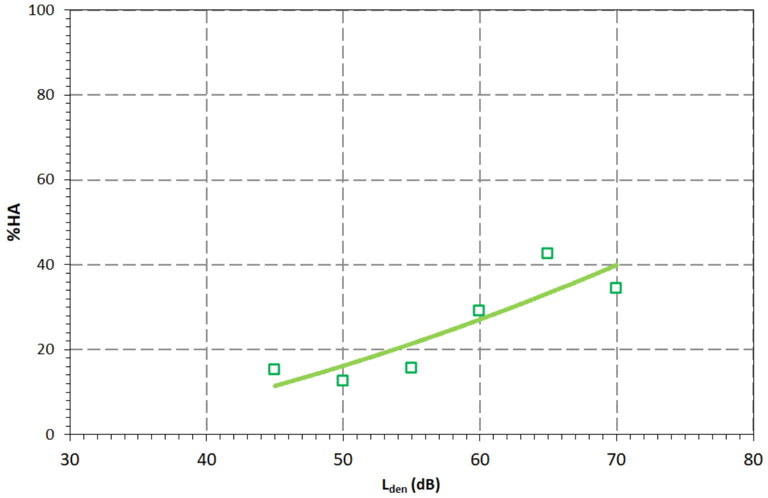


Figure D.2 Railway ERF curve

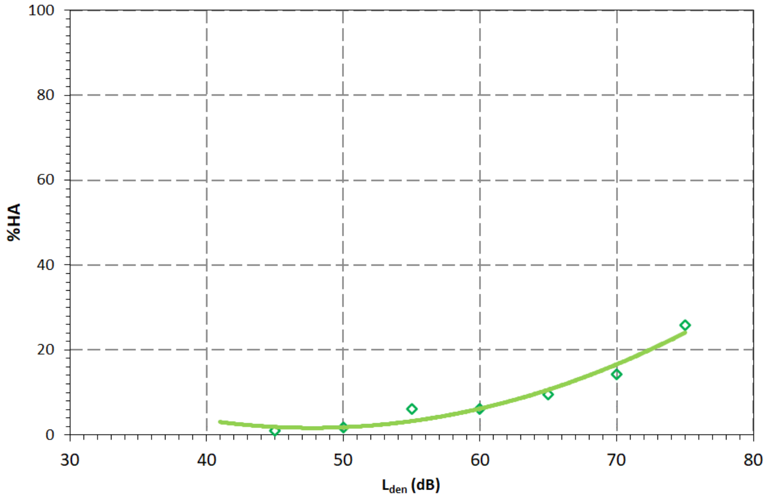


Figure D.3 Aircraft ERF curve