National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Review of evidence relating to environmental noise exposure and annoyance, sleep disturbance, cardio-vascular and metabolic health outcomes in the context of ICGB(N)

RIVM Report 2019-0088

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Colophon

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Synopsis

Review of Evidence Relating to Environmental Noise Exposure and Annoyance, Sleep Disturbance, Cardio-Vascular and Metabolic Health Outcomes in the Context of the Interdepartmental Group on Costs and Benefits Noise Subject Group (IGCB(N))

In 2018 the WHO Guidelines for Environmental Noise were published. The Guidelines are based on reviews of the scientific literature between 2000 and 2015. Since then many new publications have emerged, describing results of existing and new studies of good quality, which were not yet part of the WHO reviews. Also, these reviews did not cover all noise sources relevant for noise policies in the UK. These include, apart from transport noise and wind turbine noise, noise from neighbours and the neighbourhood, industrial noise and low frequency noise from building services such as heat pumps, cooling-and ventilation systems.

RIVM investigated whether there is sufficient new evidence to make an update to the literature reviews worthwhile for the noise policies in the UK. RIVM is of the view that there is sufficient new evidence that warrants an update to the WHO reviews on the health effects of noise from transport and wind turbines for some health outcomes. RIVM also thinks it important to study the health effects of other sources in more detail. However, more research is needed to do this in a proper way; evidence for an association between health effects and these other sources is scarce or has been understudied

This literature review was prepared at the request the Department for Environment, Food and Rural Affairs (DEFRA) of the UK and on behalf of the Interdepartmental Group on Costs and Benefits Noise Subject Group (IGCB(N)). DEFRA asked RIVM to provide advice, since they have a good overview of the literature and evidence in the noise and health domain. To support the advice, this report summarises the results of the literature published between 2014 and the end of 2019 in relation to transport and wind turbine noise and between 2000 and 2019 in relation to noise sources not included in the WHO reviews.

Keywords: noise, health, WHO environmental noise guidelines for the European region, annoyance, sleep disturbance, cardiovascular disease and metabolic disorders

Publieksamenvatting

Literatuuroverzicht van bewijs van een relatie tussen omgevingsgeluid en hinder, slaapverstoring, hart en vaatziekten en stofwisselingseffecten in de context van de Interdepartementale Kosten en Baten Groep met betrekking tot geluid (IGCB(N))

In 2018 is de WHO Richtlijn voor Omgevingsgeluid verschenen. De richtlijn is gebaseerd op reviews van de wetenschappelijke literatuur die tussen 2000 en 2014 is verschenen. Sinds 2014 zijn er veel nieuwe publicaties bijgekomen, waarin bestaande en nieuwe studies van hoge kwaliteit zijn verwerkt. Deze waren nog niet opgenomen in de WHO-reviews. Ook zijn in de gebruikte reviews minder geluidbronnen betrokken dan voor het geluidbeleid in het Verenigd Koninkrijk van belang zijn. Dit beleid omvat, behalve geluid van transport en windturbines, ook geluid van industrie, buren- en buurt, en laagfrequent geluid van gebouw installaties zoals koel- en ventilatiesystemen en warmtepompen.

Het RIVM heeft gekeken of een update van de literatuur reviews de moeite waard is voor het geluidbeleid in het Verenigd Koninkrijk. Volgens het RIVM is er voldoende nieuw bewijs om een de WHO-reviews over de gezondheidseffecten van geluid van transport en windturbines met de nieuwste kennis aan te vullen voor sommige gezondheidseffecten. Het RIVM vindt het ook belangrijk om de gezondheidseffecten van de geluidbronnen die nu nog ontbreken, nader te evalueren. Meer onderzoek is nodig om dat goed te doen; het bewijs voor een relatie tussen een gezondheidseffect en deze geluidbronnen is nu nog mager of onvoldoende in kaart gebracht.

Dit literatuuroverzicht is gemaakt op verzoek van het Departement voor Environment, Food and Rural Affairs (DEFRA) van het Verenigd Koninkrijk en namens de Interdepartementale Kosten en Baten Groep over Geluid (IGCB(N)). DEFRA heeft het RIVM om dit advies gevraagd, omdat het een goed overzicht heeft van de stand van zaken op gebied van geluid en gezondheid. Als onderbouwing van het advies vat dit rapport de resultaten samen van de literatuur over omgevingsgeluid en gezondheid die tussen 2014 en eind 2019 is verschenen over transport en wind turbine geluid. Hetzelfde geldt voor de publicaties die tussen 2000 en 2019 zijn verschenen over de geluidbronnen die niet in de WHO reviews werden opgenomen.

Kernwoorden: geluid, gezondheid, WHO richtlijnen voor omgevingsgeluid voor Europa, hinder, slaapverstoring, hart en vaatziekten en stofwisselingsziekten

Contents

Summary

Background
In 2018 the Environmental Noise Guidelines for the European Region were published by WHO. At the base of the Guidelines were eight systematic reviews on adverse birth effects, hearing loss and tinnitus, cognitive effects, mental health, annoyance, sleep disturbance, cardiovascular and metabolic effects and the effects of interventions. Most of the reviews cover a time frame between 2000 and 2014. Since then a considerable number of high quality studies was published. Also, the WHO guidelines did not cover all sources relevant within the framework of the Interdepartmental Group on Costs and Benefits Noise Subject Group (IGCB(N)) convened by DEFRA. As well as transport and wind turbine noise these include industrial noise, neighbourhood and neighbour noise, low frequency noise from building services. In light of the publication of the WHO and new, high-quality evidence, DEFRA has convened the IGCB(N) and invited RIVM to contribute. The aim of this assignment is to prepare written advice for the IGCB(N) on the evidence base to determine whether updates to its current recommendations might be considered.

Method
Four databases for observational studies were screened, addressing the exposure to transport related noise and wind turbine noise and its health consequences as addressed in the WHO reviews. The same method was employed in relation to industrial noise, neighbourhood noise and neighbour noise. Thirdly, the exposure to low frequency noise from building services in relation to annoyance and sleep disturbance was reviewed. Data were extracted on study design, type and measurements of exposures and outcomes and confounders and their associations. The quality of the studies was indirectly assessed by only including studies with a case control design or cohort design for cardiovascular and metabolic endpoints. For studies on annoyance and sleepdisturbance and for the new sources, the risk of bias was taken into account in terms of exposure misclassification, selective participation and confounding.

Structure of the report
This report describes the results of a qualitative synthesis of the literature into the effects of environmental noise on health in the period between 2014 and December 2019.[1] Noise sources included are road, rail and air traffic, windfarms as covered in the WHO Guidelines and underlying reviews. In addition, industrial noise, neighbour and neighborhood sounds and low frequency sounds due to building services installation, including heat pumps were covered in the period between 2000 and 2019.

An overview of these new studies/publications is given in tables and includes the first author, year of publication, papers, audit trail of screening and decision process, reasons for inclusion, quality rating of evidence review. In the context of this assignment no meta-analysis

[1] Also pre-publications were included

were performed nor were exposure effect relations (EEr) derived. Based on these new articles, qualitative statements are made about the strength of the new evidence and possible implication for the conclusions drawn on previous reviews regarding health related relationships, as far as the sources and effects are concerned that are covered by the WHO reviews. Further conclusions are drawn regarding the potential to derive EErs for the new sources based on evidence since 2000. The background, process and results of this review are described in four chapters. After a short introduction in chapter 1, chapter 2 deals with the method and and selection criteria. Chapter 3 presents the results per outcome : Annoyance and Sleep disturbance due to transport noise and wind turbine noise (3.1) ; Cardiovascular and metabolic effects due to transport noise and wind turbine noise (3.2); Annoyance and Sleep disturbance and (other) health effects due to low frequency noise caused by cooling-, ventilation systems and heat-pumps 3.3); Health effects of Industrial noise, neighbour noise and neighbourhood noise (3.4). In chapter 4 we draw some conclusions and make statements about the options to update the WHO Guidelines evidence base and about the feasibility to derive exposure effect relations for new noise sources.

Results and Recommendation
The number, size and quality of the new studies suggest new meta-analyses could be undertaken over a whole range of sources and effects incuded in the WHO reviews. In summary, RIVM advises the IGCB(N) to consider taking the new evidence into account where the new publications justify such an effort. For annoyance, meta- analysis for all source is possible. For annoyance due to air traffic noise, the current debate regarding the selection of studies included in the WHO meta-analysis, [13, 14, 15] suggest consideration of the review and its consequences for the current Guideline values for airtraffic noise and annoyance need close examination. For sleep-related effects a meta-alaysis for all transport related sources is possible and a separate meta-analysis for for wind turbine noise is advised. For the latter we suggest to make a distinction between self reported sleepdisturbance and more objective measures. For cardiovascular effects all end point for some transport sources are liable for an update. New evidence regarding wind turbine noise and cardiovascular effects does not justify a new meta-analysis. New evidence warrants a meta-analysis for diabetes (Road - and Airtraffic), from BMI (Road and Rail traffic) and for a change in Waist Circumference (Road traffic). As for the other noise sources only a handful of articles met the inclusion criteria. In the first place, these sources have to be better defined, and secondly more well designed field studies are needed to understand the direct and indirect health effects of low frequency noise, neighbour and neighbourhood noise and industrial noise.

1 Introduction

It had been a while since the first WHO guidelines for health protection against environmental noise were published in 1999. Since then many new studies on the health effects of environmental sound exposure at home have been performed and an update of the WHO environmental noise guideline saw light in November 2018. Detailed systematic reviews were carried out to support and inform these guidelines [1-7] . Exposure effect relations (EErs) are now available to relate the noise exposure (expressed in L*den* and L*night*) for the percentage highly sleep disturbed, the percentage highly annoyed, *incidence* and *mortality* due to coronary heart disease (numbers of cases/death attributable to noise). This is also the case for cognitive effects [3], but an update for these effects will be reported separately.

1.1 Update of the evidence

The WHO European Guidelines for Environmental Noise for the European Region are based on evidence published between 2000 and December 2014, as far as annoyance is concerned. The systematic reviews of environmental noise and sleep disturbance and cardiovascular and metabolic effects considered evidence published between 2000 and August 2015. Since then several studies were published, that may further develop the knowledge and understanding of the link between noise exposure and a broad range of health outcomes. In addition, the reviews underlying the new WHO Guidelines do not include the health effects of industrial noise, neighbourhood and neighbour noise including low frequency noise from building services, such as ground- and air source heat pumps (as defined by Noise Policy Statement for England[2]). In light of this and other subsequent high-quality evidence, DEFRA has convened the Interdepartmental Group on Costs and Benefits Noise Subject Group (IGCB(N)) and invited RIVM to contribute. The aim of this assignment is to prepare written guidance for the IGCB(N) on the evidence base they will use to determine whether updates to its current recommendations on environmental noise are advisable. This report describes the results of the first, qualitative stage of an update of a literature review into the effects of environmental noise on annoyance, sleep disturbance, metabolic and cardiovascular effects in the period between 2015 and 2019. This effort is primarily aimed at the identification of new publications and selection of eligible studies for those sources used in the Guidelines : road, rail and air traffic and , windfarms. In addition, sources covering industrial noise, neighbours and neighbourhood, and low frequency noise from building services equipment are included for a literature review covering the period between 2000 and 2019. The next stage would be to perform a systematic evaluation of these studies and a quantitative meta-analysis, combining the results of these studies where this is deemed feasible, and adviceable.

[2] "neighbour noise" includes noise from inside and outside peoples homes; "neighbourhood noise"'includes noise arising from within the community such as industrial and entertainment premises, trade and business premises, construction sites and noise in the street (other than transport noise)

1.2 Criteria for evaluation

For this advice statements are made about the potential to adapt the WHO EErs within the IGCB(N) framework based on new evidence. For the new sources, statements are made about the number and quality of the studies, the strength of the evidence and future needs to derive exposure response relations for these sources as well. To help the IGCB(N) evaluate whether an update of their current guidelines should be undertaken, the main aim of this paper is to provide guidance on:
1. The criteria to make a statement about use or option for adaptation of the exposure effect relationships (EErs) proposed in the WHO systematic reviews, which could be considered by the IGCB(N) (cardiovascular, metabolic effects, annoyance, sleep).
2. The criteria to make a statement about the potential to derive EErs for sources not included in the WHO systematic reviews, and identify how appropriate exposure response functions and/or risk ratios could be identified (if appropriate) for LFN, industrial noise, neighbour and neighbourhood noise as defined by Noise Policy Statement for England.

To make a statement suggesting whether a new meta-analysis aimed at confirming or adapting existing EERs is justified, we used our professional judgement. Study size, response rate, design, quality/risk of bias and the way in which the exposure and outcome were measured or estimated and the confounders which were considered all played a role in this evaluation. For cardiovascular and metabolic outcomes in addition only case control and cohort studies (= high quality design) are considered. This restriction was not applied to sleep and annoyance. Also the rule of thumb was followed that a meta-analysis is only adviced when at least three studies are available. In order to make statements about the potential to derive EErs of sources not yet included in the WHO systematic reviews, the same study features were considered. In addition it was evaluated whether there is enough study material to derive an EEr, meaning that of the available studies, the methods should be comparable, and that there is sufficient statistical detail to derive an EEr.

2 Study design and Method

2.1 Structure of the work

The work was subdivided in four work packages

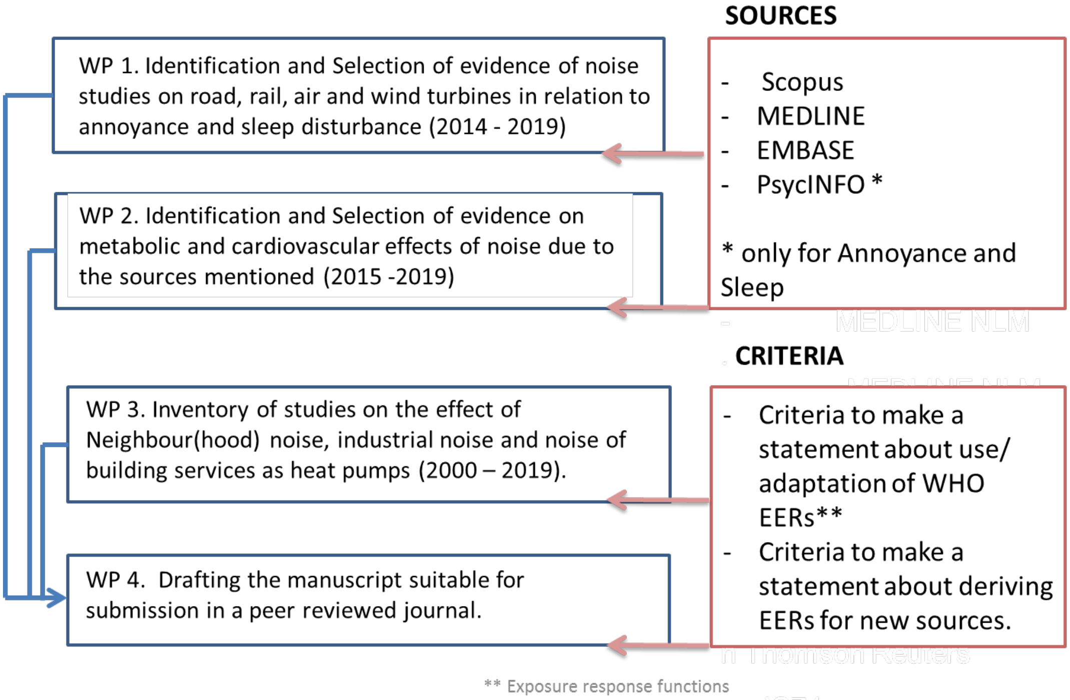

Figure 1.1: Overview of work-packages, sources and criteria

An overview of new and/or updated studies/publications that were identified and selected is presented in tables per outcome, and per noise source in line with the structure of the WHO reviews (see Annex 1). In order to make statements about the selected, studies data extraction was performed, but limited in view of time. For annoyance and sleep these include the authors, year, study design, study size, response rate, adjustment for confounding, measurement of exposure and effect, and the association between them, and risk of bias. For cardiovascular and metabolic effects these include all but the association and risk of bias and adjustment of confounders. Below the audit trail of screening and decision process, reasons for inclusion/exclusion are decribed. In the context of this assignment, no meta-analyses were perfomed, nor were Exposure Effect relations (EEr) derived. For cardiovascular and Metabolic effects no data were extracted about study quality and outcomes for single studies. Based on these new articles, statements are rather made whether the number of eligble studies justifies (an update of) meta-analyses per source and outcome. For the new sources statements are made about the number and quality of the studies, the strength of the evidence and the feasibility and future needs to derive EErs for these sources as well.

2.2 Procedure

During the first phase of screening, the information specialist of RIVM provided the first search results (see profiles in Annex 2). The members of the project team screened the titles and the abstracts of the identified studies independently and by two evaluators as much as possible. This was done in line with the selection protocol as outlined in the research proposal for DEFRA. Studies that clearly did not match our inclusion criteria were excluded in the first phase of the screenings process. Studies that possibly qualified for inclusion were fully read. During the second phase of the screening potentially relevant studies were evaluated independently again by two researchers where possible in order to enhance the reliability of the study choice. Raters were given the details of the studies, but not shown each other's evaluations, thus the assessments were independent of each other. The selection process was documented in sufficient detail to apply the PRISMA-flowchart.[8] Discrepancies during this selection and screening process were solved by discussion and seeking consensus between the project team members/evaluators.

2.2.1 Search and selection criteria [3]

1. Published or accepted papers in peer-review Journals ,
2. Published papers in conference proceedings,
3. Individual studies, so no reviews, meta-analyses[4] or "commentaries",
4. In principal no language limitation,
5. Population: general population, adults; (cardiovascular effects also include children, for other outcomes not relevant or available),
6. Setting: Environmental exposure at home or at school (for children) only (NO exposure to noise in occupational setting nor in health care setting e.g. in a hospital),
7. Study design: observational studies only (NO experimental studies following the WHO protocol), for the update on cardiovascular effects and metabolic effects only case control studies and cohort studies are selected,
8. Relevant outcomes: annoyance, sleep disturbance, cardiovascular effects, metabolic effects (self-reported or clinically diagnosed).

The primary literature search strategy was carried out in the period March/May 2019 and subdivided in four main parts (see Figures 3.1.1, 3.2.1, 3.3.1, 3.4.1).

2.2.2 Primary Search

In a first step, we searched for the most important publications, as in the WHO review based on a pilot search by the librarian. Next, we developed our literature search protocol for the different outcomes and new sources, based on relevant search terms from identified papers, discussions in the team and in close interactions with the information

[3] For additional criteria see references Chapter 3.2

[4] Reviews and meta-analysis published between 2015 and 2019 will be accounted for in the conclusions in view of duplication

specialists at RIVM. The literature search strategy was based on the following main data sources:

- Scopus
- MEDLINE NLM
- EMBASE 2014 Elsevier B.V.
- PsycINFO (only for annoyance and sleep disturbance)

Study selection: the studies/publications that were identified by means of the search were selected for data extraction. For the noise sources and end points that were already covered by the existing evidence reviews, we applied the criteria that were developed in the relevant evidence review. For the noise sources and/or end points that were not covered by the existing evidence reviews, new criteria had to be developed. These will be discussed in the separate paragraphs.
For the (limited) extraction of data, a data collection form was used and tested on at least five selected studies. After reaching consensus, the data were extracted, coded and imported into the tables. In the case of disagreement, the evaluators and librarian discussed the options. In principle, the following characteristics of the studies were extracted and coded for each selected study:

- Acronym/Author and Year of Publication;
- Study Design;
- Type and source of exposure;
- Sample characteristics /Demographic features of the respondents and sample;
- Exposure type and assessment;
- Outcome type and assessment;
- Confounders;
- Direction and strength of reported exposure effect relations; [5]
- Study quality /risk of bias. [5]

Note that sections 3.1, 3.2, 3.3 and 3.4 follow a slightly different pattern, due to available detail in the papers, and/or disciplinary differences in reporting and related to specific publication cultures in the epidemiology, acoustics and social surveys.

2.2.3 *Assessment of Quality and risk of bias*

In view of limited time, evaluation of the study quality and risk of bias was dealt with differently for the separate parts of the review and different from the WHO reviews which used the GRADING system.

In view of quality, for cardiovascular and metabolic effects, only case control or cohort studies were included in the update. For annoyance, sleep and the new noise sources two evaluators evaluated the study quality. In view of time, for the assessment of the quality of the study we used a short and user-friendly instruments of the National Institute of Health (NIH) (https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools). The risk of bias (see also footnote [4]) due to exposure misclassification, selective participation and confounding was assessed for the relevant studies as proposed by Grimes and Schulz. [9] The method of rating was broadly based on schemes used by previous

[5] Due to time constraints, this was only done for annoyance and sleep disturbance but not for cardiovascular and metabolic effects

systematic reviews.[10] Ratings are categorised as low, medium or high risk of bias.
The third screening was based on the following criteria: is the design relevant, study size, do we know the response rate, exposure presented at least in categories, outcome measures relevant and standard, confounders relevant, (quality, bias) relevant statistical data available to be included in future meta-analysis.

3 Results

3.1 Environmental Noise (road, rail, aircraft noise, wind turbines) in relation to annoyance and sleep disturbance

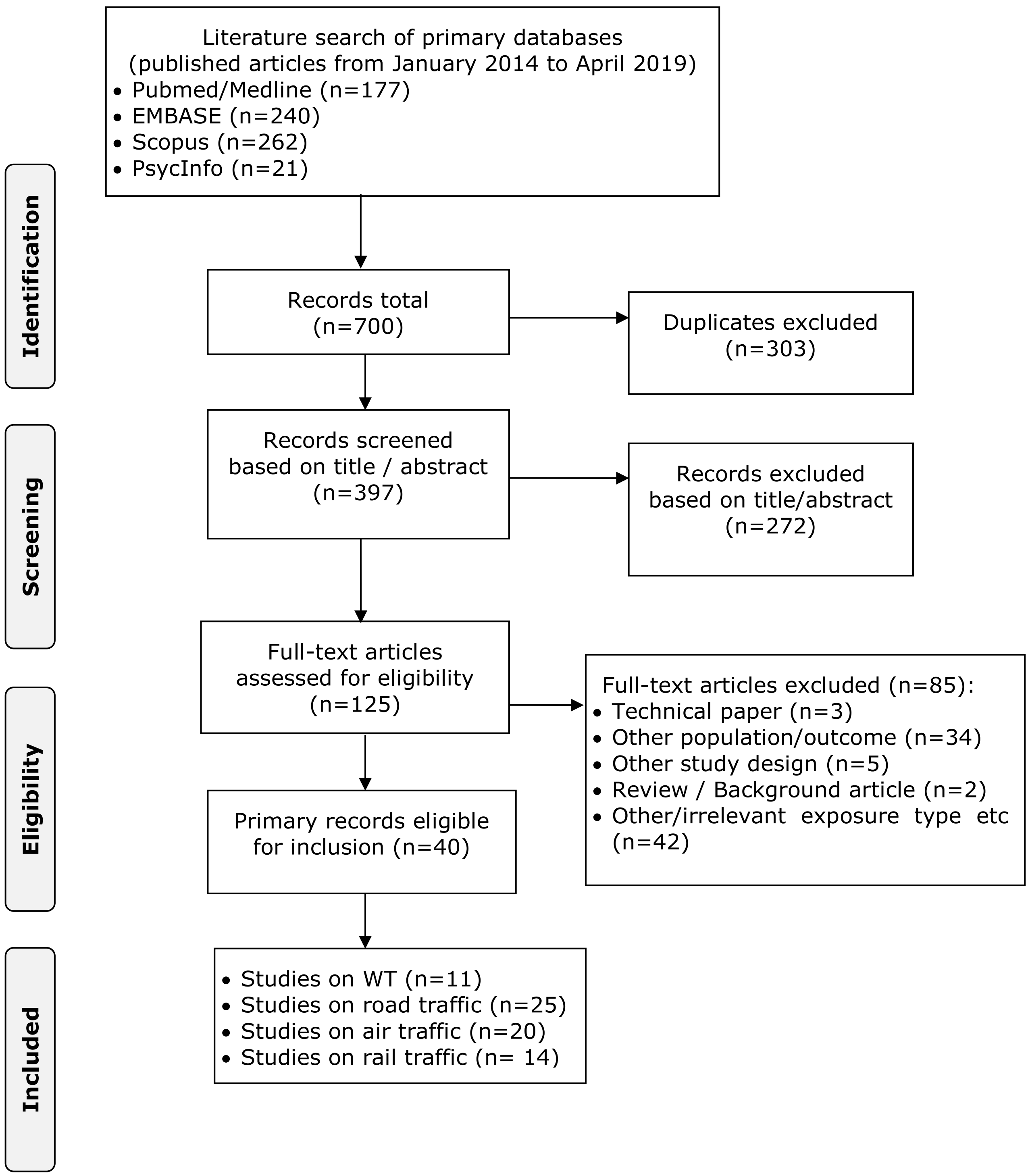

Figure 3.1.1: Flowchart outlining the study selection process

In total forty new papers [20-59] pertaining to seventy three (sub) studies were identified which fulfilled our selection criteria, and of which fourteen address wind turbine noise, twenty five road traffic noise, twenty air traffic noise and forteen rail traffic noise, respectively. Of these fourteen were on sleep, eighteen on annoyance and eight on both. Distribution over the sources is partly comparable to the WHO reviews with respectively thirty seven, eighteen, and fourteen eligible studies pertaining to road traffic noise, air traffic noise and rail traffic noise and zero for wind turbine noise. Most studies are, as expected, of cross-sectional design, and one study was a case control study. Several sleep studies have longitudinal elements, but are still of cross-sectional design. Typical is the geographical spread of the studies including more studies from Asia(8), South America(1), India(1) and Canada (4) than was previously the case. Also for the latter, it needs to be considered whether only the EU studies should be pooled or all studies are eligible for such a comparison, as was done in the WHO review. In view of the issues raised by Guski et al [2] and the current debate [13, 14, 15] regarding the effect of selection of studies in the WHO meta-analyses or meta regression analysis on the Guideline values, closer examination would be worthwhile from a scientific as well as a policy point of view. Guski et al [2] showed for example that including the Alpine studies and the Asian studies strongly affected the EERs for road traffic noise, potentially due to geographical differences, urban form and airconditioners use. Therefore, they computed an additional EEr for the WHO Road dataset excluding five Alpine and ten Asian studies. The new curves are more comparable with the original Miedema curves, but an increase is observed above 70 dB. The commentary of Gjetsland [13, 14, 15] also concerned the effect of in- and exclusions of studies for airtraffic noise.

3.1.1 *Studies investigating the impact of noise on sleep disturbance*

For the WHO evidence review [1] seventy four studies were identified and thirty three studies selected investigating the association between noise and sleep. Separate meta-analysis were performed per noise source and per type of outomce (selfreported sleep disturbance versus polysomnographics). All studies were cross-sectional by design.
The new literature research yielded forty two[38-59] new studies investigating the association between transport noise and wind turbine noise and sleep. Overall the sleep disturbance effects are not consistent, possibly due to methodological differences between the studies. Twelve of the studies are related to airtraffic noise, ten to road and six to rail. The largest increase in the field of wind turbine noise, with eleven studies using selfreported disturbance as outcome and three using objective indicators. The sleep studies performed in relation to other sources provide inconclusive evidence and the outcome measures were not always comparable. The number of studies with large size and of good quality has increased in particular for wind turbine noise and this justifies a meta-analysis. For aircraft noise new evidence from the DEBATS (France) and NORAH study (Germany) in relation to sleep disturbance suggest an update and this could also be considered for road and rail traffic noise, although for these sources no large differences are to be expected as far as annoyance reactions are concerned. A separate meta-analysis on the objective measures is suggested, analogous to the WHO review. The new studies also provide more evidence on the role of the number of events and the Lmax levels

and it would be worthwhile comparing the outcomes from the different new studies including the different noise indicators.

3.1.2 *Studies investigating the impact of noise on annoyance*

For the WHO [2] evidence review, sixty two studies were identified investigating the association between noise and annoyance of which fiftyseven studies were selected to be included in the meta-analysis. Separate meta-analyses were performed per noise source fifteen for aircraft noise, twentysix/eleven studies for road traffic noise, in and excluding the Alpine study data and the Asian data, eleven studies on railtrafic noise and four studies on wind turbine noise. All but one studies were cross-sectional by design.

The new literature research yielded forty new studies [20-38] investigating the association between transport noise and wind turbine noise and annoyance. Overall the annoyance outcomes show a similar pattern across noise levels. Thirteen of the studies are related to airtraffic noise, ten to road and eight to rail. The largest increase we see in the field of wind turbine noise, with nine studies using annoyance as outcome. The number of studies with large size and of good quality has increased in particular for wind turbine noise and justifies a meta-analysis. For aircraft noise new evidence from the DEBATS (France) and NORAH study (Germany) in relation to annoyance suggest an update and this could also be considered for road and rail traffic noise, although for these sources no large differences are to be expected as far as annoyance reactions are concerned.

3.2 Environmental noise (road, rail air traffic and windturbines) in relation to cardiovascular and metabolic effect

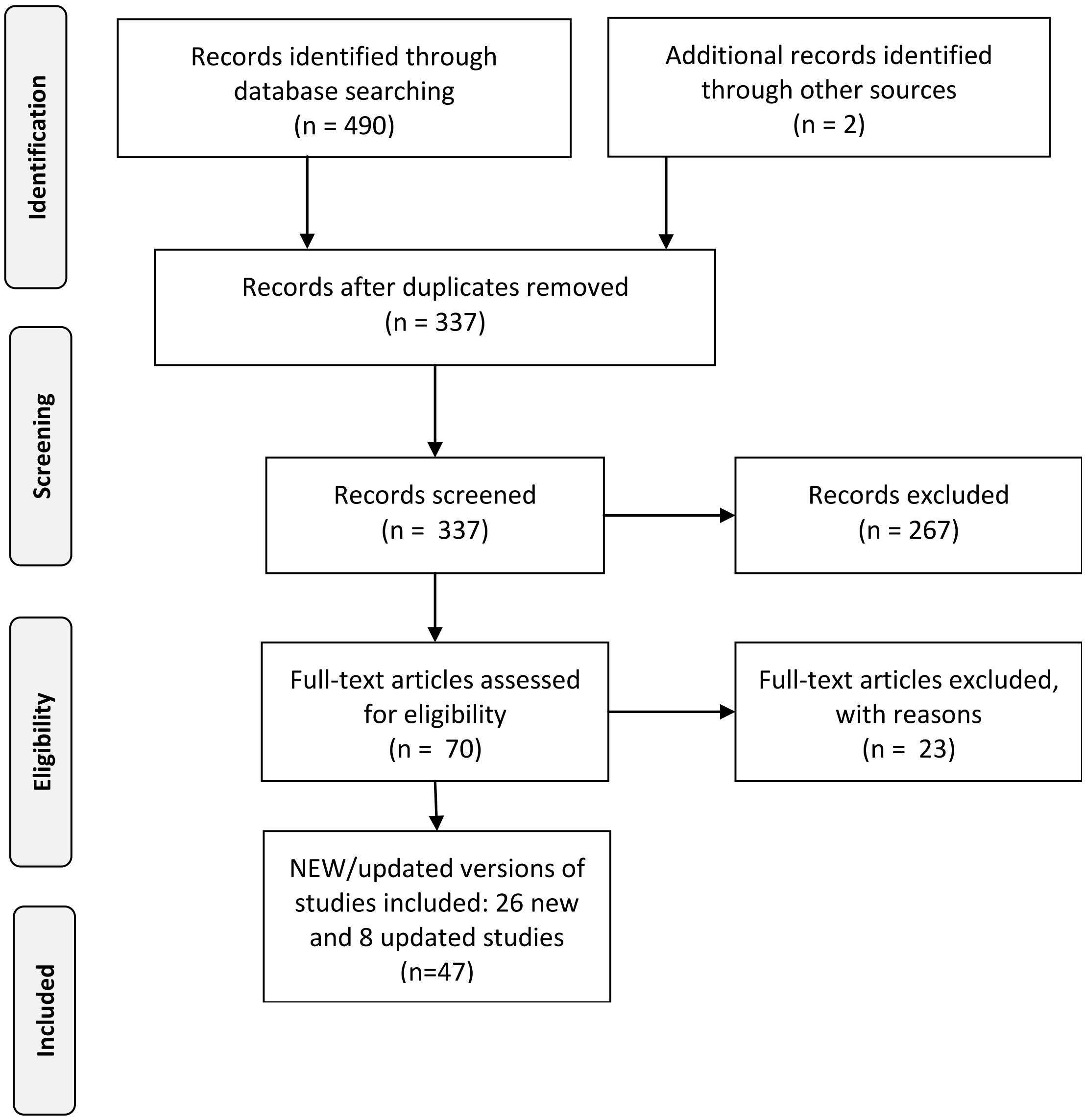

Figure 3.2. 1: Flowchart outlining the study selection process for cardiovascular and metabolic effects

The WHO evidence review on cardiovascular and metabolic effects[4] evaluated sixty one studies in total. The new literature search yielded three hundred and thrirty seven references (after removal of duplicates) in total. The screening of references for the eligibility resulted in seventy references. Following further screening, forty seven [60-106]references fulfilled our inclusion criteria. These references described thirty four different studies. Eight of these studies were already included in the WHO evidence review and contained updated and/or additional results. Twenty-six studies were new and not already included in the evidence review.

3.2.1 *Studies investigating the impact of noise on the incidence of hypertension*[6]

Aircraft noise and hypertension

The new literature research yielded three different studies investigating the association between aircraft noise and hypertension: three cross-sectional studies [62-64], one case-control study [65-67] and two cohort studies [60,61]. Two of the studies, identified as part of the new literature research, were already included in the WHO evidence review; they contained new and/or additional results.

For this report, we will only focus on case-control and cohort studies, since these are regarded as high quality studies. As part of the WHO evidence review, only one cohort study was included investigating the association between aircraft noise exposure and the *incidence* of hypertension: The cohort of the Stockholm Diabetes Preventive Program (SDPP). As part of the new literature search, we found that the researchers of the SDPP-study reported new results. [61] In contrast with the results of their earlier analyses, the researchers of the SDPP study now reported a statistically significant positive association between aircraft noise and the *incidence* of hypertension. According to the researchers of the SDPP study several methodological improvements were responsible for this change in effect.

In addition to the new results of the SDPP study, the literature search also found a new small cohort study [60] and a large case-control study [65-67] investigating the association between aircraft noise and the *incidence* of hypertension. After adjustment for confounders, the case-control study did not find an association between aircraft noise exposure and the *incidence* of hypertension. In the small cohort study, an elevated risk for hypertension was found in relation to aircraft noise exposure.

Road traffic noise and hypertension

The new literature research yielded sixteen [68-75] studies investigating the association between road traffic noise and the *incidence* of hypertension: of which nine case-control or cohort studies. [60,65, 66, 67 71,72] Five of the studies, identified as part of the new literature research, were already included in the WHO evidence review but contained new and/or additional results.

A systematic evaluation and meta-analysis would demonstrate whether and how the results of these newly found studies affect the conclusions of the WHO review with regard to road traffic noise and hypertension.

Rail traffic noise and hypertension

For the WHO evidence review, already eight studies were evaluated that investigated the association between rail traffic noise and hypertension. All studies were cross-sectional, except one cohort study.

[6] *Mortality* from hypertension was considered, but we were not able to identify case-control or chort studies that investigated the association between traffic noise and mortality due to hypertension. We only found one Spanish ecological study that in vestigated the association between road traffic noise and mortality due to hypertension.

The new literature research yielded three studies [61, 65-67, 74] investigating the association between road traffic noise and hypertension: one cross-sectional study7 [4], one case-control study [65-67] and one cohort study.[61] The latter two studies did not find an association between rail traffic noise and the *incidence* of hypertension. Although it is not believed likely that the new results will change the conclusions of the WHO evidence review with regard to the association between rail traffic noise and the *incidence* of hypertension, a systematic evaluation and meta-analysis can be applied to demonstrate this hypothesis

Wind turbine noise and hypertension
The new literature research yielded two studies investigating the association between wind turbine noise and hypertension: one cross-sectional study [76-78] and one cohort study.[79, 80]

The authors of the cohort study (The Danish Wind turbine Study (DWS) concluded that their study does not support an association between wind turbine noise and redemption of antihypertensive medication.

Note that redemption of antihypertensive medication is considered to be an indicator of hypertension.

The number of high quality studies is too limited to justify a meta-analysis.

3.2.2 *Studies investigating the impact of noise on ischemic heart disease*

Aircraft noise and ischemic heart disease
The new literature research yielded five studies investigating the association between aircraft noise and ischemic heart disease (IHD): one ecological study [83, 84], three cohort studies [60, 81, 82, 86] and one case-control study.[66, 85] One of the cohort studies, identified as part of the new literature research, was already included in the WHO evidence review; it contained new and/or additional results of the Swisss National Cohort study (SNC).

The association between aircraft noise and the *incidence* of IHD was investigated in two of the three cohorts and in the case control study; the association between aircraft noise and *mortality* due to IHD was investigated in one of the three cohorts and the case control study. A systematic evaluation and meta-analysis would demonstrate whether and how the results of the newly found studies affect the conclusions of the WHO review with regard to aircraft noise and IHD.

Road traffic noise and ischemic heart disease
The new literature research yielded fourteen studies investigating the association between road traffic noise and *incidence* of IHD, including ten cohort studies [61, 81, 82, 86, 87, 88, 89, 90, 91], and one case-control study [66, 85] investigating the association between road traffic noise and *mortality* due to IHD. One of the cohort studies, identified as part of the new literature research, was already included in the WHO evidence review; it contained new and/or additional results.

A systematic evaluation and meta-analysis will find out whether and how the results of the newly found studies affect the conclusions of the WHO review with regard to road traffic noise and IHD.

Rail traffic noise and ischemic heart disease
The new literature research yielded four studies investigating the association between rail traffic noise and IHD: one cross-sectional study [74], two cohort studies [81, 82, 86] and one case-control study [66, 85] The latter investigated the impact of rail traffic noise exposure on both the incidence and mortality due to IHD. In one of the cohort studies (SNC), the effect on mortality was studied, while in the other cohort studie (CAENS) the association with the incidence was investigated. most of these dealt with the *incidence* of IHD.
As part of the literature search, we found one new cohort study and one case control study investigating the association between rail traffic noise and *mortality* due to IHD.

Noise from wind turbines and ischemic heart disease
In total, we have identified and selected two new studies investigating the association between wind turbine noise and ischemic heart disease (IHD). Both were cohort studies [80, 93, 94], investigating the association between wind turbine noise and the *incidence* of IHD. Table 3.2.8 presents the characteristics of these studies. Both studies were identified and selected as part of the new search. The WHO evidence review included only three cross-sectional studies investigating the association between wind turbine noise and self-reported cardiovascular disease.

There is still not enough evidence to justify a meta-analyis on these data.

3.2.3 *Studies investigating the impact of noise on stroke*

Aircraft noise and stroke
The new literature research yielded five studies investigating the association between aircraft noise and stroke, of which three cohort studies [81, 82, 60, 86] and one case-control study. [66.95] One of the cohort studies, identified as part of the new literature research, was already included in the WHO evidence review but contained new and/or additional results.

The association between aircraft noise and the *incidence* of stroke was investigated in two of the three cohorts and in the case control study; the association between aircraft noise and *mortality* due to stroke was investigated in one of the three cohorts and the case control study.

A systematic evaluation and meta-analysis will confirm whether and how the results of the newly found studies affect the conclusions of the WHO review with regard to aircraft noise and the *incidence* of stroke.

Road traffic noise and stroke
The new literature research yielded eleven studies investigating the association between road traffic noise and stroke: two ecological studies

[70, 92], one cross-sectional study [74], seven cohort studies [60, 82, 86, 89, 90 91], and one case-control study. [66]
The new search yielded six cohort studies and one case-control study that investigated the association between road traffic noise and the *incidence* of stroke. The new search yielded one cohort study and one case-control study that investigated the association between road traffic noise and *mortality* due to stroke.
A systematic evaluation and meta-analysis will find out whether and how the results of the newly found studies affect the conclusions of the WHO review with regard to road traffic noise and stroke.

Rail traffic noise and stroke
The new search yielded four studies investigating the association between rail traffic noise and stroke: one cross-sectional study [74] , two cohort studies [82, 86] and one case control study. [66, 95] In this group of newly identified studies, the association between rail traffic noise and the *incidence* of stroke was investigated in the NORAH study (case-control study) and the CAENS study (cohort study); the association between rail traffic noise and *mortality* due to stroke was investigated in the SNC-study (cohort study) and the NORAH study. In the WHO evidence review, no cohort nor case-control studies were included that investigated the association between rail traffic noise and the *incidence* or *mortality* due to stroke.

Given the number of eligible studies, we do not think it is recommendable to carry out a meta-analysis in order find out whether and how the results of the newly found studies affect the conclusions of the WHO review with regard to rail traffic noise and the *incidence* or *mortality* due to stroke.

Wind turbine noise and stroke
The new search yielded only one study [80, 94] that investigated the association between wind turbine noise and stroke. It was a cohort carried out in Denmark, investigating the association between wind turbine noise exposure and the *incidence* of stroke. Included were 712.402 persons aged 25-85 years.

The number of studies is too limited to justify a new meta-analysis.

3.2.4 *Studies investigating the impact of noise on diabetes*

Aircraft noise and diabetes
The new literature research yielded two studies investigating the association between aircraft noise and the *incidence* of diabetes: two cohort studies. [60, 96] As part of the WHO evidence review, already one study with high quality was included.

A follow-up of the Greek respondents of the HYENA study revealed no association between aircraft noise and the *incidence* of doctor-diagnosed diabetes. However, the results of the HYENA study were based on a relatively small number of participants and a small number of incident cases of diabetes. In contrast to the results of the SDPP study and the HYENA study, the researchers of the Swiss cohort study on Air Pollution and Lung and heart Disease In Adults (SAPALDIA) found a positive association between aircraft noise exposure and the *incidence* of diabetes.

The number of studies is too limited to justify a new meta-analysis on the association between air traffic noise and mortality. For the association between air traffic noise and the incidence of diabetes in total three studies were available, which makes it worthwile to try to carry out a meta-analysis.

Road traffic noise and diabetes
The new literature research yielded six studies investigating the association between road traffic noise and diabetes: two ecological studies [69, 98, 99], one cross-sectional study [74] and three cohort studies. [60, 96, 97] One of the cohort studies, identified as part of the new literature research, was already included in the WHO evidence review but contained new and/or additional results.

The new search revealed three new cohort studies, including new results from the Danish Cohort Study (DCH) study.
The number of studies is too limited to justify a new meta-analysis on the association between road traffic noise and mortality. For the association between road traffic noise and the incidence of diabetes in total three studies were available, which makes it worthwile to try to carry out a meta-analysis.

Rail traffic noise and diabetes
The new literature research yielded three studies investigating the association between rail traffic noise and the *incidence* of diabetes: one cross-sectional study [74] and two cohort studies. [96, 97] One of the cohort studies, identified as part of the new literature research, was already included in the WHO evidence review; it contained new and/or additional results from the DCH study.
The number of studies is too limited to justify a new meta-analysis.

Wind turbine noise and diabetes
The new literature research yielded two studies investigating the association between wind turbine noise and the *incidence* of diabetes : one cross-sectional study [76, 78] and one cohort study. [80, 100]

The number of studies is too limited to justify a new meta-analysis.

3.2.5 *Studies investigating the impact of noise on (indicators of) obesity*

Aircraft noise and obesity
The new literature research yielded two cohort studies investigating the association between aircraft noise and obesity: the SDPP study (presenting new results) and the SAPALDIA study. [101, 102] The SAPALDIA study also presented cross-sectional results. [101] The new results of the SDPP study confirmed the results of the first analyses: again, an increase in aircraft noise exposure was statistically significant associated with an increase in waist circumference. Instead of change in BMI, the researchers used other indicators of obesity: weight gain, the *incidence* of overweight, and the *incidence* of central obesity (measured by waist

circumference). All these indicators were statistically significantly associated with aircraft noise. In the SAPALDIA study, similar indicators of obesity were used as in the SDPP study. It appeared that not all these indicators were statistically significantly associated with obesity.

The number of studies is too limited to justify a new meta-analysis.

Road traffic noise and obesity
The new literature research yielded five studies investigating the association between road traffic noise and obesity: two cross-sectional studies [104, 105] and three cohort studies. [101, 102, 103] One of the cohort studies (SAPALDIA) also presented cross-sectional results. From two of the cohort studies (SDPP and DCH), identified as part of the new literature research, the results of cross-sectional analyses were already included in the WHO evidence review. The new results include longitudinal data.

For the association between road traffic noise and the change in body mass index in total three studies were available, which makes it worthwile to try to carry out a meta-analysis.

Rail traffic noise and obesity
The new literature research yielded three cohort studies [101, 102, 103] investigating the association between road traffic noise and obesity. One of the cohort studies (SAPALDIA) [101] also presented cross-sectional results. The results of cross-sectional analyses of two other cohort studies (SDPP and DCH) were already included in the WHO evidence review. The new results include longitudinal data.

For the association between rail traffic noise and the change in body mass index in total three studies were available, which makes it worthwile to try to carry out a meta-analysis.

Wind turbine noise and obesity
We did not identify any studies that investigated the impact of wind turbine noise on obesity.

3.2.6 *Blood pressure in children*

Aircraft noise and blood pressure in children
The new search did not reveal any new studies investigating the association between aircraft noise and children's blood pressure.

Road traffic noise and blood pressure in children
The new search revealed only one new cross-sectional study [106] investigating the association between road traffic noise and children's blood pressure.

Rail traffic noise and children's blood pressure
We did not identify any studies that investigated the impact of rail traffic noise on children's blood pressure.

Wind turbine noise and children's blood pressure
We did not identify any studies that investigated the impact of wind turbine noise on children's blood pressure.

3.3 Annoyance, sleep disturbance and other health effects due to low frequency noise from building services

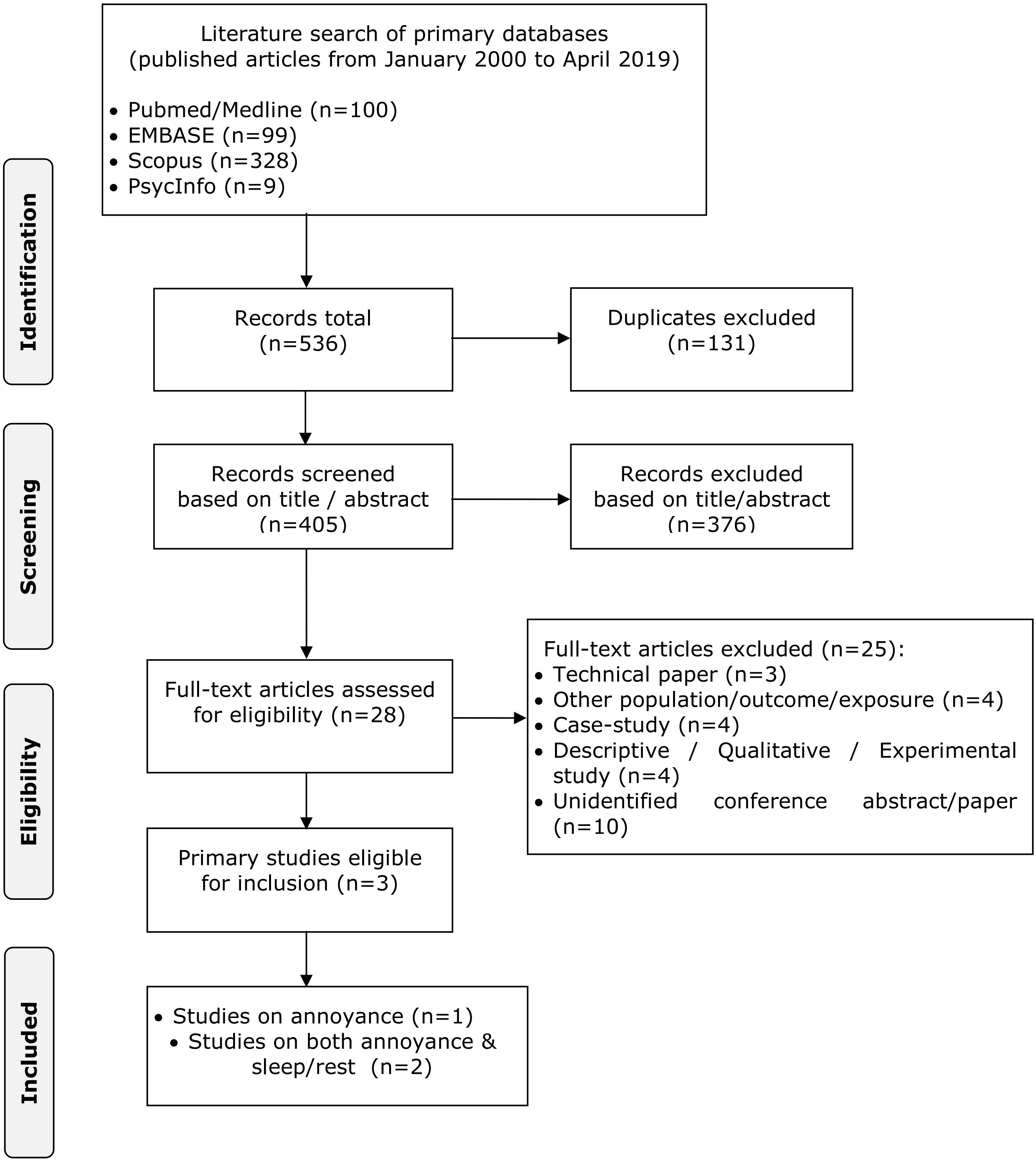

Figure 3.3.1. Flowchart outlining the study selection process for low frequency noise (LFN).

Figure 3.3.1 illustrates the selection process regarding the studies on building service related low-frequency noise (LFN). We examined more than fourhundred records in total. The vast majority of them were excluded during the first stage of screening (title/abstract). Main reasons were: experimental designs, occupational setting/exposure, focus on other outcomes/population/source and publication type (e.g. reviews/reports). In addition, a large part of the "potentially relevant" records referred to studies included in conference proceedings or abstracts. Based on our criteria, three observational studies were identified on the association between annoyance and/or sleep and sources such as ventilation systems and heat/water pumps. All studies were of cross-sectional design; n=2 conducted in Europe (Sweden) and one in China. Exposure was assessed based on objective measurements, while outcome evaluation was self-reported.

As shown in Table 3.3.1, one study suggested a significant association between LFN and annoyance. Risk of bias appeared to be moderate to high. Among the most important limitations were use of A-weighting, small sample size and limited adjustment for confounders. But the most prominent limitation is that all studies included only an estimate of exposed versus non-exposed. No indicidual exstimates of exposure are available and that enlarges the risk of exposure misclassification.

Results are in agreement with the findings of a rigorous systematic review (focusing on the period 2000-2015) on the association between everyday-life LFN and health effects, [16] indicating that the "state of the art" has not changed much and that epidemiological research in this field remains scarce. The previous review on the health effects of low frequency noise in general concluded that part of the population reports high annoyance attributed to LFN sources. LFN is associated with self-reported outcomes, mainly neurological , but current evidence is very limited, especially regarding chronic conditions. More epidemiological research on LFN and health effects is needed.

As a result, it is currently not possible to perform a quantitative synthesis/meta-analysis.

3.4 Annoyance, sleep disturbance and other health effects due to new sources (neihgbourhood, neighbours, industrial noise)

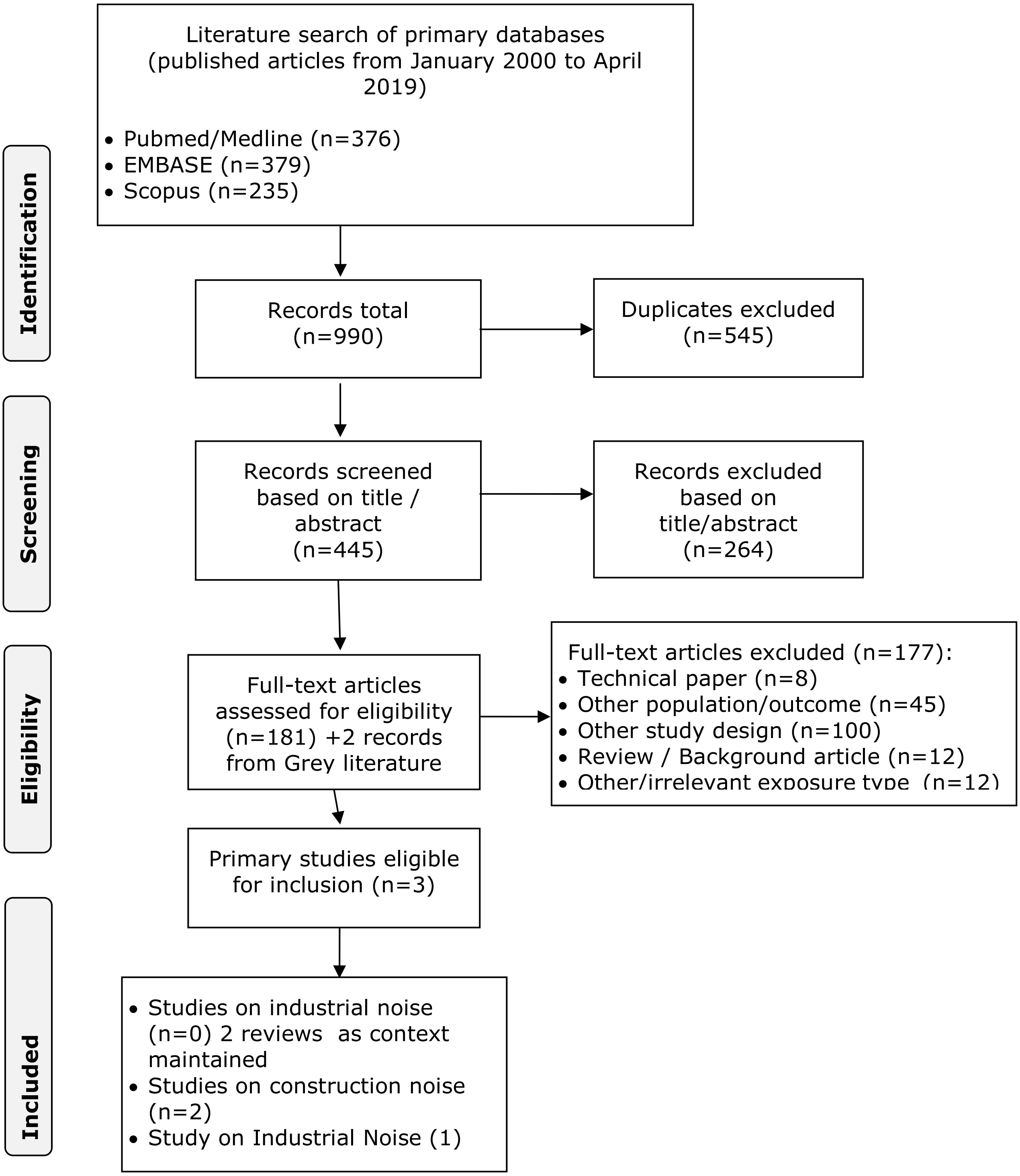

Figure 3.4.1. Flowchart outlining the study selection process for other sources

Within the category of other sources in relation to annoyance and sleep disturbance only a hand full of studies was identified that fulfilled the selection criteria to a degree. Within the category industrial sound only one study was selected. It concerns a crossectional study of considerable size in the Netherlands by Miedema and Vos [115] among over 1800 residents in the Lden range of 45-65 dBA from industrial sources. Residents were sampled from 5dB bands available before the study. Annoyance was measured using an 11-point scale, with verbal anchors at 0 (Not at all) and 10 (Very much), which was translated to a 0 to 100 scale based on the assumption that the annoyance categories divide this range in equally spaced intervals. The relationship between Lden and annoyance was modeled, with various situational and personal characteristics added stepwise as covariates. Lden was a significant predictor in simple models. Further, significant predictors included source type (highest for sources with vibration), age (highest in middle age), ownership of dwelling, working at the source, type of dwelling (lowest in flats), visibility of the source from specific rooms, fear of the industry, and annoyance with vibration or odour from the industry. Exposure effect relations were derived for seasonal activities, shunt sound and other and form the base for the regulation of industrial noise in several countries.

According to Baker [110] and based on a review on available evidence, it is unlikely that simple exposure effect curves could be produced for industrial noise annoyance in all cases due to the heterogeneity of sources, different noise characteristics, combinations of noise vibration, smoke, odour, etc. This standpoint was also adopted by WHO when it was decided not to include industrial noise in the Guidelines. Another relevant review was produced earlier by Berry and Porter [112]. However, most studies reviewed were from an earlier date, including the studies on which Miedema [115] based his review in 1993. They note a lack of clear definition in the field. It was then also concluded that in general industrial noise could be compared to road traffic noise, except when dealing with impulse noise and large differences in tonality. Note that by then wind turbine noise was still considered as industrial noise and current insights on the comparability of industrial noise and road traffic noise are changed and are seen as too different in nature.

In general, we can conclude that most industrial studies either are focused on occupational effects or are of an experimental design, both defined as exclusion criteria. Except for conference papers, we did not include grey literature, although it is very well possible that industrial studies at the local level (see e.g. the type of locations Miedema reports on) are published in reports, rather than in the peer reviewed literature. Current evidence does not allow for a meta- analysis.

The primary search in this domain of other sources resulted in Ninehundred and ninety references and contained a mix of papers dealing with industrial, neighbour and neighbourhood noise, including many irrelevant ones. Specifying the search terms in particular for impact noise (neighbours) and construction noise (neighbourhood noise) resulted in a more coherent selection. The high quality and well-designed studies into the effects of impact sound were nearly all excluded because of their experimental design and/or their focus on low frequency noise [7] and on acoustic detail rather than effect. Two Swedish studies [114, 116] are of longitudinal design and provide sufficient detail about exposure and annoyance, but the associations are only relevant in view of a reduction in annoyance due to insulation rather than an association between impact sound and levels of annoyance. In addition, it is not fully clear whether confounding was sufficiently accounted for in analysis. The evidence on the effect of neighbour noise as operationalised in impact sound is too limited to justify a meta-analysis at this stage. However, it could be considered instead to meta-analyse the high quality experiments in this domain which were excluded thus far also in the WHO reviews. Two high quality and well-designed construction noise studies were selected as examples. [111, 113] Both studies report on a strong association between mean annoyance scores and dB sound pressure levels related to construction noise, where the number of confounders adjusted for is quite limited. Again, the evidence is too limited to base a meta-analysis on at this stage.

[7] These have not been included in the low frequency section, because the focus there is in low frequency noise from building services.

4 Discussion and Conclusion

4.1 Summary of the Findings

The number of identified relevant/eligible studies in the different categories in the period between 2014 and 2019 on environmental noise and their effects on annoyance, sleep disturbance and cardiovascular and metabolic disease exceeded the initial expectations considerably. In general, the new studies are of considerable size, with low to medium risk of bias and have a larger geographical spread as compared to the evidence reviews. The number of studies related to low frequency noise from in and outdoor building services such as cooling and ventilation systems and heat pump published in the period between 2000 and 2019 that fulfilled our criteria is extremely small. Lastly, the literature searches in the category "other noises" including industrial, neighbour and neighbourhood noise yielded many references, but only a few fulfilled the criteria. In view of quality, for cardiovascular and metabolic outcomes only case-control and cohort studies were considered for selection, even though the tables include cross-sectional and ecological studies as well, just for completeness. For the other outcomes and sources, the risk for methodological bias was estimated and was generally evaluated as moderate in the studies on environmental noise and high in the few studies on low frequency noise.

4.2 Relation to previous reviews

Since the publication of the WHO reviews on annoyance and sleep disturbance, several new studies have been published and /or new results of existing studies were published. Below the findings of the WHO reviews are discussed per outcome and an overview is given of the number of studies included in the reviews and the number of new studies eligible to be included in any potential future meta-analysis.

The textboxes below show the details of the WHO literature reviews. First an overview is given of the method and results and gaps found in the WHO review. Next we present a table giving an overview of the number of studies included in the WHO review, the number of new studies eligible for a meta-analyses per outcome and per noise source and the potential for an actual meta-analysis. The recommendation of a potential meta-analysis was based on our professional view on whether there is sufficient new evidence to make updating the meta-analysis worthwhile. Whether such a meta-analysis would lead to significant relationships where there were none before or confirm or cancel existing relations can not be shown until the new analysis is complete.

4.2.1 *Annoyance and Sleep*

Annoyance[2]

Method: The WHO review identified 62 studies, using 46 studies used in quantitative meta-analyis; a systematic review search covering January 2000-2014

WHO Conclusions regarding the strength of the evidence:
- The quality of the evidence of for an association between air traffic noise levels and %HA was mainly judged as moderate .
- The quality of the evidence for an association between noise from road traffic %HA is mainly judged as "moderate"
- The quality of the evidence for an association between noise from rail traffic and %HA is being judged as "moderate" to "high"
- The quality of the evidence for an association between noise from wind turbines and %HA is mainly being judged as "low".

Research gaps & needs
- Main sources of heterogeneity seem to be the variance in the characterisation of exposure and the measurement and ascertainment of %HA
- Only very few studies on wind turbines were available.

Source	Total in WHO review	Eligible for MA-New	Update Meta analysis
Air	12	13	Yes
Road	25	10	Yes
Rail	9	8	Yes
Wind	0	9	Yes

Update
The new search revealed **40** studies studying the effects of noise on annoyance covering 2015 – 2019.

Figure 4.2.1: Summary of the strength of the evidence from the WHO review of annoyance; the number of studies in the WHO reviews, the number of new studies and advice on and update of the meta-analysis.

Sleep Disturbance and objective sleep indicators[1]

Method: The WHO review identified 74 studies of which 33 were used in a quantitative meta-analysis a systematic review search covering January 2000-2015

WHO Conclusions regarding the strength of the evidence:

- The quality of the evidence for an association with traffic noise was judged as "moderate" for cortical awakenings and self-reported sleep disturbance (for questions that referred to noise) induced by traffic noise,
- The quality of the evidence for an association with traffic noise and noise from wind turbines was judged as "Low" for motility measures of traffic noise induced sleep disturbance, and as "very low" for all other noise sources and investigated sleep outcomes on hyperactivity.
- The odds ratio for the percent highly sleep disturbed for a 10 dB increase in *Lnight* was significant for aircraft road and noise when the question referred to noise,
- The odds ratio for the percentage highly sleep disturbed was non-significant for aircraft , road and rail noise when the question did not refer to noise.
- The evidence that wind turbine noise affects sleep is still limited.
- Based on the available evidence, transportation noise affects objectively measured sleep physiology and subjectively assessed sleep disturbance in adults.
- For other outcome measures and noise sources the examined evidence was conflicting or only emerging.

Research gaps & needs:

- The number, size, and generalizability of studies on the effects of noise using objective indicators of sleep were not sufficient.
- Sleep disturbance can be problematic, as sleepers are unaware of themselves and their surroundings during large parts of the night. The heterogeneity of the studies thus limits the value of the generic EErs.

	In WHO MA	Eligible for MA-new	Potential to update Meta analysis
Air	8	12	yes
Road	15	10	yes
Rail	6	6	yes
Wind	4	14*	yes

Update

The new search revealed **42** studies addressing the effects of noise on sleep, covering the 2015 – 2019 period.

* Separate meta-analysis on objective sleep measures (3 studies) for windturbine noise are suggested

Figure 4.2.2: Summary of the strength of the evidence from the WHO review of sleep the number of studies in the WHO reviews, the number of new studies and advice on and update of the meta-analysis.

4.2.2 *Cardiovascular Outcomes*

Since the work of the WHO-evidence review was finished, several new case-control and cohort studies have been published investigating the impact of traffic noise on ischemic heart disease; in addition several studies which were already included in the WHO-evidence review have presented new results.

Cardiovascular Effects[4]

Method: The WHO review identified **61** studies, of which **53** were used in the quantitative meta-analyses a systematic review search covering January 2000-August 2015

WHO Conclusions regarding the quality of the evidence:

- A majority of the studies concerned traffic noise and hypertension, but most were cross-sectional Despite the fact that most of these studies adjusted for important confounders, and were able to ascertain individual exposure levels, the quality of the evidence from these studies was mainly rated as "very low".
- The most comprehensive evidence was available for road traffic noise and Ischemic Heart Diseases (IHD). Revealing a significant association
- We rated the quality of the evidence based on these longitudinal studies as "high".

Research gaps & needs:

For a comprehensive assessment of the impact of noise exposure on the cardiovascular system, we need more and better quality evidence best provided by case-control and cohort studies.

Update

The new search revealed 30 studies styding the effects of noise on the cardiovascular system covering 2015 – March 2019.

Hypertension: incidence

	Total in WHO review	Eligible for MA-new*	Potential to update Meta analysis
Air	1	3	yes
Road	1	9	Yes
Rail	1	3	Yes
Wind	0	3	No

IHD: incidence

	Total in WHO review	Eligible for MA-new*	Potential to update Meta analysis
Air	0	3	Yes
Road	7	15	Yes
Rail	0	2	No
Wind	0	2	No

IHD: mortality

	Total in WHO review	Eligible for MA-new*	Potential to update Meta analysis
Air	1	2	No
Road	3	5	Yes
Rail	0	2	No
Wind	0	0	No

Stroke: incidence

	Total in WHO review	Eligible for MA-new*	Potential to update Meta analysis
Air	0	3	Yes
Road	1	8	Yes
Rail	0	2	No
Wind	0	1	No

Stroke: mortality

	Total in WHO review	Eligible for MA-new*	Potential to update Meta analysis
Air	1	2	No
Road	3	5	Yes
Rail	0	2	No
Wind	0	0	No

*Total number of studies: newly identified and already included in WHO review

Figure 4.2.3: Summary of the strength of the evidence from the WHO review of cardiovascular effects; the number of studies in the WHO reviews, the number of new studies and advice on and update of the meta-analysis.

4.2.3 *Metabolic Outcomes*

Metabolic Effects[5]

Method: The WHO review evaluated the results and quality of **8** studies using a systematic review search covering January 2000-August 2015

WHO Conclusions regarding the quality of the evidence:
- Only a few studies reported on the association between transportation noise and stroke, diabetes, and/or obesity.
- The quality of evidence for these associations was rated from moderate to very low, depending on transportation noise source and outcome, primarily based on longitudinal studies.

Research gaps & needs:
For a comprehensive assessment of the impact of noise exposure on metabolic system, we need more and better quality evidence

Update
The new search revealed 8 studies studying the effects of noise on the metabolic system, covering 2015 – March 2019.

Diabetes: incidence

	Total in WHO review	Eligible for MA-new	Update Meta analysis
Air	1	3	Yes
Road	1	3	Yes
Rail	1	2	No
Wind	0	1	No

Change in BMI*

	Total in WHO review	Eligible for MA-new	Update Meta analysis
Air	1	2	No
Road	0	3	Yes
Rail	0	3	Yes
Wind	0	0	No

Change in WC†

	Total in WHO review	Eligible for MA-new	Update Meta analysis
Air	1	2	No
Road	0	2	Yes
Rail	0	2	No
Wind	0	0	No

Central obesity: incidence (waist circumference)

	Total in WHO review	Eligible for MA-new	Update Meta analysis
Air	0	2	No
Road	0	2	No
Rail	0	2	No
Wind	0	0	No

Overweight: incidence

	Total in WHO review	Eligible for MA-new	Update Meta analysis
Air	0	2	No
Road	0	2	No
Rail	0	2	No
Wind	0	0	No

*BMI = Body Mass Index, WC† = Waist circumference

Figure 4.2.4: Summary of the strength of the evidence from the WHO review of metabolic effects; the number of studies in the WHO reviews, the number of new studies and advice on and update of the meta-analysis.

4.3 Strength and limitations of this review

As stated before, the number of new studies potentially relevant was much larger than originally foreseen. Therefore, within the limited time for this qualitative review, it was a challenge to screen the many full papers. We had to compromise sometimes at the cost of the level of detail. For cardiovascular and metabolic effects such screening was partly performed earlier, which shows in the level of detail in some of the presented materials within this domain as compared to the other parts of the review. On the other hand, data extraction was more extensive for annoyance and sleep disturbance and for the new sources and includes the results of the single studies and an estimate for the risk of bias.

Despite the limited time, we expanded the search (publication) period on LFN starting from 2000 instead of 2014 as initially (planned/requested), in search of more relevant studies. The findings were compared with those of our systematic review from 2016 on LFN and health.[16] Also, a search was performed on other sources (industrial noise, neighbour and neighbourhood noise) in relation to annoyance and sleep. For the latter group and in particular neighbour and neighbourhood noise, refinements are needed to detect the relevant literature. Also it impresses that most studies in this domain might require a closer search in the grey literature, which except for conference papers, was not part of this assignment.

The present qualitative review focused on studies that investigated annoyance and/or sleep and cardiovascular as a primary outcome, and objectively measured or estimated noise levels as primary predictor. However, several studies were identified that considered noise exposure or annoyance as a confounder or mediator/moderator and therefore effect sizes of noise-outcome associations were not provided in the published article. These studies were excluded in the current review update, but it might be worthwhile to reconsider them in future meta-analyses, under the condition that the necessary data are available.

Risk of bias assessment was only estimated for annoyance and sleep and for the new noise sources. It primarily focused on aspects such as exposure misclassification, selective participation and confounding as proposed by Grimes and Schulz. [9] The rating method was qualitative and comparable to schemes applied in recent systematic evaluations of the observational literature on different exposures. [10, 16]
However, this assessment was not a prerequisite for the consideration of a study as eligible for inclusion. Besides risk of bias, at a later stage further and more elaborate evaluation of study quality, based on a validated instrument specialized in observational research is needed.

4.4 Criteria for guidance and implications for future research

To evaluate whether an update of the Guidelines is needed and/or should be extended two sets of criteria as a base of guidance were formulated in the contract:

1) *Criteria to make a statement about use or need for adaptation of the exposure response relationships and/or risk ratios proposed in the WHO systematic review should be considered by the IGCB(N) (cardiovascular, metabolic effects, annoyance, sleep)*
2) *Criteria to make a statement about the potential to derive ERR/EER relations for sources not included in the WHO systematic reviews, and identify how appropriate exposure response functions and/or risk ratios could be identified (if appropriate): LFN, industrial noise, neighbour and neighbourhood noise as defined by Noise Policy Statement for England.*

Criteria underlying the statements include: Number of studies, Quality of studies, same studies but other endpoints; Results seem to deviate strongly from what was concluded by earlier WHO reviews (for statement 1). Enough evidence to derive an EEr; Study methods are comparable and there is sufficient statistical detail to derive an EEr (for statement 2).

Based on our findings we think that a meta-analysis including the newly identified studies in the field of environmental noise is feasible. In view of study heterogeneity and to perform the meta-analyses properly, it is crucial to obtain accurate data with comparable cut-off points in outcomes where relevant (e.g. % HA, HSD, Low on well-being etc.) when those are not derivable from the publications. Communication with the original authors often constitutes a great challenge and a time-consuming process. However, research groups that belong to our broader scientific network, which is important facilitating factor, conducted several of the published studies.

Below our tentative guidance is given per outcome and noise source.

Annoyance
For Aircraft noise, local EErs for Annoyance are available in the UK based on the SoNA project in 2014.[12] For aircraft noise new evidence from some large studies (the DEBATS study in France and the NORAH study in Germany) in relation to annoyance warrant an update and potential meta-analysis. In this context, it is important to mention the current debate about the validity of the presented evidence in the WHO review of Guski et al [2] , as "some of the referenced studies have not been conducted according to standardized methods, and the selection of respondents is not representative of the general airport population. [13, 15]
The critique is that the new WHO Guidelines are based on a questionable selection of existing aircraft noise studies. Guski et al [14] have commented on this. In light of this discussion, an update of the review and its consequences for the current Guideline values for air traffic noise and annoyance need close examination of which studies should be included in a meta-analysis.
Based on the new material an update could also be considered for *road and rail traffic noise*.
It needs to be considered whether only the EU studies should be pooled or (as was done in the WHO reviews) that all studies are eligible for such a comparison.
For *wind turbine noise* new evidence from e.g. the Public Health Canada study, the Danish cohort study, studies from Japan and Poland about the association between noise and annoyance warrants closer examination of the studies regarding the feasibility to derive a EErs.
For the *other sources,* insufficient evidence is available to derive a relevant EEr.
For *industrial noise*, it might be worthwhile studying the local, gray literature. For neighbour noise, it could be worthwhile to study the results of the high quality experimental studies.

Sleep Disturbance
The sleep studies performed in relation to different sources provide inconclusive evidence and the outcome measures are not always comparable. It could be considered to perform a meta-analysis on the new evidence on self-reported sleep disturbance for the different transport sources separate and perform a separate meta-analysis on the objective measures. This distinction between self-reported (long-term) and objective (acute) effects was also made in the WHO review on sleep.[1.]
For *all transport sources combined,* a meta-analysis is suggested for self-reported sleep disturbance.
For *wind turbine noise* new evidence from especially the Public Health Canada study and the Danish cohort study on the association between noise and objective sleep measures a meta-analysis would be worthwhile considering.
The new studies also provide more evidence on the role of the number of events and the Lmax levels and it would be worthwhile comparing the outcomes from the different new studies including the different noise indicators such as the number of events and maximum noise levels (*Lmax*).
For the *other sources*, insufficient evidence is available to derive a relevant EEr.

Cardiovascular disease
For the *incidence* of hypertension, it would be worthwhile to have a closer look at the new evidence and decide whether it is feasible to derive generalised EErs for road traffic, rail traffic and air traffic. In the WHO evidence review, hypertension is included as an endpoint, since WHO considered it as one of the critical endpoints for deriving their noise guideline values.
In our method report for the EU commission we concluded that in the Health Impact Assessment Context [11] hypertension is not necessarily a good endpoint, since it might lead to double counting. [8] There are methods to deal with this. In former health impacts for example, we estimated how many cases of hypertension are related to noise, and in the next step we estimated how many strokes/or heart attacks or other health effects can be explained by these cases of hypertension.[17] In other words, the value of this indicator and the different approaches depends on the aims it is used for (HIA versus norm setting). The current UK methodology for valuing hypertension-related impacts due to environmental noise can be characterised as a health impact assessment. [18] Hypertension, but also diabetes or obesity, are considered as risk factors for a broader set of outcomes than described by WHO, including not only IHD and stroke, but also dementia, renal disease in its end stages etc. However, in relation with the assessment of the magnitude of environmental noise we nowadays do not include these endpoints. In earlier assessments the two step approach [19] of calculating the risk of hypertension due to noise first and subsequentially link these extra cases to the risk of each outcome associated with hypertension was applied. We believe it is an adequate one in the context of a health impact assessment. But is highly dependent on the research or policy question, whether one decides to include indicators such as hypertension, diabetes or obesity.
The number of newly identified studies/publications suggests that the WHO relationships may already require updating for road, and air and IHD (re-run meta-analysis with new studies included). For stroke, a new meta-analysis is suggested for *road and air traffic.*
Especially for *road traffic noise*, it is suggested to carry out a systematic evaluation and possible meta-analysis to find out how the conclusions of the WHO evidence review change.
In order to increase the robustness of a possible new exposure-effect relationships, it is suggested not only to derive source-specific EErs (also for normsetting), but also to try to derive “overall” EErs. The latter is especially relevant in the framework of health impact assessment.
To this end, we suggest to include also the new studies investigating the effects of *aircraft and rail traffic noise* in this systematic evaluation.

Metabolic Effects
It is suggested to carry out a systematic evaluation on diabetes in relation to *road- and air traffic* noise to find out whether the conclusions of the WHO evidence review change with the new evidence. New exposure-effect relationships could be derived by means of meta-analyses. However, given the limited number of studies, these relationships are expected not to be very robust.

[8] There will always be double counting e.g. when you calculate the number of cases per source (road and air)

It is suggested to carry out a systematic evaluation (or to improve the quality of the evidence) to find out whether the conclusions of the WHO evidence review change with new evidence on obesity. New exposure-effect relationships could be derived by means of meta-analyses. However, given the limited number of studies, these relationships are expected not to be very robust.
Although the associations between *wind turbine noise* and cardiovascular /metabolic effects is weak, the new studies justify a closer look at quality and strength of evidence. A meta-analysis is not expected to be feasible.
For the *other sources,* there is insufficient evidence for an association with cardiovascular or metabolic outcomes.

4.5 End conclusion

This review was performed to draw conclusions about the need for an update of the exposure effect relations derived in the WHO noise reviews. The review also includes noise sources, which were not included in the WHO evidence reviews, which were focussed on transport noise and wind turbine noise low frequency noise, neighbour-neighbourhood noise, and industrial noise.
Results showed that since 2014 an impressive number of articles was published addressing the association between transport related noise and wind turbine noise and annoyance, sleep disturbance and cardiovascular effects. The average quality is moderate to high (with regard to sleep and annoyance!) and remarkable is the broad geographic spread of the studies described. The number and size of the new studies warrant new meta-analyses in particular where the cardiovascular effects are concerned, but also for annoyance and sleep disturbance. For the Cardiovascular and metabolic effects the recent meta-analysis by Vienneau et al[117] should be taken into account. Differences in effect due to the in- or exclusion of different types of study should be discussed. In addition, the new evidence regarding wind turbine noise and effects would justify meta-analyses on all effects studied. Overall, it is worthwhile to have a closer look at the transport related source- specific new findings on annoyance and sleep before deciding whether new meta-analyses are needed. As for the other noise sources, only a handful of articles met the inclusion criteria. In the first place, these sources need to be defined better, and secondly more well designed field studies are needed to understand the direct and indirect health effects of low frequency noise, neighbour and neighbourhood noise and industrial noise.

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5 References

1. Mathias Basner and Sarah McGuire WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Effects on Sleep Int. J. Environ. Res. Public Health 2018, 15(3), 519; doi:10.3390/ijerph15030519
2. Guski R, Schreckenberg D, Schuemer R. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Annoyance. International journal of environmental research and public health. 2017 Dec 8;14(12):1539.
3. Clark C, Paunovic K. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cognition. International journal of environmental research and public health. 2018 Feb 7;15(2):285.
4. Kempen van EEMM, et al., Cardiovascular and metabolic effects of environmental noise. Systematic evidence review in the framework of the development of the WHO environmental noise guidelines for the European Region. 2017, RIVM: Bilthoven.
5. Kempen van EEMM, Casas M, Pershagen G, Foraster M. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Cardiovascular and Metabolic Effects: A Summary. International journal of environmental research and public health. 2018 Feb 22;15(2):379.
6. Nieuwenhuijsen MJ, Ristovska G and Dadvand P. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Adverse Birth Outcomes. Int. J. Environ. Res. Public Health 2017, 14(10), 1252; doi:10.3390/ijerph14101252
7. Śliwińska-Kowalska, M and Zaborowski K. WHO Environmental Noise Guidelines for the European Region: A Systematic Review on Environmental Noise and Permanent Hearing Loss and Tinnitus. Int. J. Environ. Res. Public Health 2017, 14(10), 1139; doi:10.3390/ijerph14101139
8. Moher D, Liberati A, Tetzlaff J, Altman DG. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. Annals of internal medicine. 2009 Aug 18;151(4):264-9.
9. Grimes DA, Schulz KF. Bias and causal associations in observational research. The lancet. 2002 Jan 19;359(9302):248-52.
10. Röösli M, Frei P, Mohler E, Hug K. Systematic review on the health effects of exposure to radiofrequency electromagnetic fields from mobile phone base stations. Bulletin of the World Health Organization. 2010;88:887-96
11. van Kamp I, Schreckenberg D, van Kempen EE, Basner M, Brown AL, Clark C, Houthuijs DJ, Breugelmans OR, van Beek AJ, Janssen-Stelder BM. Study on methodology to perform an environmental noise and health assessment-a guidance document for local authorities in Europe.

12. Wright, H, & Turner, S. 2017, SoNA 2014 Peer Review, Final Report, Department for Transport Contract: SO 16241-2, 26 January.
13. 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. 2018 Dec;15(12):2717.
14. Guski R, Schreckenberg D, Schuemer R, Brink M, Stansfeld SA. 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. 2019 Jan;16(7):1088.
15. Gjestland T. 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. 2019 Jan;16(7):1105.
16. Baliatsas C, van Kamp I, van Poll R, Yzermans J. Health effects from low-frequency noise and infrasound in the general population: Is it time to listen? A systematic review of observational studies. Science of the Total Environment. 2016 Jul 1;557:163-9.
17. Knol AB, Staatsen BA. Trends in the environmental burden of disease in the Netherlands, 1980-2020. RIVM rapport 500029001. 2005 Aug 8.
18. Defra (2014). Environmental Noise: Valuing impacts on: sleep disturbance, annoyance, hypertension, productivity and quiet
19. Harding A.H. et al., 2011 Quantifying the links between environmental noise related hypertension and health effects HSL Report for DEFRA http://randd.defra.gov.uk/
20. Banerjee, D. Road traffic noise exposure and annoyance: A cross-sectional study among adult Indian population. Noise and health. 2013; 15: 342.
21. Bunnakrid K, Sihabut T, Patthanaissaranukool W. The relationship between road traffic noise and annoyance level in Phuket province, Thailand. Asia-Pacific Journal of Science and Technology. 2017; 22.
22. Camusso C, Pronello C. A study of relationships between traffic noise and annoyance for different urban site typologies. Transportation Research Part D: Transport and Environment. 2016; 44:122-33.
23. Ragettli MS, Goudreau S, Plante C, Perron S, Fournier M, Smargiassi A. Annoyance from Road Traffic, Trains, Airplanes and from Total Environmental Noise Levels. International journal of environmental research and public health. 2015; 13.
24. Bartels S, Rooney D, Müller U. Assessing aircraft noise-induced annoyance around a major German airport and its predictors via telephone survey – The COSMA study. Transportation Research Part D: Transport and Environment. 2018; 59:246-58.

25. Cho Y, Kim J, Kim T, Hong J, Lee S. Comparative study on civil aircraft noise metrics as annoyance estimators for interoperability between other aircraft noise metrics. Journal of Mechanical Science and Technology. 2014; 28:3997-4003.
26. Quehl J, Muller U, Mendolia F. Short-term annoyance from nocturnal aircraft noise exposure: results of the NORAH and STRAIN sleep studies. International archives of occupational and environmental health. 2017; 90:765-78.
27. Licitra G, Fredianelli L, Petri D, Vigotti MA. Annoyance evaluation due to overall railway noise and vibration in Pisa urban areas. The Science of the total environment. 2016; 568:1315-25.
28. Pennig S, Schady A. Railway noise annoyance: exposure-response relationships and testing a theoretical model by structural equation analysis. Noise & health. 2014; 16:388-99.
29. Michaud DS, Keith SE, Feder K, Voicescu SA, Marro L, Than J, et al. Personal and situational variables associated with wind turbine noise annoyance. The Journal of the Acoustical Society of America. 2016; 139:1455-66.
30. Klaeboe R, Sundfor HB. Windmill Noise Annoyance, Visual Aesthetics, and Attitudes towards Renewable Energy Sources. International journal of environmental research and public health. 2016; 13.
31. Pawlaczyk-Luszczynska M, Dudarewicz A, Zaborowski K, Zamojska-Daniszewska M, Waszkowska M. Evaluation of annoyance from the wind turbine noise: a pilot study. International journal of occupational medicine and environmental health. 2014; 27:364-88.
32. Pawlaczyk-Łuszczyńska M, Zaborowski K, Dudarewicz A, Zamojska-Daniszewska M, Waszkowska M. Response to noise emitted by wind farms in people living in nearby areas. International journal of environmental research and public health. 2018; 15.
33. Pawlaczyk-Łuszczyńskaw M, Dudarewicz A, Zaborowski K, Zamojska-Daniszewska M, Waszkowska M. Annoyance related to wind turbine noise. Archives of Acoustics. 2014; 39:89-102.
34. Brink M, Schaffer B, Vienneau D, Foraster M, Pieren R, Eze IC, et al. A survey on exposure-response relationships for road, rail, and aircraft noise annoyance: Differences between continuous and intermittent noise. Environment international. 2019; 125:277-90.
35. de Paiva Vianna KM, Alves Cardoso MR, Rodrigues RM. Noise pollution and annoyance: an urban soundscapes study. Noise & health. 2015; 17:125-33.
36. Nguyen TL, Yano T, Nishimura T, Sato T. Exposure-response relationships for road traffic and aircraft noise in Vietnam. Noise Control Engineering Journal. 2016; 64:243-58.
37. Sung JH, Lee J, Park SJ, Sim CS. Relationship of Transportation Noise and Annoyance for Two Metropolitan Cities in Korea: Population Based Study. PloS one. 2016; 11:e0169035.
38. Evandt J, Oftedal B, Hjertager Krog N, Nafstad P, Schwarze PE, Marit Aasvang G. A Population-Based Study on Nighttime Road Traffic Noise and Insomnia. Sleep. 2017; 40

39. Han ZX, Lei ZH, Zhang CL, Xiong W, Gan ZL, Hu P, et al. Noise monitoring and adverse health effects in residents in different functional areas of Luzhou, China. Asia-Pacific journal of public health. 2015; 27:93s-9s.
40. Joost S, Haba-Rubio J, Himsl R, Vollenweider P, Preisig M, Waeber G, et al. Spatial clusters of daytime sleepiness and association with nighttime noise levels in a Swiss general population (GeoHypnoLaus). International journal of hygiene and environmental health. 2018; 221:951-7.
41. Martens AL, Reedijk M, Smid T, Huss A, Timmermans D, Strak M, et al. Modeled and perceived RF-EMF, noise and air pollution and symptoms in a population cohort. Is perception key in predicting symptoms? Science of the Total Environment. 2018; 639:75-83.
42. Holt JB, Zhang X, Sizov N, Croft JB. Airport noise and self-reported sleep insufficiency, United States, 2008 and 2009. Preventing chronic disease. 2015; 12:E49.
43. Kim K, Shin J, Oh M, Jung JK. Economic value of traffic noise reduction depending on residents' annoyance level. Environmental science and pollution research international. 2019; 26:7243-55.
44. Kwak KM, Ju YS, Kwon YJ, Chung YK, Kim BK, Kim H, et al. The effect of aircraft noise on sleep disturbance among the residents near a civilian airport: a cross-sectional study. Annals of occupational and environmental medicine. 2016; 28:38.
45. Nassur AM, Lefevre M, Laumon B, Leger D, Evrard AS. Aircraft Noise Exposure and Subjective Sleep Quality: The Results of the DEBATS Study in France. Behavioral sleep medicine. 2017:1-12.
46. Kageyama T, Yano T, Kuwano S, Sueoka S, Tachibana H. Exposure-response relationship of wind turbine noise with self-reported symptoms of sleep and health problems: A nationwide socioacoustic survey in Japan. Noise & health. 2016; 18:53-61.
47. Michaud DS, Feder K, Keith SE, Voicescu SA, Marro L, Than J, et al. Effects of Wind Turbine Noise on Self-Reported and Objective Measures of Sleep. Sleep. 2016; 39:97-109.
48. Michaud DS, Feder K, Keith SE, Voicescu SA, Marro L, Than J, et al. Erratum: Effects of wind turbine noise on self-reported and objective measures of sleep (Sleep (2016) 39:1 (97-109) DOI: 10.5665/sleep.5326). Sleep. 2018; 41.
49. Nassur AM, Leger D, Lefevre M, Elbaz M, Mietlicki F, Nguyen P, et al. The impact of aircraft noise exposure on objective parameters of sleep quality: results of the DEBATS study in France. Sleep medicine. 2019; 54:70-7.
50. Poulsen AH, Raaschou-Nielsen O, Pena A, Hahmann AN, Nordsborg RB, Ketzel M, et al. Impact of Long-Term Exposure to Wind Turbine Noise on Redemption of Sleep Medication and Antidepressants: A Nationwide Cohort Study. Environmental health perspectives. 2019; 127:37005.
51. Perron S, Plante C, Ragettli MS, Kaiser DJ, Goudreau S, Smargiassi A. Sleep Disturbance from Road Traffic, Railways, Airplanes and from Total Environmental Noise Levels in Montreal. International journal of environmental research and public health. 2016; 13.
52. Paiva KM, Cardoso MRA, Zannin PHT. Exposure to road traffic noise: Annoyance, perception and associated factors among Brazil's adult population. The Science of the total environment. 2019; 650:978-86.

53. Carugno M, Imbrogno P, Zucchi A, Ciampichini R, Tereanu C, Sampietro G, et al. Effects of aircraft noise on annoyance, sleep disorders, and blood pressure among adult residents near the Orio al Serio International Airport (BGY), Italy. La Medicina del lavoro. 2018; 109:253-63.
54. Pultznerova A, Eva P, Kucharova D, Argalasova L. Railway noise annoyance on the railway track in northwest slovakia. Noise & health. 2018; 20:90-100.
55. Radun J, Hongisto V, Suokas M. Variables associated with wind turbine noise annoyance and sleep disturbance. Building and Environment. 2019; 150:339-48.
56. Song K, Di G, Xu Y, Chen X. Community survey on noise impacts induced by 2MW wind turbines in China. Journal of Low Frequency Noise Vibration and Active Control. 2016; 35:279-90.
57. Argalášová L, Jurkovičová J, Ševčíková L, Štefániková Z, Hirošová K, Babjaková J, et al. Environmental noise and annoyance in the urban area at different time intervals C3 - Applied Mechanics and Materials. Trans Tech Publications Ltd; 2014. p. 110-5.
58. Douglas O, Murphy E. Source-based subjective responses to sleep disturbance from transportation noise. Environment international. 2016; 92-93:450-6.
59. Bodin T, Bjork J, Ardo J, Albin M. Annoyance, sleep and concentration problems due to combined traffic noise and the benefit of quiet side. International journal of environmental research and public health. 2015; 12:1612-28.
60. Dimakopoulou, K., et al., Is aircraft noise exposure associated with cardiovascular disease and hypertension? Results from a cohort study in Athens, Greece. Occupational and Environmental Medicine, 2017. 74(11): p. 830-837.
61. Pyko, A., et al., Transportation noise and incidence of hypertension. International journal of hygiene and environmental health, 2018. 221(8): p. 1133-1141.
62. Evrard, A.S., et al., Does aircraft noise exposure increase the risk of hypertension in the population living near airports in France? Occupational and Environmental Medicine, 2017. 74(2): p. 123-129.
63. Carugno, M., et al., Effects of aircraft noise on annoyance, sleep disorders, and blood pressure among adult residents near the Orio al Serio International Airport (BGY), Italy. La Medicina del lavoro, 2018. 109(4): p. 253-263.
64. Hiroe, M., et al. A questionnaire survey on health effects of aircraft noise for residents living in the vicinity of Narita International Airport: Part-2 analysis and result detail C3 - Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future. 2016. German Acoustical Society (DEGA).
65. Zeeb, H., et al., Traffic noise and hypertension – results from a large case-control study. Environmental Research, 2017. 157: p. 110-117.
66. Seidler, A., et al. Disease risks of traffic noise - A large case-control study based on secondary data C3 - Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future. 2016. German Acoustical Society (DEGA).

67. Zur Nieden, A., et al. NORAH - Field study: The Effects of chronic exposure to traffic noise (aircraft, railway and road traffic) on hypertension C3 - Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future. 2016. German Acoustical Society (DEGA).
68. Banerjee, D., P.P. Das, and A. Fouzdar, Urban residential road traffic noise and hypertension: a cross-sectional study of adult population. Journal of urban health : bulletin of the New York Academy of Medicine, 2014. 91(6): p. 1144-1157.
69. Barceló, M.A., et al., Long term effects of traffic noise on mortality in the city of Barcelona, 2004-2007. Environmental Research, 2016. 147: p. 193-206.
70. Carey, I.M., et al., Traffic pollution and the incidence of cardiorespiratory outcomes in an adult cohort in London. Occupational and Environmental Medicine, 2016. 73(12): p. 849-856.
71. Fuks, K.B., et al., Long-termexposure to ambient air pollution and traffic noise and incident hypertension in seven cohorts of the European study of cohorts for air pollution effects (ESCAPE). European Heart Journal, 2017. 38(13): p. 983-990.
72. Pitchika, A., et al., Long-term associations of modeled and self-reported measures of exposure to air pollution and noise at residence on prevalent hypertension and blood pressure. Science of the Total Environment, 2017. 593-594: p. 337-346.
73. Halonen, J.I., et al., Associations of night-time road traffic noise with carotid intima-media thickness and blood pressure: The Whitehall II and SABRE study cohorts. Environment International, 2017. 98: p. 54-61.
74. Zock, J.P., et al., The impact of social capital, land use, air pollution and noise on individual morbidity in Dutch neighbourhoods. Environment International, 2018. 121: p. 453-460.
75. Han, Z.X., et al., Noise monitoring and adverse health effects in residents in different functional areas of Luzhou, China. Asia-Pacific journal of public health / Asia-Pacific Academic Consortium for Public Health, 2015. 27(2): p. 93S-99S.
76. Michaud, D.S. Self-reported and objectively measured outcomes assessed in the health Canada wind turbine noise and health study: Results support an increase in community annoyancea C3 - INTER-NOISE 2015 - 44th International Congress and Exposition on Noise Control Engineering. 2015. The Institute of Noise Control Engineering of the USA, Inc.
77. Michaud, D.S., et al., Exposure to wind turbine noise: Perceptual responses and reported health effects. J Acoust Soc Am, 2016. 139(3): p. 1443-54.
78. Michaud, D.S., et al., Clarifications on the Design and Interpretation of Conclusions from Health Canada’s Study on Wind Turbine Noise and Health. Acoustics Australia, 2018. 46(1): p. 99-110.
79. Poulsen, A.H., et al., Long-term exposure to wind turbine noise and redemption of antihypertensive medication: A nationwide cohort study. Environment International, 2018. 121: p. 207-215.

80. Poulsen, A.H. and M. Sørensen. Wind Turbine Noise and health, a nationwide prospective study in Denmark C3 - Proceedings of the INTER-NOISE 2016 - 45th International Congress and Exposition on Noise Control Engineering: Towards a Quieter Future. 2016. German Acoustical Society (DEGA).
81. Héritier, H., et al., A systematic analysis of mutual effects of transportation noise and air pollution exposure on myocardial infarction mortality: A nationwide cohort study in Switzerland. European Heart Journal, 2019. 40(7): p. 598-603.
82. Héritier, H., et al., Transportation noise exposure and cardiovascular mortality: a nationwide cohort study from Switzerland. European Journal of Epidemiology, 2017. 32(4): p. 307-315.
83. Evrard, A.S., et al., Does exposure to aircraft noise increase the mortality from cardiovascular disease in the population living in the vicinity of airports? Results of an ecological study in France. Noise & health, 2015. 17(78): p. 328-336.
84. Evrard, A.S., et al., Does exposure to aircraft noise increase mortality from cardiovascular disease in people living near airports in France? L'exposition au bruit des avions augmente-T-elle la mortalité par maladie cardiovasculaire dans les communes riveraines des aéroports en France ? Environnement, Risques et Sante, 2016. 15(6): p. 506-514.
85. Seidler, A., et al., Myocardial infarction risk due to aircraft, road and rail traffic noise - Results of a case-control study based on secondary data Herzinfarktrisiko durch Flug-, Straßen- und Schienenverkehrslärm. Deutsches Arzteblatt International, 2016. 113(24): p. 407-414.
86. Pyko, A., et al., Long-term transportation noise exposure and incidence of ischaemic heart disease and stroke: A cohort study. Occupational and Environmental Medicine, 2019. 76(4): p. 201-207.
87. Roswall, N., et al., Long-term residential road traffic noise and NO2 exposure in relation to risk of incident myocardial infarction - A Danish cohort study. Environ Res, 2017. 156: p. 80-86.
88. Bodin, T., et al., Road traffic noise, air pollution and myocardial infarction: a prospective cohort study. International archives of occupational and environmental health, 2016. 89(5): p. 793-802.
89. Cai, Y., et al. Road traffic noise, air pollution and cardio-respiratory health in European cohorts: A harmonised approach in the BioSHaRE project C3 - INTERNOISE 2014 - 43rd International Congress on Noise Control Engineering: Improving the World Through Noise Control. 2014. Australian Acoustical Society.
90. Cai, Y., et al., Road traffic noise, air pollution and incident cardiovascular disease: A joint analysis of the HUNT, EPIC-Oxford and UK Biobank cohorts. Environment International, 2018. 114: p. 191-201.
91. Hoffmann, B., et al., Air quality, stroke, and coronary events: results of the Heinz Nixdorf Recall Study from the Ruhr Region. Dtsch Arztebl Int, 2015. 112(12): p. 195-201.
92. Halonen, J.I., et al., Road traffic noise is associated with increased cardiovascular morbidity and mortality and all-cause mortality in London. European Heart Journal, 2015. 36(39): p. 2653-2661.

93. Bräuner, E.V., et al., Long-term wind turbine noise exposure and incidence of myocardial infarction in the Danish nurse cohort. Environment International, 2018. 121: p. 794-802.
94. Poulsen, A.H., et al., Long-Term Exposure to Wind Turbine Noise and Risk for Myocardial Infarction and Stroke: A Nationwide Cohort Study. Environmental health perspectives, 2019. 127(3): p. 37004.
95. Seidler, A.L., et al., The effect of aircraft, road, and railway traffic noise on stroke - results of a case-control study based on secondary data. Noise Health, 2018. 20(95): p. 152-161.
96. Eze, I.C., et al., Long-term exposure to transportation noise and air pollution in relation to incident diabetes in the SAPALDIA study. International Journal of Epidemiology, 2017. 46(4): p. 1115-1125.
97. Roswall, N., et al., Long-term exposure to residential railway and road traffic noise and risk for diabetes in a Danish cohort. Environmental Research, 2018. 160: p. 292-297.
98. Clark, C., et al., Association of long-term exposure to transportation noise and traffic-related air pollution with the incidence of diabetes: A prospective cohort study. Environmental Health Perspectives, 2017. 125(8).
99. Clark, C., et al. A prospective cohort study of road traffic noise effects on diabetes C3 - INTER-NOISE 2015 - 44th International Congress and Exposition on Noise Control Engineering. 2015. The Institute of Noise Control Engineering of the USA, Inc.
100. Poulsen, A.H., et al., Long-term exposure to wind turbine noise at night and risk for diabetes: A nationwide cohort study. Environmental Research, 2018. 165: p. 40-45.
101. Foraster, M., et al., Long-term exposure to transportation noise and its association with adiposity [markers and development of obesity. Environment International, 2018. 121: p. 879-889.
102. Pyko, A., et al., Long-Term Exposure to Transportation Noise in Relation to Development of Obesity—a Cohort Study. Environmental health perspectives, 2017. 125(11): p. 117005.
103. Christensen, J.S., et al., Long-term exposure to residential traffic noise and changes in body weight and waist circumference: A cohort study. Environmental Research, 2015. 143: p. 154-161.
104. Dzhambov, A.M. and D.D. Dimitrova, Road traffic noise exposure association with self-reported body mass index. Noise Control Engineering Journal, 2015. 63(6): p. 572-581.
105. Cramer, J., et al., Road traffic noise and markers of adiposity in the Danish nurse cohort: A cross sectional study. Environmental Research, 2019: p. 502-510.
106. Belojevic G, et al., The relationship between exposure to traffic noise and resting blood pressure in children and adolescents from Belgrade, in How to create quietness, The 10th European Congress and Exposition on Noise Control Engineering (EuroNoise 2015) Glorieux C, Editor. 2015, Nederlands Akoestisch Genootschap, Belgian Acoustical Association, European Acoustics Association: Maastricht.
107. Persson Waye K, Bengtsson J, Agge A, Björkman M. A descriptive cross-sectional study of annoyance from low frequency noise installations in an urban environment. Noise and Health. 2003; 5:35-46.

108. Persson Waye K, Rylander R. The prevalence of annoyance and effects after long-term exposure to low-frequency noise. Journal of Sound and Vibration. 2001; 240:483-97.
109. Wang SQ, Xu L, Zhang L, Li XK, editors. The management and relationship between different frequency noise and subjective annoyance C3 - Proceedings of 2012 3rd International Asia Conference on Industrial Engineering and Management Innovation, IEMI 20122013.
110. Baker D. Application of noise guidance to the assessment of industrial noise with character on residential dwellings in the UK. Applied Acoustics. 2015;93:88-96.
111. Darus N, Haron Z, Bakhori SN, Han LM, Jahya Z, Hamid MF. Construction Noise Annoyance among the Public Residents. Jurnal Teknologi. 2015 May 25;74(4).
112. DEFRA Ref. NANR 5 (2004) Review and analysis of published research into the adverse effects of industrial noise, in support of the revision of planning guidance. FINAL REPORT MARCH 2004 Berry and Porter (Eds).
113. Liu Y, Xia B, Cui C, Skitmore M. Community response to construction noise in three central cities of Zhejiang province, China. Environmental Pollution. 2017;230:1009-17.17
114. Ljunggren F, Simmons C, Öqvist R Applied Acoustics. 2017;123:143-51. Correlation between sound insulation and occupants' perception – Proposal of alternative single number rating of impact sound, part II.
115. Miedema H M E and H Vos, 2003. Noise Annoyance from Stationary Sources: Relationships with Exposure Metric DENL and their Confidence Intervals.J.J. Acoust. Soc. Amer. 2003.Boek A124.
116. Milford I, Lovestad A, Rindel JH, Klaeboe R. Socio-acoustic survey of sound quality in dwellings in Norway. InINTER-NOISE and NOISE-CON Congress and Conference Proceedings 2016 Aug 21 (Vol. 253, No. 7, pp. 1606-1613). Institute of Noise Control Engineering.
117. Danielle Viennea, Ikenna C Eze, Nicole Probst-Hensch, Martin Röösli (2019) Association between transportation noise and cardio-metabolic diseases: an update of the WHO meta-analysis. ICA Proceedings , Aachen.

List of excluded references cane be obtained via the first author (Irene.vankamp.@rivm,.nl)

Annex 1: Tables

Table 3.1.1: Selected studies Part 1

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
Banerjee et al., 2013 [20]	India	CS	221 Response rate unknown	Road traffic Measurements in 5 dB categories between 60-80 dBA Lden	Annoyance	Age , length of residency	Significant for woman≥65 dB (A) 45.4 (% HA) 2.73 (1.89-6.26) 2.35 (0.99-5.58) But not in men : ≥65 dB (A) 50.0 (%HA) 1.61 (0.75-3.47) 1.41 (0.57-3.50)	**Medium**
Bunnakrid et al., 2017 [21]	Thailand	CS	253 Response rate unknown	Road traffic Noise measures at specific point 3 times for 24 hours + traffic volumes counted	Annoyance	Age, length of residence	Mean scores at area level noise levels (per area) not very precise and very large variation between areas, indication imprecision of the noise estimates CHECK	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
Camusso et al., 2016 [22]	Italy	CS	830 Response rate unknown	Road traffic (measured)	Annoyance	Urban Morphology, with and without trams, composition of traffic etc. broad versus narrow streets , attitudes	Noise levels and annoyance show a weak correlation (rho= max .30) Social class important mediator	**Medium**
Ragettli et al., 2015 [23]	Canada	CS	4336 (47)	Road, and total traffic A-weighted outdoor noise levels (LAeq24h) and day-evening-	Annoyance	Age, gender, education, distance to the source	Prevalence Proportion Ratios (PPR) for highly disturbed people of 1.10 (95% CI: 1.07–1.13) per 1 dB Lden	**Low**
Bartels et al., 2018 [24]	Germany	CS	1200 (34)	Air traffic noise recorded for every participant /dwelling	Annoyance	Type of flight, altitude Noise sensitivity, Attitudes, Urbanisation Age gender education	Weak association between noise estimates (17% variance explained)	**Low**
Cho et al., 2014 [25]	South Korea	CS	381 (99)	Aircraft noise Modelled exposure levels	Annoyance (mean)	Length of residency, age gender	Lden related to mean annoyance levels (.45)Peak level gave a	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
				expressed in Lden and measured			slightly better prediction than Lden Variability important component in prediction of annoyance	
Quehl et al., 2017 [26]	Germany	CS (Field study)	157 (eligible)	Aircraft Noise Recorded continuously inside the bedroom at the sleeper's ear.	Annoyance (acute and long-term)	Age gender, perceived loudness, noise sensitivity , long term annoyance, chronotype	Laeq seq short term High?)annoyance : OR = 1.090 (1.047 1.143) Number of overflights: OR= 1.060 (1.036 1.089)	**Medium**
Licitra et al., 2016 27	Italy	CS	119 Response rate unknown	Rail traffic (Modelled versus measured)	Annoyance (11 and 5 points scale)	Vibration	average increase of 3 points of %HA at the Same noise levels resulted between the simulated and measured values, which include the unconventional sources.	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
							(very different from Miedema generalized curve)	
Pennig et al., 2014 [28]	Germany	CS	320 (22)	Railway An acoustical simulation model for this area calculated individual noise exposure levels.	Annoyance	Worry, coping, control , noise sensitivity	60% HA which is extremely high compared to German federal findings (3%HA) EEr compared to Miedema curve also much higher levels	**Low**
Michaud et al, 2016c [29]	Canada	CS	1238 (79)	Wind turbines A waited SPL outdoors estimated + C weighted	Annoyance	Age, gender, education, lifestyle, chronic illness , stress, WHOqol, dwelling characteristics shadow flickering etc.	Increase in Percentage high annoyance with increasing A-weighted levels R2= 9 % OR 2.38 (1.42, 3.99)	**Low**
Klæboe et al., 2016 [30]	Norway	CS	90(38)	Wind turbines calculations range	Annoyance	Attitudes, demographics	Noise from windmills is	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
		(after) study		between 37-47	(ISO 5 point scale)	visual judgements, noise sensitivity	considered 17–18 dBA worse than road traffic noise–if we take the results at face value and disregard the large impact on annoyance from non-acoustic factors. This is within the range of 11–26 reported by Michaud et al. Role of non-acoustical factors large	
Pawlaczyk-Łuszczyńska et al., 2014 [31]	Poland	CS	361 Response rate unknown	Wind turbine Calculated and measured in situ at selected addresses	Annoyance	Attitude, visual aspects age gender education type of house,	Significant association between level of noise and annoyance Exp(b) = 2.16,(ci aaddd)	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
Pawlaczyk-Łuszczyńska et al., 2014b [32]	Poland	CS (pilot study)	156 Response rate unknown	Wind turbine Calculated levels and measurements	Annoyance (5 point scale)	Attitude, visual aspects age gender education type of house,	Wind turbine noise SPLs associated with increased (high?0annoyance (OR = 2.1; 95% CI: 1.22–3.62)	**Medium**
Pawlaczyk-Łuszczyńska et al., 2018 [33]	Poland	CS	517 (78)	Wind turbines Calculated levels and randomly verified by in situ measurement	Annoyance (5 point scale)	Satisfaction, visual aspects, demographics, attitude	Annoyance, High annoyance increase with increase in SPl (OR > 1.00), negative attitude towards wind turbines, and decreased with an increasing distance from the nearest wind turbine (OR < 1.00),	**Medium**
Brink M, et al., 2019 [34]	Switzerland	CS	5592 (31)	Road, Rail, Air traffic) Laeq , Lden and Intermittency ratio	Annoyance	Intermittent noise demographics, seasonal differences,	Sign. association for all sources and all outcomes but highest for road traffic noise	**Low**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
de Paiva Vianna et al., 2015 [35]	Portugal	CS	180 (65-75)	Urban soundscapes at home, recreational, work Noise maps at façade expressed in *Lden* Exposed-non exposed.	Annoyance per sources (self reported, 3 point scale l	Demographic characteristics , sex, age and marital status;, type of noise (related to activity)	*Lden* related to % of annoyed, highly annoyed in three different scenario's (activity is included as co-variate)	**Medium**
Nguyen et al., 2016 [36]	Japan	Series of CS studies	9900 Response rates 85, 74 (road, air)	Road, Air (Measurement s)	Annoyance	Demographics,	The results show that Vietnamese respondents were less annoyed by road traffic noise than respondents in the European aKorean studies and that the aircraft noise annoyance Curve for Vietnam was slightly higher than that for the	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
							EU but considerably lower than that in the Korean study.	
Sung et al., 2016 [37]	South Korea	CS	1000 (43%) 1000 (51%) Total 1836 (after selection)	Road and Air day-night equivalent sound level (Ldn). Categorized into 3 levels.	Annoyance	Age, gender, residency duration, income, marital status, lifestyle	Increase %AH m 9.0% <55 dBA group, to 11.5% and 17.3% in the 55±65 dBA and greater than 65 dBA groups, respectively (p<0.001). OR2.056 (95% [CI] 1.225±3.450), 3.519 (95% CI 1.982±6.246) in Seoul and 1.022 (95% CI 0.585± 1.785), 1.704 (95% CI1.005±2.889) in Ulsan, respectively	Medium

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
Evandt et al., 2017a [38]	Norway	CS	13019 (48)	Road traffic noise Night time Modelled at façade Lnight, A-weighted night time)	Sleep disturbance (self-reported)	age, sex, marital status, alcohol use, smoking, physical activity, and night-shift work, socioeconomic status Noise sensitivity, Chronic disease	Difficulties falling asleep (OR) 1.05 (95% confidence interval [CI]: 1.01–1.09) Awakenings during the night, OR 1.04 (95% CI: 1.00–1.08) Waking up too early, OR 1.06 (95% CI: 1.02–1.11).	**Low**
Han et al., 2015 [39]	China	CS	400 (from 4 areas) -Residential-Construction -Transportation hub -Commercial	Road traffic/transport Noise measurements (monitoring, at different moments) 78 dBA , 71 at night	Sleep quality (self-reported) measured by the Pittsburg Sleep Index	age, sex, and educational level.	Sleep quality lowest I transportation hub $Chi^{2=}$ 11.556 .(009) With 65% low sleep quality (versus 47% in the other areas)	**High**
Joost et al., 2018 [40]	Switzerland	CS Within Cohort	3697 (73) + 10% excluded	Road traffic noise Night time	Daytime Sleepiness (self-reported)	BMI, neighbourhood level income. Gender, age, beta-blockers,	Weak association with levels, stronger when spatial distribution was accounted for.	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
				(Modelled)at 10x10 grid level		antihypertensive drugs		
Martens et al., 2018 [41]	Netherlands	CS (within a cohort)	14929, (16) 7905 at follow up (54)	Road traffic modelled at address level (Stamina) expressed in *Lden*	Sleep quality (self-reported)	Age gender smoking	β (95%CI) 0.05 (0.01,0.09) 0.008	**Medium**
Holt et al., 2015 [42]	US	CS (Surveillance data)	745,868 (88)	Aircraft Modelled noise levels	Sleepdisturbance (self reported) i	Age, gender , race/ethnicity educational level, smoking and obesity,	No significant associations between airport noise and sleep insufficiency.	**Low**
Kim et al., 2014 [43]	South Korea	CS	1005(47)	Aircraft Modelled High, Low Control	Sleep quality (self reported)	Mental health, age, gender, residence duration	Firstly, the prevalence of sleep disturbance significantly differed according to the noise level (p for trend < 0.001).	**Medium**
Kwak et al., 2016 [44]	South Korea	CS	3308 Response rate unknown	Aircraft High, Low and No exposure groups based	Sleep self reported Insomnia Index and	Age, gender, education, lifestyle, hospital,	The risk of insomnia was 3.45 times (95 % CI 2.64- 4.50) higher	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
				on modelled noise level	Epworth sleepiness scale (self-reported)	smoking, drinking, physical activity, length of residency	in the low exposure group and 3.24 times (95 % CI 2.48-4.22) higher in the high exposure group, as compared to that of the control group. The risk of insomnia was 3.41 times (95 % CI 2.61-4.46) higher in the low exposure group and 3.26 times (95 % CI 2.50-4.25) in the high exposure group after adjustment for confounders	
Nassur et al., 2017 [45]	France	CS	1,244 (30)	Aircraft noise (modelled) Noise maps	Subjective Sleep time and tiredness next day	Demographics, lifestyle, SES	OR of 1.63 (95% CI: 1.15–2.32) for a short sleep time OR of 1.23 (95% CI: 1.00–1.54) for the feeling of tiredness next day	**Low**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
Kageyama et al., 2016 [46]	Japan	CS	1079 (47)	Wind turbines Field measurements during the survey estimates per address 36-40 dB and <35	Sleep symptoms (self-reported) Insomnia (self-reported)	Road traffic Noise sensitivity Attitudes wind turbine Age gender, education	Insomnia more prevalent in areas with levels > 40 at night, But on 1.2 was defined as Insomniac Note also more women participated (52% and 61 in the control group)	**Medium**
Michaud, 2016b [47]	Canada	CS	1238 (79)	Wind turbines A waited SPL outdoors estimated + C weighted	Sleep disturbance (self reported)	Age, gender, education, lifestyle, chronic illness , stress, WHOqol, dwelling characteristics shadow flickering annoyance	No effect on any of the sleep indicators	**Low**
Michaud, 2016b [48]	Canada	CS	742 (subsample)	Wind turbines A waited SPL outdoors estimated + C weighted	Sleep (Actigraphics)	Michaud, 2016b	No effect on any of the sleep indicators	**Low**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
Nassur et al., 2019 [49]	France	CS (Field study)	112 volunteers selected from 1244 (30)	Aircraft noise Measured noise levels indoor during night	Sleep (Actigraphics)	Age; gender; marital status; education; and body mass index (BMI).	Increased levels of aircraft noise and increased numbers of aircraft noise events increased the time required for sleep onset (SOL) and the total wake time after sleep onset (WASO) and decreased sleep efficiency (SE). increase in total sleep time (TST) and time in bed (TB).with OR range of 1.10-1.60	**Low**
Poulsen et al., 2019 [50]	Denmark	CS	583,968 addresses after exclusion of people who emigrated etc	Wind turbines Modelled and > 24 db Outdoor and LFN indoor (10-160 Hz)	Sleep (Prescribed medication)	Age, gender, income, education, marital status Dwelling, distance to the road	Five-year mean outdoor nighttime WTN of ≥42 dB was associated with a hazard ratio(HR)=1.14[95 %confidence interval(CI]:0.98,	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
							1.33) for sleep medication Indoor: Nighttime LFWTN,theHRs(95 %CIs)among persons ≥65 exposed to ≥15 dB were1.37(0.81,2.3 1)for sleep medication	
Perron et al., 2016 [51]	Canada	CS	4336 Response rate unknown	Road Rail Air noise Night for each study participant was estimated using a land use regression	Sleep disturbance (self-reported)	Noise sensitivity age gender	Percentage of people sleep disturbed by road traffic, airplane and railway noise was 4.2%, 1.5% and 1.1% respectively, respectively	Medium
Paiva et al., 2019 [52]	Brazil	CS	225 Non-response unclear	Road (modelled)	Annoyance, sleep disturbance (self reported) (three point scale and dichotomous)	Demographics, year of residence etc. etc	Strong association but the scale was not properly used and the necessary statistics are not available.	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
Carugno et al., 2018 [53]	Italy	CS	400 (35)	Aircraft noise While adjusting for other sources Acoustic Zones 60-65, 65-77, > 75 Lden	Annoyance, Sleep disturbance (self-reported)	Demographics, drugs, clinical history, other noise sources , housing type, lifestyle occupation, BMI	Association /trend between zones and mean annoyance scores (range from 33, 66, and 80%). Zones A and B: more sleep disorders (awakenings, sleep onset, poor quality duration	**Low**
Pultznerova et al., 2018 [54]	Slovakia	CS	107 (100)	Rail traffic measured and modelled (noise maps)	Annoyance, sleep quality (self-reported)	Age, gender, type of home, type of work, floor level,	%HA OR 7.80 (4.02–15.14)*** Sleep Quality: OR 1.95 (1.20–3.18), chi2= 7.31 (0.006)	**Medium**
Radun et al., 2019 [55]	Finland	CS	429 (57) 318 eligible	Wind turbines Modeled levels And categorised [25–30],[30–35], [35–40), and [40–46] Lden	Annoyance, Sleep disturbance. (selfreported) (indoor, outdoor)	Trust in authorities and operators, visibility, economic benefits, age, gender, education, type of	Sound level [dB] Annoyance outdoor 1.41 (1.14, 1.74) <0.01 .(R2= .71) Indoor none Sleep 1.38 (1.16, 1.65) <0.01(R2= .50)	**Low**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
						dwelling, distance		
Song et al., 2016 [56]	China	CS	227 (77)	Wind turbine Measurements, categorized into 5 noise levels (44.1 dBA to 56.7dBA)	Annoyance, Sleep disturbance (self-reported)	Gender, age residence time, visibility, noise sensitivity, attitude, general opinion about WTs	%HA increased from 39.5% (95% CI: 28.4–51.4%) to 75.0% (95% CI: 50.9–91.3% Sleep disturbance and LAeq Spearman correlation= 0.209	**Medium**
Argalášová et al., 2014 [57]	Poland	CS Longitudinal	511 (1989) 857 (1999) 808 (2004) 932 (2013) (90)	Road, Air Measurements, categorized in exposed and controls	Annoyance, Sleep disturbance (self-reported)	Age gender smoking alcohol, type of building, quiet side	Strong increase and decrease in noise levels Per noise source odds presented over years Interference with sleep and rest disturbance by road traffic noise has been currently the most important issue (ORMH = 3.07 (95 % CI = 2.43–3.89).	**Medium**

Publication	Country*	Design†	Sample size (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
Douglas et al., 2016 [58]	Ireland	CS	208(90)	Road, Rail Air Random measurements LAeq, LA90, and LAmax. Excluded families with children and with other noise sources	Annoyance, sleep disturbance (self-reported)	gender, and social class together with dwelling information., building age, double glazing	Per source number of people annoyed and disturbed presented, *Lden* like measures are bad predictor Max levels and number of events should be taken into account as well	**Medium**
Bodin et al., 2015 [59]	Sweden	CS	2612 (54)	Rail and road traffic noise Modelled	Annoyance and sleep disturbance (self-reported)	Access quiet side, window facing yard, age, gender, smoking, hearing, bmi, noise sensitivity	OR 1,26 for each 5 dBA (combined) Significant association between noise level and annoyance, sleep disturbance	**Low**

[1] Here results are presented per publication instead of study (cardiovascular and metabolic effects per study/only the new publications are included)

Table 3.2.1. Overview of the characteristics of the selected studies on the association between aircraft noise and hypertension

Study	Country *	Design†	Study population			Exposure range (dB) in L_{DEN}	Ascertainment hypertension** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
HYENA-Gr [60]	Gre	CO	420 (46)	MF	45-70	35-40, 40-45, 45-50, 50-55, 55-60, ≥60[a]	1, 2 (inc)	1
SDPP [61]	Swe	CO	4,854	MF	35-56	<50, 50-54, 55-59, ≥60	1, 2 (inc)	2
DEBATS [62]	Fra	CS	1,244 (30)	MF	18-90	<50, 50-54, 55-59, ≥60	1, 2 (prev)	2
BGY study [63]	It	CS	400 (53)	MF	45-70	<60, 60-65, 66-75[b]	1, 2 (prev)	1
NIAS [64]	Jap	CS	3,659 (37)	MF	20-79	<52, 52-57, 57-62, 62-67, >67	1, 2? (prev)	1
NOrAH [65-67]	Ger	CC	493,168	MF	≥40	<40, 40-45, 45-50, 50-55, 55-60, ≥60	3 (inc)	1

* Jap = Japan, Swe = Sweden, Ger = Germany, It = Italy, Gre = Greece, Fra = France; †Design: CS = Cross-sectional study, CO = Cohort study, CC = Case control study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study); (%); # M = Men, F = Females; ** The way hypertension was ascertained: 1 = measurement of blood pressure levels and/or by means of a clinical interview, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: Prev = prevalence, inc = incidence, mor = mortality ; †† 1 = Study identified and selected as part of the new literature search, 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search; a Noise exposure was expressed as $L_{Aeq16hr}$ in dB; b Unclear what the noise metric is.

Table 3.2.2. Overview of the characteristics of the selected studies on the association between road traffic noise and hypertension

Study	Country*	Design†	Study population			Exposure range (dB) in L_{DEN}	Ascertainment hypertension** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
ASANSOL [68]	Ind	CS	909 (83)	MF	18-80	~55-78	2 (prev)	1
CMR [69]	Sp	ECO	1,578,546	MF	NR	~35–80[a]	3 (mor)	1
CPRD [70]	UK	ECO	200,457	MF	40-79	0-55, 55-60, 60+[b]	3 (inc)	1
DCH [71]	Den	CO	24,181	MF	50-64	~ 55 – 70	2 (inc)	2
HYENA-Gr [60]	Gre	CO	420 (46)	MF	45-70	<30, 30-35, 35-40,40-45, 45-50, 50-55, 55-60, ≥60	1, 2 (inc)	1
HUBRO [71]	Nor	CO	4,462	MF	22-75	~30-75	2 (inc)	2
SNAC-K [71]	Swe	CO	1,945	MF	≥60	~55-75	1, 2 (inc)	1
HNR [71]	Ger	CO	4,507	MF	45-75	~35-70	1, 2 (inc)	2
KORA [71] [72]	Ger	CO	5,177	MF	25-74	~45 – 65	1, 2 (inc)	2
REGICOR [71]	Sp	CO	1,931	MF	36-82	~60 – 75	1, 2 (inc)	2
Whithall II [73]	UK	CS	1,965 (NR)	MF	35-55	~54–79[c]	1, 2 (prev)	1
SABRE [73]	UK	CS	627 (NR)	MF	40-69	~54–79[c]	1, 2 (prev)	1
SDPP [61]	Swe	CO	4,854	MF	35-54	<45, 45-49, 50-54, ≥55	1, 2 (inc)	1
NOrAH [65-67]	Ger	CC	493,168	MF	≥40	<40, 40-45, 45-50, 50-55, 55-60, 60-65, 65-70, ≥70	3 (inc)	1
NIVEL [74]	NL	CS	4,450 (NR)	MF	18-65?	NR	3 (prev)	1
CHINA1 [75]	Chin	CS	381 (95)	MF	7-93?	52 – 80	2 (prev)	1

* Chin= China, Ind = India, Sp = Spain, UK = United Kingdom, Den = Denmark, Gre = Greece, Nor = Norway, Swe = Sweden, Ger = Germany, NL = The Netherlands; †Design: ECO = Ecological study, CS = Cross-sectional study, CO = Cohort study, CC = Case control study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way hypertension was ascertained: 1 = measurement of blood pressure levels and/or by means of a clinical interview, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: prev = prevalence, inc = incidence, mor = mortality. †† 1 = Study identified and selected as part of the new literature search, 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search; [a] Noise exposure level expressed in $L_{Aeq7\text{-}21hr}$; [b] Noise exposure level expressed in L_{night}; [c] Noise exposure level expressed in $L_{Aeq7\text{-}23hr}$

Table 3.2.3. Overview of the characteristics of the selected studies on the association between rail traffic noise and hypertension

Study	Country*	Design†	Study population			Exposure range (dB) in L_{DEN}	Ascertainment hypertension** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
SDPP [61]	Swe	CO	4,854	MF	35-55	<45, 45-49, 50-54, ≥55	1, 2 (inc)	1
NOrAH [65-67]	Ger	CC	493,168	MF	≥40	<40, 40-45, 45-50, 50-55, 55-60, 60-65, 65-70, ≥70	3 (inc)	1
NIVEL [74]	NL	CS	4,450 (NR)	MF	18-65?	NR	3 (prev)	1

* Swe = Sweden, , NL = The Netherlands, Ger = Germany; †Design:, CS = Cross-sectional study, CO = Cohort study, CC = Case control study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way hypertension was ascertained: 1 = measurement of blood pressure levels and/or by means of a clinical interview, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database; †† 1 = Study identified and selected as part of the new literature search.

Table 3.2.4. Overview of the characteristics of the selected studies on the association between wind turbine noise and hypertension

Study	Country*	Design†	Study population			Exposure range (dB) in WTN	Ascertainment hypertension** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
CNHS [76-78]	Can	CS	1,238 (79)	MF	18-79	<25, 25-30, 30-35, 35-40, 40-46	2 (prev)	1
DWS [79, 80]	Den	CO	535,675	MF	25-85	<24, 24-30, 30-36, 36-42, ≥42	3 (inc)	1

Can = Canada, Den = Denmark; †Design:, CS = Cross-sectional study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way hypertension was ascertained: 1 = measurement of blood pressure levels and/or by means of a clinical interview, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: prev = prevalence, inc = incidence, mor = mortality. †† 1 = Study identified and selected as part of the new literature search; [a] Average age in yrs; [b] Exposure expressed as Sound Pressure Level (SPL).

Table 3.2.5. Overview of the characteristics of the selected studies on the association between aircraft noise and ischemic heart disease

Study	**Country** *	**Design**†	**Study population**			**Exposure range in L_{DEN}**	**Ascertainment IHD**** **(prev/inc/mor)**	**Status**††
			N (%)‡	**Sex**#	**Age range (yrs)**			
HYENA_GRE [60]	Gre	CO	420	MF	45-70	<30, 30-35, 35-40,40-45, 45-50, 50-55, 55-60, ≥60	2 (inc)	1
SNC [81, 82]	Swi	CO	4,404,046	MF	>30	≤30, 30-40, 40-50, 50-60, ≥60	3 (mor)	2
FRANCE [83, 84]	Fra	ECO	~1,900,000	MF	All ages	~42-64 (<45, 45-49, 49-54, ≥54)[a]	3 (mor)	1
NOrAH [66, 85]	Ger	CC	854,366	MF	≥40	<40, 40-45, 45-50, 50-55, 55-60, ≥60	3 (inc, mor)	1
CAENS [86 b]	Swe	CO	20,012	MF	≥35	<45, 45-50, 50-55, ≥55	3 (inc)	1

* Swe = Sweden, Ger = Germany, Gre =Greece, Swi = Switzerland, Fra = France; †Design:, ECO = Ecological study, CC = Case control study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way ischemic heart disease was ascertained: 1 = by means of a clinical interview/anamnesis, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: prev = prevalence, inc = incidence, mor = mortality; †† 1 = Study identified and selected as part of the new literature search; 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search. [a] Exposure expressed as population weighted average L_{DEN}; [b] This cohort comprises of respondents from four Swedish cohorts: The Stockholm Diabetes Preventive Program (SDPP), the SIXTY subcohort, the Screening Across the Lifetime Twin Study (SALTS) and the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K).

Table 3.2.6. Overview of the characteristics of the selected studies on the association between road traffic noise and ischemic heart disease

Study	Country*	Design†	Study population			Exposure range in L_{DEN}	Ascertainment IHD** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
DCH [87]	Den	CO	50,744	MF	50-64	~48-72	3 (inc)	2
CMR [69]	Sp	ECO	1,578,546	MF	NR	~35–80[a]	3 (mor)	1
SPHC [88]	Swe	CO	9,031	MF	18-80	<45, 45-55, 55-65, 65-80	3 (inc)	1
HUNT2 [89, 90]	Nor	CO	43,267	MF	≥20	~42-70	3 (inc)	1
EPIC-Oxford [89, 90]	UK	CO	23,909	MF	≥20	~51-85	3 (inc)	1
UK-Biobank [89, 90]	UK	CO	288,556	MF	40-69	~51-87	3 (inc)	1
CPRD [70]	UK	ECO	200,457	MF	40-79	0-55, 55-60, 60+[b]	3 (inc)	1
HYENA_GRE [61]	Gre	CO	420	MF	45-70	<30, 30-35, 35-40,40-45, 45-50, 50-55, 55-60, ≥60	2 (inc)	1
CAENS [86 c]	Swe	CO	20,012	MF	≥35	<45, 45-50, 50-55, ≥55	3 (inc)	1
HNR [91]	Ger	CO	4,433	MF	45-74	~28-63[b]	1 (inc)	1
M25 [92]	UK	ECO	~8,600,000	MF	≥25	<55, 55-60, >60[d]	3 (inc, mor)	1
SNC [81 82]	Swi	CO	4,404,046	MF	≥30	≤45, 45-50, 50-55, 55-60, 60-65, >65	3 (mor)	1
NOrAH [66, 85]	Ger	CC	854,366	MF	≥40	<40, 40-45, 45-50, 50-55, 55-60, ≥60	3 (inc, mor)	1
NIVEL [74]	NL	CS	4,450	MF	18-65?	NR	3 (prev)	1

* Swe = Sweden, NL = The Netherlands, Ger = Germany, UK = United Kingdom, Gre =Greece, Swi = Switzerland, Den = Denmark, Nor= Norwegen; †Design:, ECO = Ecological study, CS = Cross-sectional study, CC = Case control study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way ischemic heart disease was ascertained: 1 = by means of a clinical interview/anamnesis, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: prev = prevalence, inc = incidence, mor = mortality; †† 1 = Study identified and selected as part of the new literature search; 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search. [a] Exposure expressed as $L_{Aeq,7\text{-}21hr}$; [b] Exposure expressed as L_{night}; [c]This cohort comprises of respondents from four Swedish cohorts: The Stockholm Diabetes Preventive Program (SDPP), the SIXTY subcohort, the Screening Across the Lifetime Twin Study (SALTS) and the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K); [d] Exposure expressed as $L_{Aeq16hr}$.

Table 3.2.7. Overview of the characteristics of the selected studies on the association between rail traffic noise and ischemic heart disease

Study	Country*	Design†	Study population			Exposure range in L_{DEN}	Ascertainment IHD** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
SNC [81, 82]	Swi	CO	4,404,046	MF	≥30	≤30, 30-40, 40-50, 50-60, >60	3 (mor)	1
NOrAH [66 85]	Ger	CC	854,366	MF	≥40	<40, 40-45, 45-50, 50-55, 55-60, ≥60	3 (inc, mor)	1
CAENS [86 a]	Swe	CO	20,012	MF	≥35	<45, 45-50, 50-55, ≥55	3 (inc)	1
NIVEL [74]	NL	CS	4,450	MF	18-65?	NR	3 (prev)	1

* Swe = Sweden, NL = The Netherlands, Ger = Germany, Swi = Switzerland; †Design: CS = Cross-sectional study, CC = Case control study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way ischemic heart disease was ascertained: 1 = by means of a clinical interview/anamnesis, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: prev = prevalence, inc = incidence, mor = mortality; †† 1 = Study identified and selected as part of the new literature search; [a] This cohort comprises of respondents from four Swedish cohorts: The Stockholm Diabetes Preventive Program (SDPP), the SIXTY subcohort, the Screening Across the Lifetime Twin Study (SALTS) and the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K).

Table 3.2.8. Overview of the characteristics of the selected studies on the association between wind turbine noise and ischemic heart disease

Study	Country*	Design†	Study population			Exposure range (dB) in L_{DEN}	Ascertainment IHD** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
DNC [93]	Den	CO	23,994	F	≥44	Unexposed, <21.5, 21.5-25.4, 25.4-29.9, >29.9	3 (inc)	1
DWS [80 94]	Den	CO	535,675	MF	25-85	<24, 24-30, 30-36, 36-42, ≥42	3 (inc)	1

* Den = Denmark; †Design: CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way ischemic heart disease was ascertained: 1 = measurement by means of a clinical interview, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: prev = prevalence, inc = incidence, mor = mortality. †† 1 = Study identified and selected as part of the new literature search

Table 3.2.9. Overview of the characteristics of the selected studies on the association between air traffic noise and stroke

Study	Country*	Design†	Study population			Exposure range in L_{DEN}	Ascertainment stroke** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
SNC[81, 82]	Swi	CO	4,415,206	MF	≥30	<30, 30-40, 40-50, 50-60, >60	3 (mor)	2
HYENA_GRE [60]	Gre	CO	420	MF	45-70	<30, 30-35, 35-40,40-45, 45-50, 50-55, 55-60, ≥60	2 (inc)	1
FRANCE[83, 84]	Fra	ECO	~1,900,000	MF	All ages	~42-64 (<45, 45-49, 49-54, ≥54)[a]	3 (mor)	1
NOrAH [66, 95]	Ger	CC	853,096	MF	≥40	40-45, 45-50, 50-55, 55-60, 60-65, 65-70, ≥70	3 (inc, mor)	1
CAENS [86 a]	Swe	CO	20,012	MF	≥35	<45, 45-50, 50-55, ≥55	3 (inc)	1

* Swe = Sweden, Ger = Germany, Swi = Switzerland, Gre = Greece, Fra = France; †Design: ECO = Ecological study, CC = Case control study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way stroke was ascertained: 1 = by means of a clinical interview/anamnesis, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: prev = prevalence, inc = *incidence*, mor = *mortality*; †† 1 = Study identified and selected as part of the new literature search, 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search. [a] This cohort comprises of respondents from four Swedish cohorts: The Stockholm Diabetes Preventive Program (SDPP), the SIXTY subcohort, the Screening Across the Lifetime Twin Study (SALTS) and the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K).

Table 3.2.10. Overview of the characteristics of the selected studies on the association between road traffic noise and stroke

Study	**Country***	**Design†**	**Study population**			**Exposure range in L_{DEN}**	**Ascertainment stroke** (prev/inc/mor)**	**Status††**
			N (%)‡	**Sex#**	**Age range (yrs)**			
HYENA_GRE [60]	Gre	CO	420	MF	45-70	<30, 30-35, 35-40,40-45, 45-50, 50-55, 55-60, ≥60	2 (inc)	1
HUNT2 [89, 90]	Nor	CO	43,267	MF	≥20	~42-70	3 (inc)	1
EPIC-Oxford [89,90]	UK	CO	23,909	MF	≥20	~51-85	3 (inc)	1
UK-Biobank [89, 90]	UK	CO	288,556	MF	40-69	~51-87	3 (inc)	1
CPRD [70]	UK	ECO	200,457	MF	40-79	0-55, 55-60, 60+[b]	3 (inc)	1
M25 [92]	UK	ECO	~8,600,000	MF	≥25	<55, 55-60, >60[c]	3 (inc, mor)	1
HNR [91]	Ger	CO	4,433	MF	45-74	~28-63e	1 (inc)	1
SNC [82]	Swi	CO	4,415,206	MF	≥30	<30, 30-40, 40-50, 50-60, >60	3 (mor)	1
NOrAH [66]	Ger	CC	853,096	MF	≥40	40-45, 45-50, 50-55, 55-60, 60-65, 65-70, ≥70	3 (inc, mor)	1
CAENS [86 a]	Swe	CO	20,012	MF	≥35	<45, 45-50, 50-55, ≥55	3 (inc)	1
NIVEL[74]	NL	CS	4,450	MF	18-65?	NR	3 (prev)	1

* Swe = Sweden, NL = The Netherlands, Ger = Germany, Swi = Switzerland, UK = United Kingdom, Gre = Greece; †Design: ECO = Ecological study, CS = Cross-sectional study, CC = Case control study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way stroke was ascertained: 1 = by means of a clinical interview/anamnesis, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: prev = prevalence, inc = *incidence*, mor = *mortality*; †† 1 = Study identified and selected as part of the new literature search; [a] This cohort comprises of respondents from four Swedish cohorts: The Stockholm Diabetes Preventive Program (SDPP), the SIXTY subcohort, the Screening Across the Lifetime Twin Study (SALTS) and the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K); [b] Exposure was expressed as L_{night}; [c] Exposure expressed as $L_{Aeq16hr}$.

Table 3.2.11. Overview of the characteristics of the selected studies on the association between rail traffic noise and stroke

Study	**Country***	**Design†**	**Study population**			**Exposure range in L_{DEN}**	**Ascertainment stroke** (prev/inc/mor)**	**Status††**
			N (%)‡	**Sex#**	**Age range (yrs)**			
SNC [82]	Swi	CO	4,415,206	MF	≥30	<30, 30-40, 40-50, 50-60, >60	3 (mor)	1
NOrAH [66, 95]	Ger	CC	853,096	MF	≥40	40-45, 45-50, 50-55, 55-60, 60-65, 65-70, ≥70	3 (inc, mor)	1
CAENS [86a]	Swe	CO	20,012	MF	≥35	<45, 45-50, 50-55, ≥55	3 (inc)	1
NIVEL [74]	NL	CS	4,450	MF	18-65?	NR	3 (prev)	1

* Swe = Sweden, NL = The Netherlands, Ger = Germany, Swi = Switzerland; †Design: CS = Cross-sectional study, CC = Case control study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) (%); # M = Men, F = Females; ** The way stroke was ascertained: 1 = by means of a clinical interview/anamnesis, 2 = by means of a question as part of a questionnaire or interview (self-reported), 3 = by means of health registration database. Type of outcome: prev = prevalence, inc = *incidence*, mor = *mortality*; †† 1 = Study identified and selected as part of the new literature search; [a] This cohort comprises of respondents from four Swedish cohorts: The Stockholm Diabetes Preventive Program (SDPP), the SIXTY subcohort, the Screening Across the Lifetime Twin Study (SALTS) and the Swedish National Study on Aging and Care in Kungsholmen (SNAC-K).

Table 3.2.12. Overview of the characteristics of the selected studies on the association between aircraft noise and diabetes

Study	**Country***	**Design†**	**Study population**			**Exposure range (dB) in L_{DEN}**	**Ascertainment Diabetes** (prev/inc/mor)**	**Status††**
			N (%)‡	**Sex#**	**Age range (yrs)**			
HYENA_GRE [60]	Gre	CO	420 (78)	MF	45-75	<30, 30-35, 35-40,40-45, 45-50, 50-55, 55-60, ≥60	1 (inc)	1
SAPALDIA [96]	Swi	CO	2,631	MF	Adults	<50, 50-55, >55	1, 2 (inc)	1

* Swi = Switzerland, Gre = Greece; †Design: CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) or attrition rate (in case of a cohort or case-control study) (%); # M = Men, F = Females ** The way diabetes was ascertained: 1 = measurement/clinical interview, 2 = self-reported. Type of outcome: prev = prevalence, inc = *incidence*, mor = *mortality*; †† 1 = Study identified and selected as part of the new literature search;

Table 3.2.13. Overview of the characteristics of the selected studies on the association between road traffic noise and diabetes

Study	**Country***	**Design**†	**Study population**			**Exposure range (dB) in L_{DEN}**	**Ascertainment diabetes** (prev/inc/mor)**	**Status** ††
			N (%)‡	**Sex**#	**Age range (yrs)**			
DCH [97]	Den	CO	50,534	MF	50-64	~48-71	3 (inc)	2
CMR [69b]	Sp	ECO	1,578,546	MF	NR	~35–80[a]	3 (mor)	1
BC Medical Service Plan [98,99 b]	Can	ECO	380,738	MF	45-84	≤57, 58-61, 62-69, ≥69	3 (inc)	1
HYENA_GRE [60]	Gre	CO	420 (78)	MF	45-75	<30, 30-35, 35-40,40-45, 45-50, 50-55, 55-60, ≥60	1 (inc)	1
NIVEL [74]	NL	CS	4,450	MF	18-65?	NR	3 (prev)	1
SAPALDIA [96]	Swi	CO	2,631	MF	Adults	<50, 50-55, >55	1, 2 (inc)	1

* Den=Denmark, NL = The Netherlands, Gre=Greece, Swi = Switzerland, Sp = Spain, Can = Canada; †Design: ECO = Ecological study, CS = Cross-sectional study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) or attrition rate (in case of a cohort or case-control study) (%); # M = Men, F = Females; **) The way diabetes was ascertained: 1 = measurement/clinical interview, 2 = self-reported, 3 = healthcare registration. Type of outcome: prev = prevalence, inc = *incidence*, mor = *mortality*; ††) 1 = Study identified and selected as part of the new literature search, 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search; a) Exposure expressed as $L_{Aeq,7\text{-}21hr}$; b) cumulative exposure including different transport sources such as road, rail and air traffic.

Table 3.2.14. Overview of the characteristics of the selected studies on the association between rail traffic noise and diabetes

Study	Country*	Design†	Study population			Exposure range (dB) in L_{DEN}	Ascertainment diabetes** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
DCH [97 a]	Den	CO	50,534	MF	50-64	~ 20-80	3 (inc)	2
NIVEL[74]	NL	CS	4,450	MF	18-65?	NR	3 (prev)	1
SAPALDIA [96]	Swi	CO	2,631	MF	Adults	<50, 50-55, >55	1, 2 (inc)	1

* Den=Denmark, NL = The Netherlands, Swi = Switzerland; †Design:, CS = Cross-sectional study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) or attrition rate (in case of a cohort or case-control study) (%); # M = Men, F = Females **) The way diabetes was ascertained: 1 = measurement/clinical interview, 2 = self-reported, 3 = healthcare registration. Type of outcome: prev = prevalence, inc = *incidence*, mor = *mortality*; ††) 1 = Study identified and selected as part of the new literature search; 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search; a) the attrition rate in the DCH study could not be calculated in detail but is expected to be much less than 20%, since the outcome data were extracted from national registers.

Table 3.2.15. Overview of the characteristics of the selected studies on the association between wind turbine noise and diabetes

Study	Country*	Design†	Study population			Exposure range (dB) in LDEN	Ascertainment Diabetes** (prev/inc/mor)	Status††
			N (%)‡	Sex#	Age range (yrs)			
CNHS [76-78]	Ca	CS	1,238 (79)	MF	18-79	<25, 25-30, 30-35,35-40, 40-46	1,2 (prev)	1
DWS [80, 100]	Den	CO	614,731	MF	25-85	< 24, 24–<30, 30–<36, 36–<42, ≥42	3 (inc)	1

* Ca= Canada, Den = Denmark; †Design:, CS = Cross-sectional study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) or attrition rate (in case of a cohort or case-control study) (%); # M = Men, F = Females; **) The way diabetes was ascertained: 1 = measurement/clinical interview, 2 = self-reported, 3 = healthcare registration. Type of outcome: prev = prevalence, inc = *incidence*, mor = *mortality* ††) 1 = Study identified and selected as part of the new literature search

Table 3.2.16. Overview of the characteristics of the selected studies on the association between aircraft noise and indicators of obesity

Study	Country*	Design†	Study population			Exposure range (dB) in L_{DEN}	Indicator of obesity**	Status††
			N (%)‡	Sex#	Age range (yrs)			
SAPALDIA-a [101]	Swi	CS	3,796 (83)	MF	18-60	~30 – 58	BMI, BF, WC, CO, OW	1
SAPALDIA-b [101]	Swi	CO	3,796 (83)	MF	18-60	~30 – 58	CO, OW, BMI	1
SDPP [102]	Swe	CO	5,184 (91)	MF	35-55	<45, 45-49,50-54, ≥55	BMI, WC, WG, CO, OW	2

* Swe = Sweden, Swi = Switzerland; †Design: CS = Cross-sectional study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) or attrition rate (in case of a cohort or case-control study) (%); # M = Men, F = Females; **) Indicator of obesity: BMI = change in Body Mass Index (kg/m^2), BF = percentage body fat, WC = Change in waist circumference (cm/yr), WG = Weight gain (kg/yr), CO = *incidence* of Central Obesity, OW = *incidence* of Overweight; ††) 1 = Study identified and selected as part of the new literature search, and 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search.

Table 3.2.17. Overview of the characteristics of the selected studies on the association between road traffic noise and indicators of obesity

Study	Country*	Design†	Study population			Exposure range (dB) in L_{DEN}	Indicator of obesity**	Status††
			N (%)‡	Sex#	Age range (yrs)			
SDPP [102]	Swe	CO	5,184 (91)	MF	35-54	<45, 45-49,50-54, ≥55	BMI, WC, WG, CO, OW	2
DCH[103]	Den	CO	39,720	MF	50-64	<55, 55-60, 60-65, >65	BMI, WG, WC	2
Plovdiv [104]	Bul	CS	513 (88)	MF	18-83	50-55, 56-65, 66-75, >75	BMI, CO	1
SAPALDIA-a [101]	Swi	CS	3,796 (83)	MF	18-60	~35-75	BMI, BF, WC, CO, OW	1
SAPALDIA-b [101]	Swi	CO	3,796 (83)	MF	18-60	~35-75	CO, OW, BMI	1
DNC [105]	Den	CS	15,501	MF	≥44	<50, 50-55, 55-60, 60-65, >65	BMI, WC	1

*Swe = Sweden, Den= Denmark, Bul= Bulgaria, Swi = Switzerland; †Design: CS = Cross-sectional study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) or attrition rate (in case of a cohort or case-control study) (%); # M = Men, F = Females; **) Indicator of obesity: BMI = change in Body Mass Index, WC = Change in Waist Circumference, WG = Weight gain, CO = prevalence or *incidence* of (central) obesity, OW = prevalence or *incidence* of overweight; ††) 1 = Study identified and selected as part of the new literature search, and 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search.

Table 3.2.18. Overview of the characteristics of the selected studies on the association between rail traffic noise and obesity

Study	Country*	Design†	Study population			Exposure range (dB) in L_{DEN}	Indicator of obesity**	Status††
			N (%)‡	Sex#	Age range (yrs)			
SDPP [102]	Swe	CO	5,184 (91)	MF	35-54	<45, 45-49,50-54, ≥55	BMI, WC, WG, CO, OW	2
DCH [103]	Den	CO	39,720	MF	50-64	<55, 55-60, 60-65, >65	BMI, WG, WC	2
SAPALDIA-a [101]	Swi	CS	3,796 (83)	MF	18-60	~30-75	BMI, BF, WC, CO, OW	1
SAPALDIA-b [101]	Swi	CO	3,796 (83)	MF	18-60	~30-75	CO, OW, BMI	1

* Swe = Sweden, Den= Denmark, Swi = Switzerland; †Design: CS = Cross-sectional study, CO = Cohort study; ‡ The number of people (N) and the response rate (in case of a cross-sectional study) or attrition rate (in case of a cohort or case-control study) (%); # M = Men, F = Females; **) Indicator of obesity: BMI = change in Body Mass Index, WC = Change in waist circumference, WG = weight gain, CO = Central obesity, OW = overweight, BF = change in percentage body fat; ††) 1 = Study identified and selected as part of the new literature search, and 2 = Study already identified and selected as part of the WHO evidence review. Additional or new study results identified as part of the new literature search.

Table 3.3.1. Overview of the characteristics of the selected studies on the association between residential sources of LFN and annoyance and sleep problems

Study	Country*	Design†	Sample characteristics	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported (statistically significant) associations	Bias Risk*
Persson-Waye & Rylander, 2001 [107]	Sweden	CS	279 randomly Selected subjects, age range: 18–75 y.o. Six homogeneous residential areas selected, exposed to either residential LFN sources or mid-	Heat pumps or heat pump/ventilation systems, Spot measurements, Frequency spectra in LFN-exposed areas at 50–200 Hz, A-, B- & C-weighted SPL, range dB	Annoyance (SR) & physical and psychological symptoms (SR)	NR; However, there was similar distribution between subjects in the exposed & control areas in age, gender,	Prevalence range in different exposed vs. unexposed areas: Annoyance, 14.7%–20%, vs. 3.4%–4.2% (p > 0.05); disturbed	**Medium**

Study	**Country***	**Design†**	**Sample characteristics**	**Exposure type and assessment**	**Outcome type and assessment**	**Confounders considered in analyses**	**Reported (statistically significant) associations**	**Bias Risk***
			frequency noise (control areas).	exposed vs. controls: dB(B) = 31–38 vs. 40–51; dB(C) = 41–49 vs. 49–60; dB(A)Leq24h = 44–47 vs. 44–49.		noise sensitivity, family status, chronic illness, employment status & workload	concentration, 7.5%–17.5% vs. 0% (p > 0.05); disturbed rest/relaxation, 12.5%-22% vs. 0%–0.7%, (p > 0.05).	
Persson-Waye et al., 2003 [108]	Sweden	CS	41 randomly Selected subjects, age range: 18–80 y.o, living in blocks of flats with one side facing a street with high traffic (comparison group, n=19, f.g=53%) and the other side facing a courtyard full of domestic LFN sources (exposed group, n=20, f.g=75%); 2 persons were	Fans, compressors, air-cooling systems, Spot measurements, frequency spectra at ≥20 Hz, A- & C weighted SPL, Leq24h in whole area: dB(A) = 31(windows closed) & 43 (windows slightly opened); dB(C) = 50 (windows closed) & 56	Annoyance (SR) & sleep quality (SR)	NR; However, there was no statistically significant difference between the exposed and control group in terms of age, gender, and socio-economic status	No significant results were reported.	**High**

Study	Country*	Design†	Sample characteristics	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported (statistically significant) associations	Bias Risk*
			excluded from the analyses.	(windows slightly open).				
Wang et al., 2013** [109]	China	CS	Residents † living in an "exposed" (n=17) and "quiet (n=20) environment.	Water pump (28–39 dB) vs. "quiet environment" (27–34 dB).	Annoyance (SR)	NR	29.4% in the exposed group reported "severe annoyance" vs. 0% in the control group. It is unclear/not reported whether results are statistically significant.	**High**

Abbreviations: CS = Cross-sectional study; SPL= sound pressure levels; dB= decibel scale; Leq24h= equivalent continuous sound level; y.o, years old; F.g, female gender distribution; SR= self-reported; NR= not reported.
* Based on Baliatsas et al., 2012, 2016) ** Conference proceedings paper. Highly possible that the sample does not only contain adults but also children which would make the study ineligible for inclusion. In the text it is stated ". The eldest is 67, the youngest is 5 years old, and average age is 52.5". In this study, one additional "exposed' group is investigated which is irrelevant for the current review; we do not know whether children are included have only been included in that group.

Table 3.4.1. Overview of the characteristics of the selected studies on the association between other sources anand annoyance/sleep disturbance

Publication	Country*	Design†	Sample characteristics (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
Liu Y, Xia B, Cui C, Skitmore M. 2017; [113]	China	CS	1027 (64)	Construction noise (LAeq) every 32 hours during 24 hr measurements 65dB to 77dB	Mean rated disturbance of various activities by construction noise (including sleep) Annoyance ISO 5 point	Age, gender, occupation, awareness	%highly annoyed linked to LAaeq: increase from t 5%-20% to 30%e40% (counted by the upper three steps of the 11 numerical scale) or from 20%-40% to 50%e80% o with increase of 60 to 80 Laeq; large difference between locations	**Low**
Darus N, Haron Z, Bakhori SN, Han LM, Jahya Z, Hamid MF. 2015 [114]	Malaysia	CS	42 Response rate unknown	Construction noise Three measurements at three locations near the construction site Levels up to 80dB	Annoyance ISO 5 point scale	Gender, age	Strong association between mean annoyance score and dB sound pressure levels (y=-1.11+0.04*x+-2.03E-4*x^2, R2 Quadratic=0.515)	**Medium**

Publication	Country*	Design†	Sample characteristics (response rate)	Exposure type and assessment	Outcome type and assessment	Confounders considered in analyses	Reported associations	Bias Risk*
H M E Miedema and H Vos, 2004. Noise [115]	Netherlands	Cs	1875 (66.5)	Industrial Lden range of 45-65 dBA from industrial sources	Annoyance 11 point ISO scale	Dwelling surrounding; other sources, activities of the industry; changes,in exposure;visibi lity odour, vibration, safety; demographics; relation with or use of the source; noise sensitivity.	EERS derived for three different types of Industry Shunting: %HA= 516.980-1.367 DENL + 0.029 80 DENL2 Seasonal: %HA=18.1-320.887 DENL +0.010 91 DENL2. Other %HA=36.307-1.886 DENL +0.025 23 DENL2,	**Low**

Annex 2: Search profiles

Period: 26/03/2019-24/05/2019 by Jeanine Ridder (RIVM)

Part 1: Annoyance and Sleep disturbance -Road, Rail, Air, Windturbines (update since 2014)

Embase

Query	Results	No.
#18	#17 AND [2014-2019]/py	240
#17	#12 AND #16	586
#16	#13 OR #14 OR #15	264,858
#15	'annoyance':ti OR 'sleep*':ti	128,985
#14	'annoyance'/exp	1,233
#13	'sleep'/exp OR 'sleep disorder'/exp	341,988
#12	#6 OR #11	5,318
#11	(#7 OR #8 OR #9) AND (#7 OR #10)	177
#10	'noise'/exp OR 'sound'/exp OR 'noise pollution'/de OR 'infrasound'/exp OR infrasound*:ti,ab OR noise*:ti,ab OR 'low frequen*':ti,ab	399,689
#9	'wind'/exp AND ('renewable energy'/de OR 'electric power plant'/de OR 'power supply'/exp OR 'energy resource'/de)	308
#8	'wind power'/exp OR 'wind farm'/exp	655
#7	noise AND ((wind NEAR/3 turbine*) OR (wind NEAR/3 farm*) OR windturbine* OR windfarm* OR 'wind park*' OR 'wind mill*' OR windpark* OR windmill*)	182
#6	(#1 OR #2 OR #3 OR #5) AND (#1 OR #4 OR #5)	5,160
#5	'traffic noise'/exp OR 'aircraft noise'/exp	2,505
#4	'noise'/mj OR 'sound'/mj OR 'vibration'/mj	32,711
#3	'aircraft'/exp OR 'airport'/exp OR 'railway'/exp OR 'motor vehicle'/exp	54,095
#2	'traffic and transport'/exp/mj	100,313
#1	noise NEAR/5 (rail* OR aircraft OR airport* OR road* OR traffic* OR automobile* OR vehicle* OR motorcycle* OR transport*)	4,712

Ti: in title/Mj Major , main topic of paper /Exp not all keywords have to be mentioned separately

Scopus

((TITLE-ABS-KEY (noise W/5 (rail* OR aircraft OR airport* OR road* OR traffic* OR automobile* OR vehicle* OR motorcycle*))) AND (TITLE (sleep* OR annoyance) OR KEY (noise-annoyance)) AND PUBYEAR > 2013) OR ((TITLE-ABS-KEY (noise) AND TITLE-ABS-KEY ((wind W/3 turbine*) OR windturbine* OR (wind

W/3 farm*) OR windfarm* OR wind-park* OR windpark* OR wind-mill*)) AND (TITLE (sleep* OR annoyance) OR KEY (sleep* OR annoyance)) AND PUBYEAR > 2013)

PubMed

Search	Query	Items found
#21	Search **#20 AND 2014:2019[dp]**	177
#20	Search **#17 AND (#18 OR #19)**	514
#19	Search **annoyance[ti] OR sleep*[ti]**	88617
#18	Search **"Sleep"[mh] OR "Sleep Wake Disorders"[mh]**	131779
#17	Search **#6 OR #16**	5911
#16	Search **(#7 OR #13) AND (#7 OR #14 OR #15)**	175
#15	Search **infrasound*[tiab] OR noise[tiab] OR "low frequen*"[tiab]**	127874
#14	Search **"Noise"[mh] OR "Sound"[mh]**	38465
#13	Search **#8 AND (#9 OR #10 OR #11 OR #12)**	345
#12	Search **"Energy-Generating Resources"[mh:noexp]**	2077
#11	Search **"Electric Power Supplies"[mh:noexp]**	6837
#10	Search **"Power Plants"[mh:noexp]**	6029
#9	Search **"Renewable energy"[mh:noexp]**	745
#8	Search **"Wind"[mh]**	4139
#7	Search **noise[tiab[AND ("wind turbine*"[tiab] OR "windturbine*"[tiab] OR "wind farm*"[tiab] OR "windfarm*"[tiab] OR "wind park*"[tiab] OR windpark*[tiab] OR "wind mill*"[tiab] OR windmill*[tiab])**	141
#6	Search **(#1 OR #2 OR #3 OR #5) AND (#1 OR #4 OR #5)**	5764
#5	Search **"Noise,transportation"[mh]**	1326
#4	Search **"Noise"[mj:noexp]**	11924
#3	Search **"Aircraft"[mh:noexp] OR "Airports"[mh:noexp] OR "Railroads"[mh:noexp] OR "Motor vehicles"[mh]**	30480
#2	Search **"Transportation"[majr]**	44470
#1	Search **noise[tiab] AND (rail*[tiab] or aircraft[tiab] or airport*[tiab] or road*[tiab] or traffic*[tiab] or automobile*[tiab] or vehicle*[tiab] or "motor cycle*"[tiab] or motorcycle*[tiab] or transport*[tiab])**	5046

PsycINFO

#	Searches	Results
1	(noise adj5 (rail* or aircraft or airport* or road* or traffic* or automobile* or vehicle* or motorcycle*)).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	445
2	traffic.mp. or aircraft/ or railroad trains/ or transportation/ or motor vehicles/	18859
3	exp Noise Effects/	3294
4	exp Auditory Stimulation/	28344
5	exp VIBRATION/	1450
6	(noise*or infrasound or low frequen*).ti,ab.	9729
7	((wind adj3 turbine*) or windturbine* or (wind adj3 farm*) or windfarm* or (wind adj3 park*) or windpark* or windmill* or wind mill*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	194
8	(1 or 2) and (1 or 3 or 4 or 5 or 6)	637
9	7 and (3 or 4 or 5 or 6)	12
10	8 or 9	647
11	exp Sleep Disorders/ or exp Sleep/ or exp Sleepiness/ or exp Sleep Deprivation/	34770
12	(annoyance or sleep*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	77655
13	11 or 12	79012
14	10 and 13	145
15	limit 14 to yr="2014-current"	21

Part 2a Air/rail noise and hypertension/cardiovascular diseases (Update search 2014) -26032019

Embase

Query	Results	No.
#19	#18 AND [2014-2019]/py	109
#18	#17 NOT child*:ti	263
#17	#15 AND #16	268
#16	#8 OR #9 OR #10 OR #11 OR #12	4,488,433
#15	#13 AND #14	1,958
#14	#1 OR #2 OR #6 OR #7	18,670
#13	#1 OR #2 OR #3 OR (#4 AND #5)	16,593
#12	'ischaemic heart disease*' OR 'ischemic heart disease*' OR 'coronary heart disease*' OR 'angina pectoris' OR 'myocard* infarct*' OR 'cardiovascular disease*' OR 'heart disease*'	1,041,266
#11	'hypertension' OR 'blood-pressure'	1,233,280
#10	'cardiovascular disease'/exp	4,098,866
#9	'hypertension'/exp	695,400

Query	Results	No.
#8	'blood pressure'/exp	549,391
#7	'traffic noise'/exp	2,019
#6	'noise'/mj	16,113
#5	rail* OR 'aircraft' OR airport* OR 'air traffic'	39,708
#4	'traffic and transport'/mj	3,741
#3	'aircraft'/exp OR 'airport'/exp OR 'railway'/exp	15,746
#2	'aircraft noise'/exp	616
#1	noise NEAR/5 (rail* OR aircraft OR airport* OR 'air traffic*')	1,652

Scopus
((TITLE-ABS-KEY ((rail* OR aircraft OR airport* OR air-traffic*) W/5 noise)) AND (TITLE-ABS-KEY (hypertension OR blood-pressure OR ischemic-heart-disease* OR coronary-heart-disease* OR angina-pectoris OR myocard*-infarct* OR cardiovascular-disease* OR heart-disease*)) AND PUBYEAR > 2013) AND NOT (TITLE (child*))

PubMed

Search	Query	Items found
#16	Search #15 AND 2014:2019[dp]	61
#15	Search #14 NOT "child*"[ti]	186
#14	Search #13 AND (#7 OR #8 OR #9 OR #10 OR #11)	186
#13	Search #12 AND (#1 OR #5 OR #6)	1425
#12	Search (#1 OR #2 OR (#3 AND #4)	12269
#11	Search "ischaemic heart disease*"[tiab] or "ischemic heart disease"[tiab] or "coronary heart disease*"[tiab] or "angina pectoris"[tiab] or "myocard* infarct*"[tiab] or "cardiovascular disease*"[tiab] or "heart disease*"[tiab]	276684
#10	Search "hypertension"[tiab] or "blood pressure"[tiab]	557460
#9	Search "Cardiovascular diseases"[mh]	2258495
#8	Search "Hypertension"[mh]	244168
#7	Search "Blood pressure"[mh]	280805
#6	Search "Noise,transportation"[mh:noexp]	1320
#5	Search "Noise"[mj:noexp]	11899
#4	Search rail*[tiab] or aircraft[tiab] or airport*[tiab] or "air traffic"[tiab]	15275
#3	Search "Transportation"[mj:noexp]	4932
#2	Search "Aircraft"[mh:noexp] OR "Airports"[mh:noexp] OR "Railroads"[mh:noexp]	11604
#1	Search noise[tiab] AND (rail*[tiab] or aircraft[tiab] or airport*[tiab] or "air traffic"[tiab])	1121

Part 2b Aircraft and/or rail traffic and/or road traffic noise and stroke/diabetes/obesity (Update search 2014)

Embase

Query	Results	No.
#15	#14 AND [2014-2019]/py	131
#14	#13 NOT child*:ti	196
#13	#6 AND #12	205
#12	#7 OR #8 OR #9 OR #10 OR #11	2,426,661
#11	'diabetes' OR 'obesit*' OR 'overweight' OR 'bmi' OR 'body mass index'	1,611,441
#10	'stroke' OR 'cerebrovascular accident*' OR 'cva' OR 'cerebrovascular disorder*' OR 'brain vascular accident*' OR 'brain vascular disorder*'	500,485
#9	'obesity'/exp OR 'body mass'/exp	713,875
#8	'diabetes mellitus'/exp	908,691
#7	'cerebrovascular disease'/exp	670,481
#6	(#1 OR #2 OR #3) AND (#1 OR #4 OR #5)	4,671
#5	'traffic noise'/exp OR 'aircraft noise'/exp	2,504
#4	'noise'/mj	16,113
#3	'aircraft'/exp OR 'airport'/exp OR 'railway'/exp OR 'motor vehicle'/exp	54,074
#2	'traffic and transport'/exp/mj	100,284
#1	noise NEAR/5 (rail* OR aircraft OR airport* OR traffic* OR automobile* OR vehicle*)	4,175

Scopus 20190326
((TITLE-ABS-KEY ((rail* OR aircraft OR airport* OR road* OR traffic* OR automobile* OR vehicle*) W/1 noise)) AND (TITLE-ABS-KEY (stroke OR cerebrovascular OR cva OR brain-vascular OR diabetes OR obesit* OR overweight OR bmi OR body-mass-index)) AND PUBYEAR > 2013) AND NOT (TITLE (child*))

PubMed 20190326

Search	Query	Items found
#15	Search **#14 AND 2014:2019[dp]**	88
#14	Search **#13 NOT "child*"[ti]**	151
#13	Search **#6 AND #12**	151
#12	Search **#7 OR #8 OR #9 OR #10 OR #11**	1393382
#11	Search **diabetes[tiab] or obesit*[tiab] or overweight[tiab] or bmi[tiab] or "body mass index"[tiab]**	786753
#10	Search **stroke[tiab] or cerebrovascular*[tiab] or cva[tiab] or "brain vascular accident*"[tiab] or "brain vascular disorder*"[tiab]**	260145
#9	Search **"Obesity"[mh] or "Overweight"[mh] or "Body Mass Index"[mh]**	269289
#8	Search **"Diabetes Mellitus"[mh]**	398690

Search	Query	Items found
#7	Search **"Cerebrovascular disorders"[mh]**	343933
#6	Search **(#1 or #2 or #3) AND (#1 or #4 or #5)**	3663
#5	Search **"Noise,transportation"[mh]**	1320
#4	Search **"Noise"[mj:noexp]**	11899
#3	Search **"Aircraft"[mh:noexp] OR "Airports"[mh:noexp] OR "Railroads"[mh:noexp] OR "Motor vehicles"[mh:noexp]**	15968
#2	Search **"Transportation"[majr]**	44421
#1	Search **noise[tiab] AND (rail*[tiab] or aircraft[tiab] or airport*[tiab] or road*[tiab] or traffic*[tiab] or automobile*[tiab] or vehicle*[tiab])**	3119

Part2c: Road traffic noise and blood pressure/hypertension (update search 2014)

Embase

Query	Results	No.
#12	#11 AND [2014-2019]/py	99
#11	#10 NOT child*:ti	260
#10	#6 AND (#7 OR #8 OR #9)	274
#9	'hypertension' OR 'blood-pressure'	1,233,687
#8	'hypertension'/exp	695,655
#7	'blood pressure'/exp	549,548
#6	(#1 OR #2 OR #3) AND (#1 OR #4 OR #5)	4,353
#5	'traffic noise'/exp	2,021
#4	'noise'/mj	16,113
#3	'motor vehicle'/exp	39,073
#2	'traffic and transport'/exp/mj	100,284
#1	noise NEAR/5 (road* OR traffic* OR automobile* OR vehicle* OR 'motor cycle*' OR motorcycle* OR transport*)	3,667

Scopus

(TITLE-ABS-KEY ((road* OR traffic* OR automobile* OR vehicle* OR motor-cycle* OR motorcycle* OR transport*) W/1 noise)) AND (TITLE-ABS-KEY (hypertension OR blood-pressure)) AND PUBYEAR > 2013 AND NOT TITLE (child*)

PubMed

Search	Query	Items found
#12	Search **#11 AND 2014:2019[dp]**	84
#11	Search **#10 NOT "child*"[ti]**	236
#10	Search **#6 AND (#7 OR #8 OR #9)**	236
#9	Search **"hypertension"[tiab] or "blood pressure"[tiab]**	557533

Search	Query	Items found
#8	Search **"Hypertension"[mh]**	244174
#7	Search **"Blood pressure"[mh]**	280818
#6	Search **(#1 or #2 or #3) AND (#1 or #4 or #5)**	5153
#5	Search **"Noise,transportation"[mh]**	1320
#4	Search **"Noise"[mj:noexp]**	11903
#3	Search **"Motor vehicles"[mh]**	19528
#2	Search **"Transportation"[majr]**	44425
#1	Search **noise[tiab] AND (road*[tiab] or traffic*[tiab] or automobile*[tiab] or vehicle*[tiab] or "motor cycle*"[tiab] or motorcycle*[tiab] or transport*[tiab])**	4321

Part 2d: Traffic noise and blood pressure in children (Update search 2014)

Embase

Query	Results	No.
#14	#10 AND #13	52
#13	#11 OR #12	4,007,781
#12	child*:ti,ab OR infant*:ti,ab OR adolescent*:ti,ab	2,152,259
#11	'child'/exp OR 'adolescent'/exp	3,471,333
#10	#6 AND (#7 OR #8 OR #9)	325
#9	'hypertension' OR 'blood-pressure'	1,234,012
#8	'hypertension'/exp	695,863
#7	'blood pressure'/exp	549,677
#6	(#1 OR #2 OR #3) AND (#1 OR #4 OR #5)	4,760
#5	'traffic noise'/exp OR 'aircraft noise'/exp	2,504
#4	'noise'/mj	16,113
#3	'aircraft'/exp OR 'airport'/exp OR 'railway'/exp OR 'motor vehicle'/exp	54,074
#2	'traffic and transport'/exp/mj	100,284
#1	noise NEAR/5 (rail* OR aircraft OR airport* OR road* OR traffic* OR automobile* OR vehicle*)	4,272

Scopus

TITLE-ABS-KEY ((rail* OR aircraft OR airport* OR road* OR traffic* OR automobile* OR vehicle*) W/1 noise) AND TITLE-ABS-KEY (blood-pressure OR hypertension) AND TITLE-ABS-KEY (child* OR infant* OR adolescent*) AND PUBYEAR > 2013

PubMed

Search	Query	Items found
#14	Search **#11 AND 2014:2019[dp]**	17
#12	Search **#10 AND (child OR children OR infant OR infants OR adolescent OR adolescents)**	59

Search	Query	Items found
#11	Search **#10 AND (child* OR infant* OR adolescent*)**	61
#10	Search **#6 AND (#7 OR #8 OR #9)**	235
	Search **"hypertension"[tiab] or "blood pressure"[tiab]**	557615
#8	Search **"Hypertension"[mh]**	244185
#7	Search **"Blood pressure"[mh]**	280825
#6	Search **(#1 or #2 or #3) AND (#1 or #4 or #5)**	3663
#5	Search **"Noise,transportation"[mh]**	1322
#4	Search **"Noise"[mj:noexp]**	11904
#3	Search **"Aircraft"[mh:noexp] OR "Airports"[mh:noexp] OR "Railroads"[mh:noexp] OR "Motor vehicles"[mh:noexp]**	15972
#2	Search **"Transportation"[majr]**	44427
#1	Search **noise[tiab] AND (rail*[tiab] or aircraft[tiab] or airport*[tiab] or road*[tiab] or traffic*[tiab] or automobile*[tiab] or vehicle*[tiab])**	3119

Part 2e: Noise wind turbines and blood pressure/cardiovascular diseases (*Update search 2014)*

Embase

Query	Results	No.
#16	#15 AND [2014-2019]/py	30
#15	#8 AND (#9 OR #10) AND (#11 OR #12 OR #13 OR #14)	43
#14	health*:ti	815,872
#13	'cardiovascular function'/exp OR 'cardiovascular disease'/exp OR 'cardiovascular system'/exp	5,316,590
#12	'blood pressure'/exp	549,677
#11	'blood pressure' OR cardiovascular*	1,806,850
#10	infrasound* OR noise* OR 'low frequenc*'	220,783
#9	'noise'/exp OR 'sound'/exp	283,427
#8	#1 OR #2 OR #7	1,131
#7	#3 AND (#4 OR #5 OR #6)	308
#6	'power supply'/exp OR 'energy resource'/de	21,068
#5	'electric power plant'/de	7,827
#4	'renewable energy'/de	2,505
#3	'wind'/exp	8,380
#2	'wind power'/exp OR 'wind farm'/exp	655
#1	(wind NEAR/3 turbine) OR (wind NEAR/3 farm) OR windturbine* OR windfarm*	467

Scopus

TITLE-ABS-KEY ((wind W/3 turbine*) OR windturbine* OR (wind W/3 farm*) OR windfarm*) AND TITLE-ABS-KEY (noise OR infrasound* OR low-frequenc*) AND (TITLE-ABS-KEY (blood-pressure OR cardiovascular*) OR TITLE (health*)) AND PUBYEAR > 2013

PubMed

Search	Query	Items found
#16	Search **#15 AND 2014:2019[dp]**	37
#15	Search **#8 AND (#9 OR #10) AND (#11 OR #12 OR #13 OR #14)**	48
#14	Search **"health"[ti]**	564308
#13	Search **"Cardiovascular Physiological Phenomena"[mh] OR "Cardiovascular Diseases"[mh] OR "Cardiovascular System"[mh]**	3185477
#12	Search **"Blood pressure"[mh]**	280825
#11	Search **"blood pressure"[tiab] OR "cardiovascular*"[tiab]**	629288
#10	Search **infrasound*[tiab] OR noise[tiab] OR "low frequenc*"[tiab]**	127595
#9	Search **"Noise"[mh] OR "Sound"[mh]**	38411
#8	Search **#1 OR #7**	679
#7	Search **#2 AND (#3 OR #4 OR #5 OR #6)**	344
#6	Search **"Energy-Generating Resources"[mh:noexp]**	2076
#5	Search **"Electric Power Supplies"[mh:noexp]**	6831
#4	Search **"Power Plants"[mh:noexp]**	6024
#3	Search **"Renewable energy"[mh:noexp]**	742
#2	Search **"Wind"[mh]**	4127
#1	Search **"wind turbine*"[tiab] OR "wind farm*"[tiab] OR "windturbine*"[tiab] OR "windfarm*"[tiab]**	473

Part 3: Search profile Low frequency noise due to Building service equipment including ground and air source heat pumps, in relation to annoyance, sleep disturbance, health complaints.

Embase

Query	Results	No.
#15	#14 AND [2000-2019]/py	99
#14	#11 OR #13	128
#13	(#1 OR #2) AND #12	45
#12	('noise*' NEAR/5 'annoyance'):ti,ab	671
#11	#6 AND #10	106
#10	#7 OR #8 OR #9	6,648,140
#9	sleep*:ti,ab OR 'cardiovascular':ti,ab OR 'health':ti,ab	2,844,490
#8	'annoyance':ti,ab OR 'complain*':ti,ab OR 'well-being':ti,ab OR 'wellbeing':ti,ab OR discomfort*:ti,ab OR 'nuisance':ti,ab	347,959
#7	'annoyance'/exp OR 'sleep'/exp OR 'sleep disorder'/exp OR 'cardiovascular disease'/exp	4,398,564
#6	(#1 OR #2) AND (#3 OR #4 OR #5)	300
#5	'neighborhood'/exp OR 'home environment'/exp OR 'community'/exp OR 'residential area'/exp OR 'household'/exp	223,814

Query	Results	No.
	OR 'urban area' OR 'suburban area'/exp OR 'urban population'/exp	
#4	'neighborhood':ti,ab OR 'neighbourhood':ti,ab OR 'urban':ti,ab OR residen*:ti,ab OR 'population':ti,ab	2,089,970
#3	'environmental exposure'/exp OR 'population exposure'/exp OR 'exposure'/mj OR ((environment* NEAR/5 exposure):ti,ab) OR ((population NEAR/5 expos*):ti,ab) OR ((environment* NEAR/3 'noise'):ti,ab)	159,175
#2	(noise:ti OR 'noise'/exp) AND ('air conditioning'/exp OR 'cooling'/exp OR 'heating'/exp OR 'heat pump*':ti,ab)	574
#1	'low frequency noise'/exp OR (('low frequenc*' NEAR/3 (noise* OR sound*)):ti,ab) OR 'infrasound':ti,ab	2,445

Scopus
(((TITLE-ABS-KEY (low-frequency-noise OR infrasound)) OR (TITLE (noise) AND TITLE-ABS-KEY (heat-pump* OR low-frequency-component*))) AND (TITLE-ABS-KEY (neighbor* OR neighbour* OR urban OR residen* OR inhabitant* OR population OR house? OR dwelling OR building OR communit*)) AND (TITLE-ABS-KEY (annoyance OR complain* OR well-being OR wellbeing OR discomfort* OR nuisance OR sleep* OR cardiovascular OR health)) AND PUBYEAR > 1999) OR (((TITLE-ABS-KEY (low-frequency-noise OR infrasound)) OR (TITLE (noise) AND TITLE-ABS-KEY (heat-pump* OR low-frequency-component*))) AND (TITLE (annoyance OR complain* OR well-being OR wellbeing OR discomfort* OR nuisance OR sleep* OR cardiovascular OR health)) AND PUBYEAR > 1999)

PubMed

Search	Query	Items found
#15	Search (#14 AND 2000:2019[dp])	100
#14	Search #11 OR #13	116
#13	Search (#1 OR #2) AND #12	26
#12	Search (noise[ti] AND annoyance[ti]) OR "noise annoyance"	419
#11	Search #6 AND #10	109
#10	Search #7 OR #8 OR #9	4362159
#9	Search sleep*[tiab] OR cardiovascular[tiab] OR health[tiab]	2217384
#8	Search annoy*[tiab] OR complain*[tiab] OR well-being[tiab] OR wellbeing[tiab] OR discomfort*[tiab] OR nuisance[tiab]	240755
#7	Search Sleep[mh] OR sleep[ti] OR Cardiovascular Diseases[mh] OR cardiovascular[ti] OR Irritable Mood[mh]	2412090
#6	Search (#1 OR #2) AND (#3 OR #4 OR #5)	236
#5	Search "Residence Characteristics"[mh] OR "Urban population"[mh] OR "Suburban population"[mh]	113654

Search	Query	Items found
#4	Search neighborhood[tiab] OR neighbourhood[tiab] OR urban[tiab] OR residen*[tiab] OR population[tiab]	1576862
#3	Search Environmental exposure[mj] OR "environmental exposure"[tiab] OR "population exposure"[tiab] OR "environmental noise"[tiab]	171819
#2	Search (Noise[mh] OR noise[ti]) AND (Air Conditioning[mh] OR Heating[mh] OR Ventilation[mh] OR "heat pump"[tiab] OR "heat pumps"[tiab])	330
#1	Search ((Noise[mj] AND low-frequen* OR infrasound) OR "low frequency noise"[tiab] OR infrasound[tiab])	1352

PsycINFO <1806 to April Week 1 2019>

#	Searches	Results
1	(noise adj5 (rail* or aircraft or airport* or road* or traffic* or automobile* or vehicle* or motorcycle*)).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	445
2	traffic.mp. or aircraft/ or railroad trains/ or transportation/ or motor vehicles/	18859
3	exp Noise Effects/	3294
4	exp Auditory Stimulation/	28344
5	exp VIBRATION/	1450
6	(noise*or infrasound or low frequen*).ti,ab.	9729
7	((wind adj3 turbine*) or windturbine* or (wind adj3 farm*) or windfarm* or (wind adj3 park*) or windpark* or windmill* or wind mill*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	194
8	(1 or 2) and (1 or 3 or 4 or 5 or 6)	637
9	7 and (3 or 4 or 5 or 6)	12
10	8 or 9	647
11	exp Sleep Disorders/ or exp Sleep/ or exp Sleepiness/ or exp Sleep Deprivation/	34770
12	(annoyance or sleep*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures]	77655
13	11 or 12	79012

#	Searches	Results
14	10 and 13	145
15	limit 14 to yr="2014-current"	21

Part 4: New source: Industrial Noise, Neighbour Noise and Neighbourhood Noise (excluding transport)[9]

Embase

Query	Results	No.
#21	#20 NOT (occupation*:ti OR worker*:ti OR traffic:ti OR transport*:ti OR aircraft:ti OR airport:ti OR rail*:ti OR mental:ti)	379
#20	#19 AND [2000-2019]/py	557
#19	#16 OR #18	825
#18	#15 NOT #17	812
#17	#15 AND [animals]/lim	50
#16	#15 AND [humans]/lim	656
#15	#9 AND #14	862
#14	#10 OR #11 OR #12 OR #13	5,555,253
#13	'health'/exp/mj	221,486
#12	sleep*:ti,ab OR 'cardiovascular':ti,ab OR 'health':ti	1,454,848
#11	'annoyance':ti,ab OR 'complain*':ti,ab OR 'well-being':ti,ab OR 'wellbeing':ti,ab OR discomfort*:ti,ab OR 'nuisance':ti,ab	350,335
#10	'annoyance'/exp OR 'sleep'/exp OR 'sleep disorder'/exp OR 'cardiovascular disease'/exp	4,417,514
#9	#4 AND #8	2,432
#8	#5 OR #6 OR #7	1,074,059
#7	'neighborhood'/exp OR 'home environment'/exp OR 'community'/exp OR 'residential area'/exp OR 'household'/exp OR 'urban area' OR 'suburban area'/exp OR 'urban population'/exp OR 'housing'/exp OR 'home'/exp	252,069
#6	'neighbor*':ti,ab OR 'neighbour*':ti,ab OR 'urban':ti,ab OR residen*:ti,ab OR 'population':ti OR 'indoor':ti,ab	810,180
#5	'environmental exposure'/exp OR 'population exposure'/exp OR 'exposure'/mj OR ((environment* NEAR/3 exposure):ti,ab) OR ((population NEAR/3 expos*):ti,ab) OR ((environment* NEAR/1 'noise'):ti,ab)	147,676
#4	#1 OR #2 OR #3	16,269
#3	noise:ti AND (((noise NEAR/3 (industr* OR building* OR equipment* OR neighbor* OR neighbour* OR floor OR footstep* OR walking OR impact)):ti,ab) OR 'noise pollution':ti,ab)	2,251
#2	(noise:ti OR 'noise'/exp/mj) AND ('air conditioning'/exp OR 'air condition*':ti,ab OR ventilat*:ti,ab OR 'cooling'/exp OR	402

[9]: *neighbour noise*" defined as noise which includes noise from inside and outside people's homes; and "*neighbourhood noise*" which includes noise arising from within the community such as industrial and entertainment premises, trade and business premises, construction sites and noise in the street other than transport related

	'heating'/exp OR 'heat pump*':ti,ab OR 'airborne':ti,ab OR ((contact NEAR/1 induced):ti,ab))	
#1	'noise pollution'/mj OR 'industrial noise'/de OR ('noise'/mj AND noise:ti) OR ((impact NEAR/1 sound*):ti,ab)	15,289

Scopus

(((TITLE-ABS-KEY (noise W/1 (impact OR structure-born* OR walking OR floor OR footstep* OR contact-induced))) OR (TITLE-ABS-KEY (impact W/1 sound*)) OR (TITLE-ABS-KEY ((airborne W/3 noise) AND building*))) AND (TITLE-ABS-KEY (building* OR neighbor* OR neighbour* OR indoor OR residen* OR home* OR house OR apartment* OR annoyance))) AND (TITLE-ABS-KEY ((sleep* OR annoyance OR cardiovascular* OR health))) AND PUBYEAR > 1999 AND NOT TITLE (traffic OR transport* OR aircraft* OR airport* OR rail*)

PubMed

Search	Query	Items found
#17	Search #16 NOT (occupation*[ti] OR worker*[ti] OR traffic[ti] OR transport*[ti] OR aircraft[ti] OR airport[ti] OR rail*[ti] OR mental[ti])	314
#16	Search #15 AND 2000:2019[dp]	451
#15	Search #9 AND #14	629
#14	Search #10 OR #11 OR #12 OR #13	3578006
#13	Search health[mj]	194007
#12	Search sleep*[tiab] OR cardiovascular[tiab] OR health[ti]	1124189
#11	Search annoyance[tiab] OR complain*[tiab] OR well-being[tiab] OR wellbeing[tiab] OR discomfort*[tiab] OR nuisance[tiab]	240750
#10	Search "emotions"[mj] OR "sleep"[mh] OR "sleep wake disorders"[mh] OR "cardiovascular diseases"[mh]	2515453
#9	Search #4 AND #8	1860
#8	Search #5 OR #6 OR #7	773746
#7	Search "Residence Characteristics"[mh] OR "urban population"[mh] OR "suburban population"[mh] OR "population"[mj:noexp]	116957
#6	Search neighbor*[tiab] OR neighbour*[tiab] OR urban[tiab] OR residen*[tiab] OR population[ti] OR indoor[tiab]	651565
#5	Search "environmental exposure"[mh:noexp] OR "environmental exposure"[tiab] OR "population exposure"[tiab] OR "environmental noise"[tiab]	76751
#4	Search #1 or #2 or #3	10518

Search	Query	Items found
#3	Search "noise pollution"[tiab] OR (noise[ti] and (industrial[tiab] or building*[tiab] or equipment*[tiab] or neighbor*[tiab] or neighbour*[tiab] or floor*[tiab] or footstep*[tiab] or walking[tiab]))	2369
#2	Search (noise[mh] or noise[ti]) and (air conditioning[mh] or ventilation[mh] or ventilation[tiab] or heating[mh] or "air condition*"[tiab] or "heating"[tiab] or "heat pump*"[tiab] or airborne[tiab] or "contact induced"[tiab])	555
#1	Search (noise [mj:noexp] AND noise[ti]) OR "impact sound"[tiab] OR "impact noise"[tiab]	8736

Annex 3: Glossary

DR	dose-response
CI	Confidence interval
DALY	Disability-adjusted life year
DEN	Day-evening-night equivalent level
DW	Disability weight
EBoDe	Environmental Burden of Disease in the European Region
EBD	Environmental Burden of Disease
EEA	European Environment Agency
END	Environmental noise directive (2002/49/EC)
EEr	Eposure Effect Relation
ERR	Exposure Respons Relation
ERF	Exposure Response Function
HIA	Health Impact Assessment
EU	European Union
HA	Highly annoyed people
HSD	Highly sleep disturbed people
Incidence	Measure of the probability of occurrence of a given medical condition in a population within a specific period of time
LAeq,th or Leq,th	A-weighted equivalent sound pressure level over (t) hours
L_{den}	Day-evening-night equivalent sound level
L_{dn}	Day-night equivalent sound level
L_{night}	Night equivalent sound level
Morbidity	the rate of disease in a population.
Mortality	A measure of the number of deaths in a given population
NAP	Noise action plan
NafP	Number of affected people
OR	Odds ratio
Prevalence	Actual number of cases of disease or injury present in a population at any particular moment in time.
PSG	Polysomnography
REM	Rapid eye movement (sleep stage)
RR	Relative Risk
SD	Standard deviation
SWS	Slow wave sleep
WHO	World Health Organizatio

RIVM

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