Review of additional evidence for NHMRC Information Paper: Evidence on Wind Farms and Human Health

FINAL REPORT

Prepared for NHMRC by

Australasian Cochrane Centre (ACC) and

Monash Centre for Occupational and Environmental Health (MonCOEH)

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Contents

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Declarations of Interest

All authors declare they have no financial, personal or professional interests that could be construed to have influenced the conduct or reporting of this review of additional evidence.

Background

Independent Systematic Review

In August 2012, the National Health and Medical Research Council (NHMRC) commissioned an independent reviewer to undertake a comprehensive review of existing scientific literature on the possible effects of wind farms on human health ('the Independent Review'). This review considered a wide range of evidence, comprising both peer reviewed and non-peer reviewed literature. The Independent Review was supplemented by a call (in September 2012) for submissions of evidence for consideration in the systematic review.

The purpose of the systematic literature review was to determine whether there was evidence to establish that emissions from wind farms cause human health effects (Direct Evidence). A background literature review was also conducted to investigate the physiological mechanisms by which the emissions of wind farms could produce adverse health effects (Mechanistic Evidence) and whether health effects had been observed from similar emissions in other exposure settings (Parallel Evidence).

A comprehensive search of the available scientific literature was conducted by the reviewer in October 2012. While 2848 papers were identified in the literature search for the systematic review component of the Independent Review, and an additional 506 references were submitted to NHMRC for consideration, only 161 papers were found to be relevant to the topic and were considered by the reviewers in detail. Of these, only 11 publications (describing seven studies) met the inclusion criteria to address the systematic review questions.

The reviewer assessed the design, quality, relevance and strength of each study included in the systematic review. The overall body of evidence was then analysed for its quality and consistency. The process and findings of the Independent Review were summarised in a report, *Systematic review of the human health effects of wind farms* (the Independent Review report), which was finalised in late 2013[1].

NHMRC Information Paper

The Wind Farms and Human Health Reference Group ('the Reference Group') was established by NHMRC in early 2012 to oversee the systematic review of the literature. The Reference Group comprises experts in public and environmental health, epidemiology and research methodology, acoustics, psychology and sleep, and also includes a consumer advocate.

Under its terms of reference, the Reference Group was also asked to consider the outcomes of the review to inform any update of NHMRC's 2010 Public Statement: *Wind Turbines and Health*, and to identify gaps in the current evidence base that may warrant further research. In response to this task, the Reference Group guided the development of a new draft Information Paper: *Evidence on Wind Farms and Human Health*, with the assistance of a Technical Writer. The draft Information Paper provided the Australian community with a summary of the available evidence on the potential human health effects of wind farm emissions of noise, shadow flicker and electromagnetic radiation (EMR), based on the comprehensive review of the scientific literature. It also explained the process by which the evidence was identified and critically appraised in the Independent Review, and included an explanation of the evidence by the Reference Group together with their recommendations for further research to address gaps in the available evidence.

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[1] Available on the NHMRC website at http://www.nhmrc.gov.au/guidelines/publications/eh54.

Context for this review of additional evidence

The Council of NHMRC considered the draft Information Paper in late 2013 and recommended to the Chief Executive Officer (CEO) that the draft paper be released for public consultation.

On 24 February 2014 the CEO released the draft Information Paper for public consultation, for a period of 45 days[2]. At that time, the Independent Review report was also released by the CEO as background, to assist interested parties in considering the draft Information Paper.

We were contracted to repeat the literature search carried out for the Independent Review, to capture any additional evidence published since October 2012 that addressed the systematic review questions in the final Independent Review report. In consultation with the Office of NHMRC (ONHMRC) and the Reference Group, we assessed whether the additional literature identified in this search met the specific inclusion criteria for the systematic component of the Independent Review.

In addition, we were provided with a list of additional evidence submitted during the public consultation from 24 February to 11 April 2014, and assessed whether this submitted literature met the specific inclusion criteria for the systematic (Direct Evidence) and background (Supporting Evidence) components of the Independent Review. Literature that met the specific inclusion criteria was critically appraised and the outcomes were summarised narratively. Details of the literature that was excluded from the review are listed in the appendices.

Objectives

The objectives of this report are as follows:

1. To repeat the systematic literature search from a comprehensive review of the evidence commissioned by NHMRC in September 2012, to capture any additional evidence published between October 2012 and May 2014. The purpose of the repeat systematic literature search is to determine whether there is evidence to establish that emissions from wind farms cause human health effects (Direct Evidence).
2. To review evidence submitted during the public consultation process on the NHMRC draft Information Paper: *Evidence on Wind Farms and Human Health*, with the purpose of identifying any Direct Evidence not already identified by the repeat systematic literature search, any Background Evidence relevant to the issue of wind farms and human health, plus any Mechanistic or Parallel Evidence that considers similar emissions from wind farms in the laboratory or other exposure settings and reports on one or more health (or health-related) outcomes (Supporting Evidence).

Methods

The methods described below cover the repeat systematic review search, data extraction and critical appraisal for the Direct Evidence component; and the data extraction and critical appraisal for the Supporting Evidence component of the review. We have used the inclusion criteria specified by ONHMRC, and have followed the methods and forms used in the Independent Review for data extraction and critical appraisal.

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[2] Details on the NHMRC website at http://consultations.nhmrc.gov.au/public_consultations/wind_farms.

Criteria for considering studies for inclusion

To be classified as 'included' in the systematic component of the review (i.e. Direct Evidence), the evidence had to:

1. be publicly available in English;
2. be based on systematically collected data relevant to wind farms and human health;
3. look at human exposure to wind farm emissions;
4. not exclusively select participants only because they had reported health effects;
5. compare participants with different levels of exposure to wind turbines (e.g. a "near" group and a "far" group);
6. explain how the data were collected;
7. report on one or more health (or health-related) outcomes; and
8. analyse the results.

The questions to be addressed in the Direct Evidence component of the review relate to distance, audible noise, infrasound and low-frequency noise, shadow flicker, and EMR (as detailed in Appendix 1).

Search methods for identification of studies

Electronic searches

We searched the following sources to identify peer-reviewed literature meeting the inclusion criteria for the systematic review (Direct Evidence) component: PubMed, Embase, *The Cochrane Library*, PsycInfo and health-related categories of Web of Science. The sources and search strategies replicated those used in the Independent Review, and covered the period from the date the original searches were conducted (i.e. October 2012 to May 2014). The full details of the search strategies for the databases listed above are given in Appendix 2. Searches were run across all four databases on 19 March 2014 and again on 7 May 2014 to capture any additional studies, and to ensure the review is as up-to-date as possible.

Data collection and analysis

Selection of studies for Direct Evidence

Citations identified in the repeat literature search were imported to EndNote and duplicates removed. One reviewer (SM) undertook an initial screening of titles and abstracts to exclude those citations that were very obviously outside the scope of the review. Two reviewers (GB and MS) then independently screened the titles and abstracts of the remaining 'possible' citations and classified each citation as 'potentially included' or 'excluded'. Citations to any material that had been considered for the Independent Review were excluded at this stage. The full-text of citations deemed potentially eligible were retrieved and independently assessed for inclusion. Disagreements were resolved through discussion within the wider team.

The final list of potentially eligible studies for inclusion in the Direct Evidence component of the review was circulated to the Reference Group. Following clarification on the scope of the review with the Reference Group and ONHMRC on 21 May, the final list of potentially eligible studies was agreed. The list was further refined and the selection of studies completed following a meeting with the Reference Group at the NHMRC office in Canberra on 2 July 2014.

Citations that did not meet the inclusion criteria specified above were excluded and the reason for exclusion recorded. At the request of the Reference Group, excluded studies were also considered for the Supporting Evidence component of the review.

Selection of studies from the Submissions for Supporting Evidence

For the citations submitted during the public consultation (24 February to 11 April 2014), we applied the inclusion criteria for both the Direct Evidence and Supporting Evidence components of the review, and classified the material as 'included' or 'excluded'. Evidence was classified as 'included' in the Direct Evidence component of the review if it met the conditions specified in the 'Criteria for considering studies for inclusion' section above.

To be classified as 'included' as Background Evidence in the Supporting Evidence component of the review, the evidence had to:

1. be publicly available in English;
2. be based on systematically collected data relevant to wind farms and human health;
3. explain how the data were collected; and
4. analyse the results.

Where relevant, to be 'included' as Mechanistic or Parallel Evidence in the Supporting Evidence component of the review, the evidence had to meet the conditions specified above and also had to:

1. be peer-reviewed; and
2. report on one or more health (or health-related) outcomes.

The questions addressed in the Supporting Evidence component of the review are detailed in Appendix 3.

Any material that was considered in the Independent Review was excluded (that is, citations listed under *References* and *Appendix C – Excluded Articles* in the Independent Review report). Where background material did not meet the criteria specified above it was excluded and the reason for exclusion recorded.

Data extraction and assessment of methodological quality

For the additional literature classified as 'included' in the Direct Evidence component of the review, two reviewers (GB and EW) independently undertook critical appraisal and data extraction. The steps followed were similar to the methodology outlined in the Independent Review report, namely:

1. Relevant data were extracted from each article/study into a standardised form, using the modified NHMRC Data Extraction Table; and
2. The overall methodological quality of each article or study was critically appraised (i.e. consideration of the level of evidence[3] and likelihood of chance, bias and confounding) using the NHMRC 'Checklist for appraising the quality of studies of aetiology and risk factors'[4] as a guide.

We also undertook critical appraisal and data extraction of the additional literature classified as 'included' in the Supporting Evidence component of the review, using the format: aim; design; exposure; outcome; limitations; results; and conclusions.

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[3] Level I – IV specified in the NHMRC Evidence Hierarchy. Available at:

https://www.nhmrc.gov.au/_files_nhmrc/file/guidelines/developers/nhmrc_levels_grades_evidence_120423.pdf

[4] Box 9.1. Available at: https://www.nhmrc.gov.au/_files_nhmrc/publications/attachments/cp65.pdf.

Synthesis

The two components of the review (Direct Evidence and Supporting Evidence) were synthesised separately.

For the Direct Evidence, we grouped studies by the type of emission or exposure being investigated (as outlined in Appendix 1) and narratively summarised the key findings. We noted any particular concerns or limitations of the studies' ability to inform the assessment of wind farms as a cause of adverse health effects. Where possible, we commented on the reliability of the evidence of the association between the type of emission and adverse health effects, and considered the strength of the association, its relationship to the level of exposure and the possible explanations for the association (if found).

For the Supporting Evidence, studies investigating Mechanistic and Parallel Evidence were synthesised separately. Studies deemed eligible for Background Evidence considered emissions from wind turbines, and the extent to which exposure to these emissions varies by distance and other characteristics. These studies were grouped according to the type of emission being investigated (mostly noise and infrasound). Where appropriate, we identified common themes from among the Mechanistic and Parallel studies, and summarised these narratively, noting particular limitations of the studies and their ability to help inform the review.

For both components of the review, the substantial heterogeneity between the studies, both in terms of their design and the exposures or outcomes assessed, precluded any form of quantitative analysis.

Results

Repeat systematic literature search for Direct Evidence

The combined bibliographic database searches yielded 1597 references after de-duplication. Following title and abstract screening, 1526 citations were excluded as being clearly out of scope of the review. Of the remaining 71 citations, nine had previously been considered and either included or excluded from the Independent Review; these nine citations were therefore excluded from any further consideration in this update.

The remaining 62 citations were independently assessed against the inclusion criteria. Forty-nine citations were excluded, mostly because the citation was not based on systematically collected data relevant to wind farms and human health, or the outcomes were not health or health-related. The complete description of reasons for exclusion is reported in Appendix 4.

Of the remaining 11 citations, six potentially eligible citations were initially included as Direct Evidence from the repeat systematic literature search. During the process of critical appraisal and data extraction, three of these citations (Bockstael 2012; Ruotolo 2012; Whitfield Aslund 2013) were deemed not to meet the criteria and, following clarification on the scope of the review from the Reference Group, were excluded from the Direct Evidence component. Two of the excluded citations (Bockstael 2012; Ruotolo 2012) met the criteria for Background Evidence and Mechanistic Evidence, respectively, and are assessed in those sections of the report. The three included citations of Direct Evidence identified from the repeat searches were Mroczek 2012, Pohl 2012 and Taylor 2013a. (Five additional citations, representing three separate studies, were identified for inclusion under Direct Evidence through the public consultation process and are discussed further in the Submitted literature section of the report.)

At the request of the Reference Group, we checked all excluded citations for their eligibility for the Supporting Evidence component of the review (i.e. Background, Mechanistic or Parallel Evidence), and identified ten Supporting Evidence citations (reporting ten separate studies) in this way. (Five of these were also included in the Submitted Literature following public consultation.)

The steps involved in assessing the identified literature from the searches and the flow of references through the selection process are summarised in Figure 1.

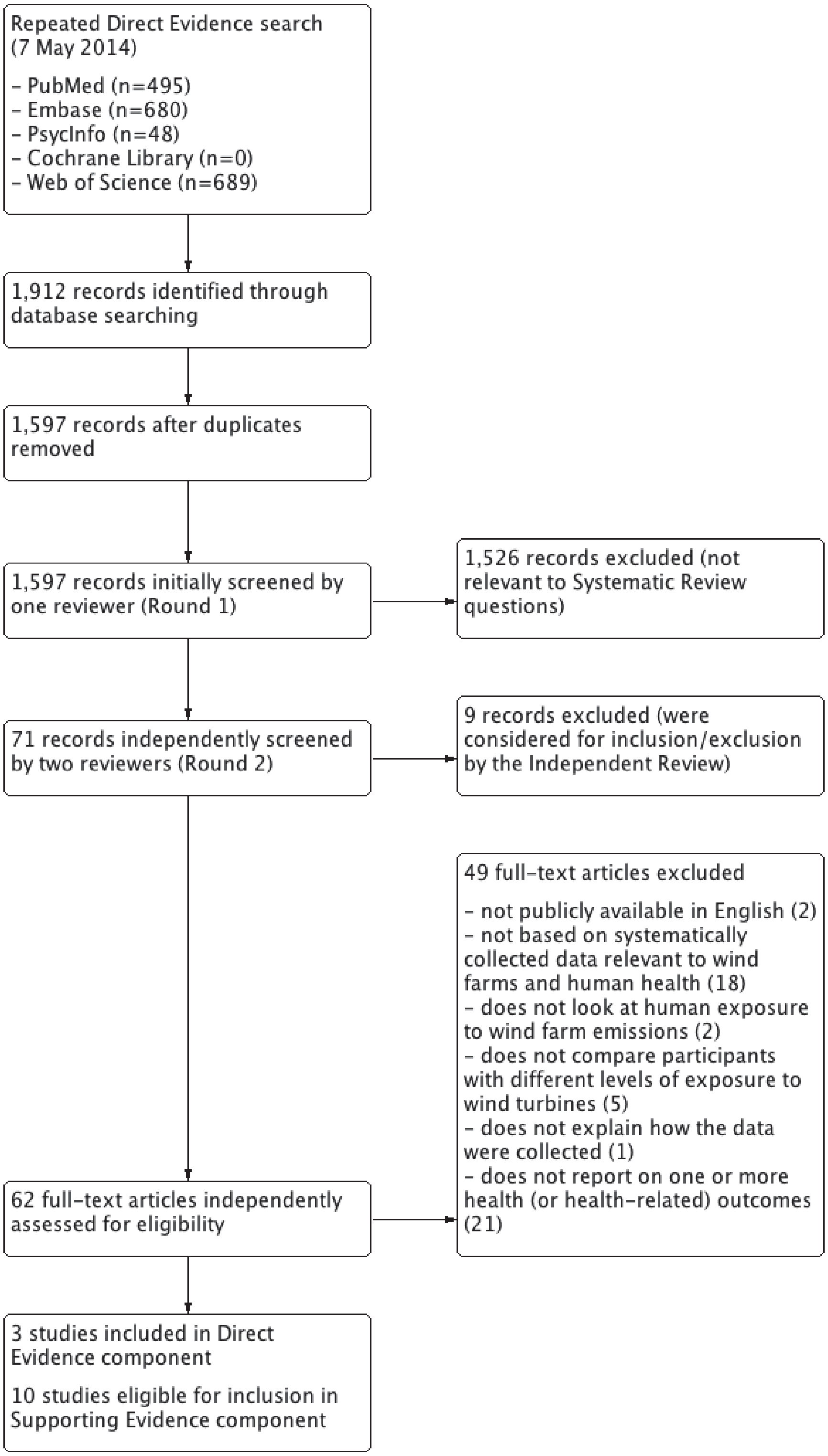

Figure 1. Flow chart showing screening and selection of studies from repeat systematic literature search

Submitted literature ('the Submissions')

Following the period of public consultation (24 February to 11 April 2014) on the NHMRC draft Information Paper: *Evidence on Wind Farms and Human Health*, we were provided with a list of additional evidence comprising 249 citations (from 36 submissions). In the first instance, we checked these citations against the Independent Review to see if they had been considered in the review, and if so, in which section. Citations appearing in the References or Appendix C of the Independent Review had previously been considered (and either included or excluded from the Independent Review) and so did not need to be considered further (Group 1). Citations listed in Appendix D of the Independent Review had already been considered (and excluded) for the systematic review (Direct Evidence) component, so only needed to be assessed for the Supporting Evidence component of the review (Group 2). None of the remaining citations was listed in the Independent Review and these citations were therefore considered for inclusion in both the Direct Evidence and Supporting Evidence components of the review (Group 3).

The 249 submitted citations were considered and grouped as follows:

- Group 1: excluded from Direct Evidence and Supporting Evidence (n = 25)
- Group 2: assessed for Supporting Evidence only (n = 48)
- Group 3: assessed for Direct Evidence and Supporting Evidence (n = 176)

The 224 citations in Groups 2 and 3 were independently assessed against the inclusion criteria. An initial screen was based on a review of title and abstract. The full-text of those deemed possibly relevant was retrieved to determine which citations should be included in the Supporting Evidence component of the review. Of the 224 citations, 192 were excluded (reasons for exclusion are reported in Appendix 5).

Following clarification on the scope of the review from the Reference Group, four citations were deemed eligible for the Direct Evidence component of the review (Kuwano 2013; McBride 2013; Paller 2013; Yano 2013). (These citations comprised three conference papers and one Masters Thesis, which explains why they were not identified through the updated systematic review search.) Two other citations included in the submissions, which were eligible for the Direct Evidence component (Mroczek 2012; Taylor 2013a), had already been identified through the updated systematic review search.

One citation submitted during public consultation (Janssen 2011) had previously been excluded from the Independent Review, however at the request of the Reference Group this study was re-assessed and subsequently included as Direct Evidence. This paper provides further analysis of data from multiple studies that were included in the Independent Review and provides an extension of their results.

Twenty citations (reporting 16 separate studies) met the criteria for the Supporting Evidence component of the review and have been grouped according to Background Evidence (shadow flicker, noise, infrasound, annoyance, EMF); Mechanistic Evidence and Parallel Evidence. Five additional citations were already identified through the repeat literature search as eligible for the Supporting Evidence component (Crichton 2013, Crichton 2014, Doolan 2013, Taylor 2013b, Tickell 2012).

The steps involved in assessing the submitted literature and the flow of references through the selection process are summarised in Figure 2.

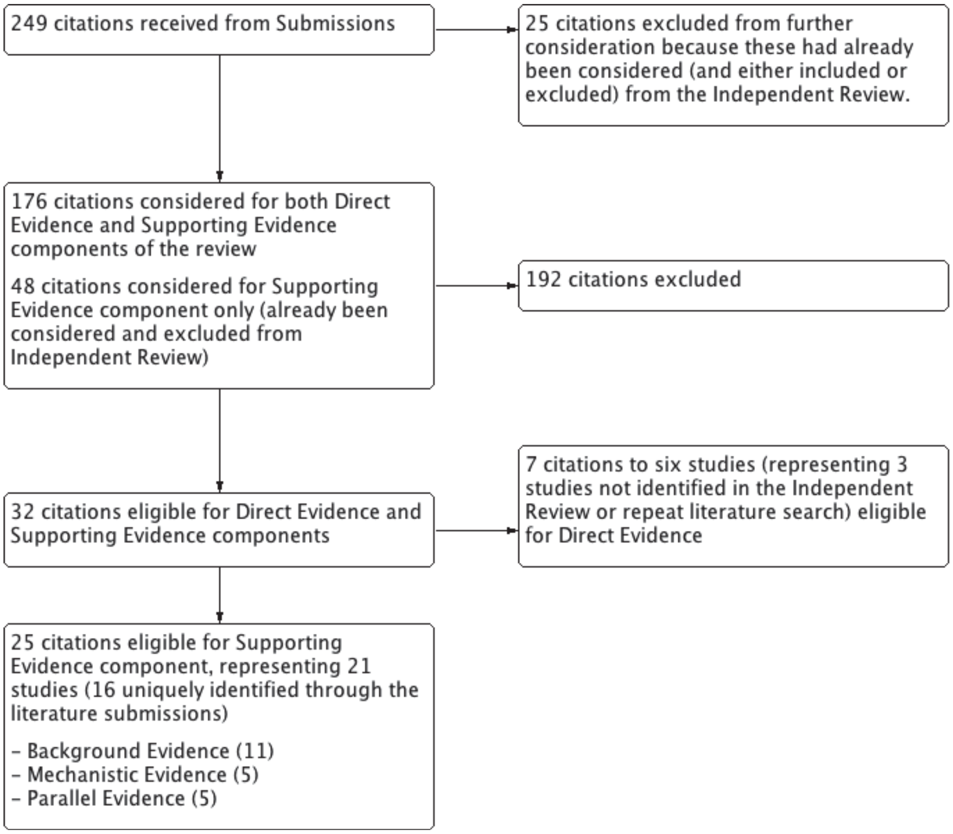

Figure 2. Flow chart showing screening and selection of submitted literature citations

Summary of studies of Direct Evidence

After review of the full papers, eight citations, representing six unique studies, met the criteria for the systematic review (Direct Evidence) component of this updated review of wind turbines and health. Since Yano 2013 is a further analysis of data collected by Kuwano 2013, we treated these as citations to the same study[5]. The Janssen 2011 paper provides further analysis of data from multiple studies that were included in the Independent Review, and is therefore not treated as a separate study. We used the modified NHMRC data extraction form (the same form that was used for the Direct Evidence papers in the Independent Review) to critically appraise and extract data for each study (see Appendix 6). A summary of the characteristics of the included studies is provided in Table 1a and a summary of the results in Table 1b.

Limitations

It is important to note that all these studies (apart from Janssen 2011) were published since the literature searches for the Independent Review were completed in September 2012. Consequently this update only reflects the literature over a period of about 18 months, and not the entire literature on this topic. In addition, while many of the included studies were identified by undertaking a systematic search of the literature, not all papers were accessed via the repeat systematic search. For example, Janssen 2011 was an excluded paper in the Independent Review, which was included in the submissions from the public consultation and re-assessed for this update at the Reference Group's request. Furthermore, not all

[5] From here on, Kuwano 2013 is used to refer to both citations.

studies have been published. The study by Paller 2014, for example, is a Master's thesis and considered 'grey literature'. Therefore, the conclusions in this report are much more cautious than if this was a systematic review of only published papers unrestricted by date or language of publication.

Summary characteristics

All studies included in the Direct Evidence component of the review were cross-sectional in design. The studies were conducted in New Zealand, the United Kingdom, Japan, Canada, Sweden, The Netherlands, Germany and Poland. Importantly, no study was conducted in Australia. Therefore, likely sociocultural differences between people in these countries and Australians make it difficult to draw conclusions about generalisability or applicability of findings in these studies to the Australian context. Of the studies reporting demographic characteristics, there was an approximately equal sex ratio, and the mean age of study respondents ranged from 46 to 56 years.

The studies mostly examined wind farm noise or proximity to wind farms and a wide range of self-reported outcomes, as follows:

- One study assessed self-reported annoyance and estimated level of wind farm noise (Kuwano 2013).
- One citation provided further analysis of data on self-reported annoyance and estimated level of wind farm noise (Janssen 2011) from three studies included in the Independent Review.
- One study assessed self-reported annoyance and exposure to wind farm markings (Pohl 2012).
- Two studies assessed self-reported physical symptoms (e.g. headache, nausea, tinnitus) and estimated level of wind farm noise (Taylor 2013a) or proximity to wind farms (Paller 2014).
- Four studies assessed aspects of self-reported mental health (stress, irritability, psychological distress, anxiety and depression) and estimated level of wind farm noise (Kuwano 2013; Taylor 2013a), proximity to wind farms (Paller 2014), or exposure to wind farm obstruction markings (Pohl 2012).
- Two studies assessed self-reported sleep quality and estimated level of wind farm noise (Kuwano 2013) or proximity to wind farms (Paller 2014).
- Four studies assessed quality of life, satisfaction with living environment or life satisfaction and estimated noise exposure or proximity to wind farms (Kuwano 2013; McBride 2013; Mroczek 2012; Paller 2014).

In all studies, health and health-related outcomes were self-reported by participants; that is, none of the outcomes was objectively measured (e.g. by using a test administered or performed by a doctor or scientist) or used medical records or health service linkage data. Widely used, validated instruments were used in some studies (e.g. SF-12, WHOQOL-BREF, GHQ and PSQI), but none of these measures was used in more than one study. Due to the wide range of outcomes, it was difficult to assess consistency in results across studies for a particular outcome, with annoyance being the most common single outcome investigated, although varying instruments were used to measure this outcome across the studies.

Study quality and bias

Based on the assessment of study quality, all studies with the possible exception of the Janssen 2011 analyses were considered to have limited capacity to inform the assessment of wind turbine noise or proximity of wind farms as a cause of any of the outcomes investigated in the studies. All studies were cross-sectional studies, so it cannot be determined objectively whether wind farm exposure preceded the self-reported outcomes.

There was potential for selection bias in almost all studies as response rates were generally low and limited information was presented on characteristics of non-responders or how non-responders differed from responders. Recall bias was likely in three of the studies identified in this review (Paller 2014; Pohl 2012; Kuwano 2013) and in the studies analysed by Janssen 2011, as it was impossible to blind participants to the nature of the study purpose. Recall bias was unclear in the remaining three studies. No study adjusted for all relevant confounders (including age, gender, education, chronic disease, and economic factors).

The reasons why confidence in the results was considered moderate for Janssen 2011, which combined data from three previously published studies, are that it had a clear and limited set of objectives, large sample size, acceptable recruitment rates in two of the three included study samples, and robust measurement of exposure. However, problems of the cross-sectional nature of the design, assessment of one outcome (annoyance) using a non-validated self-reported outcome measure, and lack of adjustment for all relevant confounders still apply.

Results

Measures of wind turbine exposure were very variable in these studies, ranging from simple proximity and estimated noise exposures to quantitative noise exposure metrics based on actual noise measurements. Most studies investigated some aspect of noise exposure, but no studies specifically examined infrasound, shadow flicker or EMR. One study (Pohl 2012) examined wind turbine markings.

After assessing the overall findings, the methodologies used and the limitations in study quality in the six studies (and further analysis of previous studies in the Janssen 2011), the following are our responses to the specific questions to be addressed by our updates to the systematic review in relation to distance, audible noise, infrasound and low frequency noise, shadow flicker and EMR:

> Is there any reliable evidence of an association between the emission/exposure from wind turbines and adverse health effects? If so, how strong is this association? How does the strength of this association relate to distance from wind turbines? And might this association be explained by: chance, bias, or confounding.

1. Distance

Only two studies (Paller 2014; Mroczek 2012) used distance or proximity as the sole measure of exposure to wind turbines, rather than assessments based on specific emissions. Mroczek 2012 was able to assess distance-response relationships, but found that quality of life (QOL) was higher for those closer to wind turbines, although no clear reason was found for this apparent counter-intuitive finding. Of the very large number of outcomes investigated by Paller 2014, only two (sleep quality and vertigo) were found to be worse in residents closer to wind turbines, while no associations were found for all other outcome measures. However, due to the many limitations in this study—including the survey distribution method, low response rate, potential biases such as selection bias and information bias and mapping of rural addresses and industrial wind turbine locations—little weight can be given to these findings. Therefore, it is concluded that there is no reliable evidence of an association between distance from wind turbines and adverse health effects in the papers included in the systematic (Direct Evidence) component of our review.

2. Audible noise

The noise level from wind turbines was the most common emission to be examined in these studies. The Janssen 2011 analyses provided the most convincing evidence for an association between noise levels and indoor and outdoor annoyance levels, including an exposure-response relationship, but the relationship is not strong when compared with the associations of wind-turbine visibility or economic benefit from wind farms with annoyance. The study described by Kuwano 2013 provided some very weak evidence supporting this association (between noise levels and annoyance), but also found that other factors, such as pre-existing beliefs about wind turbines (e.g. they disturbed the landscape), moderated this effect. Although Taylor 2013a did not investigate annoyance, the findings suggested it was the perception of noise rather than actual noise exposure that was associated with symptoms of ill-health, and that this relationship was stronger in those who had a personality characterised by negative affectivity and intolerance of negative emotion and events.

McBride 2013 also did not investigate annoyance, but found that QOL was poorer in some of its domains in participants living closer to wind turbines; a finding which is the converse of Mroczek 2012. For no other outcomes investigated in these studies was there any relevant evidence. Thus, while Janssen 2011 provides the most robust evidence of an association between wind turbine noise and annoyance, the association is not strong, but does demonstrate an exposure-response relationship and chance, bias and confounding are less likely to influence these findings than in the other Direct Evidence studies we reviewed. For no other outcome investigated in these studies is there reliable evidence of an association.

3. Infrasound and low-frequency noise

No studies investigated infrasound as such and so no conclusions can be drawn about associations between infrasound from wind turbines and any health or health-related outcomes.

4. Shadow flicker and other visual stimuli

No studies investigated shadow flicker and so no conclusions can be drawn about associations between shadow flicker from wind turbines and any health or health-related outcomes.

One study (Pohl 2012) investigated exposure to wind farm obstruction markings and provided some weak evidence that different types of lights were more or less annoying. Given this preliminary finding, this characteristic of wind turbines warrants further investigation.

5. Electromagnetic radiation

No studies we reviewed investigated EMR and so we can draw no conclusions about associations between EMR from wind turbines and any health or health-related outcomes.

Conclusions of studies of Direct Evidence

Noise from wind turbines was the most commonly investigated emission. We found there was weak evidence in support of an association between noise levels and annoyance, including an exposure-response relationship. This association was not strong and was affected by other factors, including wind turbine visibility, financial benefits and pre-existing beliefs. One small survey raised the possibility that perception of noise (rather than actual noise) predicts adverse health effects. Based on two cross-sectional studies, we found no reliable evidence of an association between distance from wind turbines and adverse health effects. No studies investigated the adverse health effects associated with infrasound as such, shadow flicker or EMR from wind turbines.

Table 1a – Characteristics of Included Studies (Direct Evidence)

Study ID	Janssen 2011 (This is a further analysis of data collected by three studies reviewed in the Independent Review)	Kuwano 2013	Yano 2013 (This is a further analysis of data collected by Kuwano 2013)	McBride 2013	Mroczek 2012	Paller 2014	Pohl 2012	Taylor 2013a
Aim	"… to derive the exposure response relationship between wind turbine noise exposure in A-weighted equivalent noise level (L*den*) and the expected percentage annoyed residents and to compare it to previously established relationships for industrial noise and transportation noise."	"… conducted a series of physical measurements, laboratory psychological experiments and social surveys of wind turbine noise… In this paper, a design of questionnaire used in the survey and a part of the results are introduced."	"The objectives are to propose the representative dose-response curves for wind turbine noise in Japan and to investigate the effects of moderating factors on annoyance caused by wind turbine noise."	"…this study was carried out to study how health-related quality of life (HRQOL) changes over 2 years in a community living within 2 km of a turbine installation and compares HRQOL in a control group over the same period."	"To assess how the quality of life is affected by the close proximity of wind farms."	"The objectives of this study were to explore the association between proximity to industrial wind turbines and self-reported health effects, specifically quality of life (both physical and mental health) and sleep disturbance, in residents living close to wind turbines."	"…this research aims to analyse whether [wind turbine] obstruction markings have the potential to cause substantial annoyance in general or influence only a sensitive minority."	"This paper aims to answer the following questions: is any link between wind turbine noise and non-specific symptoms (NSS) reporting due to actual noise levels from the turbine, or individuals' perceptions of noise?"
Study type	Cross-sectional study N = 1820 (combined across three previously published studies)	Cross-sectional study N = 511 (366 exposed, 145 not exposed)	Cross-sectional study N = 511 (366 exposed, 145 not exposed)	Cross-sectional study in the same population that was examined by Shepherd 2011. (Sample size of exposed or not exposed group not provided)	Cross-sectional survey N = 1277	Cross-sectional study N = 396	Cross-sectional survey N = 420	Cross-sectional survey N = 138

Study ID	Janssen 2011 (This is a further analysis of data collected by three studies reviewed in the Independent Review)	Kuwano 2013	Yano 2013 (This is a further analysis of data collected by Kuwano 2013)	McBride 2013	Mroczek 2012	Paller 2014	Pohl 2012	Taylor 2013a
Characteristics of population and study setting	One study in an agricultural setting in southern Sweden, another in a mixture of urban and rural settings in Sweden, and the third in a mixed setting in the Netherlands. Proximity to wind turbines not specified for the two Swedish studies; exposed participants in the Dutch study were within a 2.5 km radius from wind turbines. Mean age = 51.5 years Male = 46%	No information provided about characteristics of respondents or the setting, but assumed to be the same as Yano 2013, which was based on the same sample. Approximately equal sex ratio, c. 80% over 50 years (c. 30% over 70 years)	Respondents lived 90 m to 1466 m apart from the closest wind turbine, in various locations from Hokkaido to Okinawa in Japan.	Setting was the Makara Valley in New Zealand, hilly terrain with long ridges 250 m to 450 m above sea level. Exposed participants were recruited from 56 dwellings situated within a 2 km radius from a single wind turbine, while the non-exposed / controls resided > 10 km from turbine installation.	Polish population living within various distances of wind turbines (< 700 m to > 1500 m) at a number of different locations. Included a group unaware of plans for wind farm in their neighbourhood. Mean age = 46 years ± 16 years (range 18 to 94) Male = 55%	Respondents were located within 0.4-55,000 m* of the largest wind farms in each of eight counties in Ontario, Canada. [* as reported by the author, but assumed to mean 0.4 km to 55 km] Median age = 56 years, male = 52%, 79% married, median income $60,000, 59% post-secondary education.	Southern German population living within 8 km of wind farms, with line of sight view of turbines. Mean age = 51 years Male = 57%	Population of two cities in English Midlands living within 500 m of eight micro turbines and within 1 km of four small turbines. Mean age = 54 years ± 16 years (range 20 to 95) Male = 55%
Exposure considered	No information provided about wind farm details or exposures. Annual day/evening/night L*den* was calculated from the wind turbine noise emission data in the original three	No information provided about wind farm details or exposures considered, but assumed to be the same as Yano 2013, which was based on the same study	Exposure group consisted of residents from 36 "target sites" with audible wind turbine noise. Distance was used as a crude surrogate for noise exposure of wind	Exposed participants resided within a 2 km radius from a single wind turbine. Wind farm details: 66 turbines (Siemens SWT-2.3-82 VS), turbine height 125 m, rotor	Exposure to wind farms (noise levels not reported). Distance was used as a crude surrogate for noise and visual exposure of wind turbines. No details of wind	The number of turbines ranged from 18 to 110 turbines per farm and turbine installed capacity ranged from 1.5 megawatt (MW) to 2.3 MW.	Exposure to wind farms (with view of turbines within line of sight). Median wind farm characteristics: 8 WT; height 138 m; power 14 MW; time in operation	Exposure to wind turbines. Residences located within 500 m of 0.6 kW micro turbines, or within 1 km of 5 kW small turbines. Specific exposure

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	studies. Assumptions were made about wind velocity of 8 m/sec, a neutral atmosphere and noise at 10 m, in line with recommendations by European regulatory agencies.	sample. Exposure group consisted of residents from 36 “target sites” with audible wind turbine noise. Control group consisted of residents at 16 control sites where wind turbine noise was inaudible and no turbines were visible.	turbine. Regular electricity generation of wind turbines was from 400 kW to 3,000 kW. The average sound pressure levels $L_{Aeq,n}$ in decibels was measured with sound levels ranging from 26 dB to 50 dB. Control group consisted of residents at 16 control sites where wind turbine noise was inaudible but no turbines were visible.	diameter 82 m. (See Shepherd 2011) Typical noise exposure, measured as $L_{95(10mins)}$ ranged from 20 dB(A) to 54 dB(A). Non-exposed / control group were selected from 250 homes located in a socioeconomically and geographically matched area differing from the exposure group only by distance from wind turbines (≥ 10 km).	farms provided except the number of wind farms in the provinces from whom respondents were drawn. There is no information about how many wind farms were in proximity to the close (< 1500 m) respondents and location. Five exposure groups determined by approximate distance from turbines: < 0.7 km (17.2%); 0.7 km to 1 km (21.9%); 1 km to 1.5 km (17.3%); > 1.5 km (33.2%); plus a group (6.7%) that knew nothing about plans for wind farm in their neighbourhood, which was not apparently drawn from any specific distance group, although it is inferred that they	Distance between respondent’s home and nearest wind turbine was assessed using geocoding (ArcGIS) - ranked by percentile (1st percentile to 100th percentile) and then divided into 4: quartile 1 < 25th percentile, quartile 2 < 50th, quartile 3 < 75th and quartile 4 < 100th percentile – and compared to self-reported distances. The reference group for the analyses was the group in the quartile furthest away from the wind farms.	40 months. Five groups of markings: three types of day markings; simple versus complex landscape scenery; day and night markings; synchronised versus non-synchronised markings; with and without light intensity adjustment. No non-exposed groups included.	details: Modelled sound pressure in A-weighted decibels with a sound map with 1 m grid over map area. Grid plane located 1.5 m above ground. No non-exposed groups included.

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					were a subset of the > 1500 m group. Apart from this group, no non-exposed groups.			
Effects or outcomes considered	Indoor and outdoor annoyance, measured using a one-item self-report scale (four-point scale in both the Swedish studies and a five-point scale in the Dutch study).	Self-reported satisfaction with living environment (shopping convenience, transportation, amount of greenery, clean air, quietness, public facilities). Self-reported degree of annoyance of road traffic noise, aircraft noise, high-speed train (Shinkansen) noise, conventional train noise, noise from factories, construction noise and wind turbine noise (five step categories). Self-reported trouble with sleep.	Annoyance related to wind turbine noise evaluated by ICBEN 5-point verbal scale: extremely, very, moderately, slightly or not at all.	The WHOQOL-BREF (26-item version) measured physical (seven items), psychological (six items), and social (three items) HRQOL, an additional eight item domain measuring environmental QOL and two 'generic' items asking about general health and overall quality of life. Two amenity items were included.	Self-reported health-related quality of life using General Health Questionnaire (Short Form-36) and Visual Analogue Scale (VAS) for health assessment.	Pittsburgh Sleep Quality Index (PSQI) SF-12 The Satisfaction with Life Scale (SWLS) Wind Turbine Syndrome (WTS) Index using eight questions drawn from the Quality of Life and Renewable Energy Technologies Study survey. Frequency of the following symptoms in the past month: headache, irritability, concentration problems, nausea, vertigo, undue tiredness, tinnitus.	Stress indicators: general impact; annoyance; annoyance changes over the years; psychological and somatic symptoms; behaviour; coping response.	Self-reported outcome measures: positive affectivity; negative affectivity; neuroticism; discomfort intolerance; emotional intolerance; non-specific somatic symptoms.

Study ID	Janssen 2011 (This is a further analysis of data collected by three studies reviewed in the Independent Review)	Kuwano 2013	Yano 2013 (This is a further analysis of data collected by Kuwano 2013)	McBride 2013	Mroczek 2012	Paller 2014	Pohl 2012	Taylor 2013a
Are the study participants well defined in terms of time, place and personal characteristics? **[exposure misclassification]**	Place: Not specified for the two Swedish studies; within a 2.5 km radius from wind turbines in the Netherlands study Personal characteristics: age, gender, noise sensitivity, economic benefit, living on rural and flat terrain. Time: this is a cross-sectional study with self-reported outcome measures; therefore, it cannot be determined objectively whether wind farm exposure preceded the reported outcome(s).	No information provided, but assumed to be the same as Yano 2013, which was based on the same study sample.	Place: respondents lived 90 m to 1466 m apart from the closest wind turbine, in various locations from Hokkaido to Okinawa in Japan. Personal characteristics: no specific demographic details, but elderly residents reportedly over-represented in study sample. Time: this is a cross-sectional study with self-reported outcome measures; therefore, it cannot be determined objectively whether wind farm exposure preceded the reported outcome(s).	Place: participants were from the Makara Valley in New Zealand, and resided either < 2 km (exposed) or ≥ 10 km (control) from a wind turbine. Personal characteristics: no information on demographic details. Time: this is a two-year follow-up of a previous cross-sectional survey of the same community (different sample). As self-reported outcome measures were used, it cannot be determined objectively whether wind farm exposure preceded the reported outcome(s).	Partly—in terms of place Personal characteristics: age, gender, education and occupation. Place: residents live within different distances from turbines: < 0.7 km; 0.7 km to 1 km; 1 km to 1.5 km; > 1.5 km; the latter including a group that knew nothing about plans for wind farm in their neighbourhood. Time: this is a cross-sectional study with self-reported exposure and outcome measures; therefore, it cannot be determined objectively whether wind farm exposure preceded the reported outcome(s).	Place: respondents were located within 0.4 m to 55,000 m* of the largest wind farms in each of eight counties in Ontario, Canada. Personal characteristics: age, gender, county, marital status, income and education level were collected, but only the age, gender and county were used for adjustment in some analyses. Time: cross-sectional study undertaken between February and May 2013; as self-reported outcome measures were used, it cannot be determined objectively whether wind farm exposure preceded the reported outcome(s). [* as reported by the	Partly—in terms of place Personal characteristics: age, gender, duration in house, home ownership, marital status, education, occupation (including working from home and in the wind business) and income. Place: residents live within 8 km of wind turbines, with view of turbines within line of sight. Time: this is a cross-sectional study with self-reported outcome measures; therefore, it cannot be determined objectively whether wind farm exposure preceded the reported outcome(s).	Partly – in terms of place Personal characteristics: age and gender Place: residents live within 500 m of eight 0.6 kW micro turbine installations and within 1 km of four 5 kW small wind turbine installations. Time: this is a cross-sectional study with self-reported outcome measures; therefore, it cannot be determined objectively whether wind farm exposure preceded the reported outcome(s).

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						author, but assumed to mean 0.4 km to 55 km]		
What percentage of individuals or clusters refused to participate? **[selection bias]**	The two Swedish studies had participation rates of 68% and 58%, while participation in the Dutch study was 37%. There is potential for sample selection bias due to low response rate in the Dutch study.	No information provided, but assumed to be the same as Yano 2013, which was based on the same study sample. There is potential for sample selection bias due to low response rate.	49% of exposed group participated (n = ~366, calculated), 45% responded (n = ~145, calculated). High potential for selection bias due to low response rate. Sampling area determined by distance from wind turbines.	The sample sizes of the exposed and control groups were not reported, nor the response rates. Insufficient detail about the recruitment process and response rate to evaluate selection bias. Response rates in 2010 survey were poor, and response/selection bias may have been more likely in 2012 survey than in 2010 survey because blinding to purpose of the later study likely less effective.	Subjects randomly chosen using a two-stage sampling technique. No information provided about whether participants were blinded to the purpose of the study. Unable to determine response rate as size of initial sampling frame not reported and number of refusals and non-contacts not reported. Sampling area determined by distance from wind turbines, but unknown whether there is differential participation rates at various distances from wind farms (which may be evidence of	The survey questionnaire was sent to 4,876 residences, with 412 returned (8.5% response rate) of which only 396 (8.1%) were included due to incomplete data. High potential for selection bias due to low response rate, which also varied by county.	100 to 200 questionnaires were distributed to households near each of 13 wind farms. Average response rate = 25% (range 11% to 39%). High potential for selection bias due to low response rate. Sampling area determined by distance from wind turbines. Incentive to participate was 15 EUR or entry in a lottery.	89% of those who received a questionnaire did not complete and return it. The low response rate suggests likely selection bias. Attempt to gauge likely degree of participation bias by asking how they feel about wind power has little validity. Sampling area determined by distance from wind turbines.

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					possible selection bias). Lack of data on non-responders could also contribute to selection bias.			
Are outcomes measured in a standard, valid and reliable way? **[outcome misclassification]**	Non-validated measures of annoyance used. Outcomes self-reported.	Outcomes are self-reported, and no information has been provided about validation of measurements.	Use of ICBEN five-point verbal scale to rate annoyance due to wind turbine noise (unclear if this is a validated tool). Outcomes are self-reported.	General health and overall quality of life were measured using the WHOQOL-BREF (26-item version) measured physical (seven items), psychological (six items), and social (three items) HRQOL, an additional eight item domain measuring environmental QOL and two 'generic 'items asking about general health'. There is a high probability of exposure misclassification (exposure time not well-defined), and outcome	Use of SF-36 and VAS as tools for quality of life was well described. Outcomes self-reported.	Health outcomes were measured using a number of scales and surveys, however it is unclear whether these are validated instruments.	Overall, only low misclassification of outcomes is expected due to the methods and scales. Outcomes self-reported.	Positive and negative affectivity measured by using a modified scale. Neuroticism, frustration intolerance and nonspecific somatic symptoms used self-report scales.

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				misclassification (amenity questions apparently not validated instruments).				
What percentages of individuals or clusters recruited into the study are not included in the analysis (i.e. loss to follow-up)?	The two Swedish studies had participation rates of 68% and 58%, while participation in the Dutch study was 37%. In the Swedish studies, respondents were not found to differ from the population in the study areas on age and gender (other characteristics not reported). Early vs late respondents were reported not to differ in their answers, but no data on this were reported. In the Dutch study, 200 non-responders were sent a questionnaire about annoyance	Unknown. Response rates were not provided, but assumed to be the same as Yano 2013, which was based on the same study sample. No information was presented on characteristics of non-responders or how non-responders differed from participants. Loss to follow up not relevant as cross-sectional study.	Unknown. No information was presented on characteristics of non-responders or how non-responders differed from participants. Loss to follow up not relevant as cross-sectional study.	Unknown. Response rates were not provided. No information was presented on characteristics of non-responders or how non-responders differed from participants. Loss to follow up not relevant as cross-sectional study.	Unknown. Response rates were not provided. No information was presented on characteristics of non-responders or how non-responders differed from participants. Loss to follow up not relevant as cross-sectional study.	Survey questionnaire sent to 4,876 residences, with 412 returned (8.5% response rate) of which 396 (8.1%) were included due to incomplete data. No information was presented on characteristics of non-responders or how non-responders differed from participants. Loss to follow up not relevant as cross-sectional study.	Unknown. No information was presented on characteristics of non-responders or how non-responders differed from participants. Loss to follow up not relevant as cross-sectional study.	Unknown. No information was presented on characteristics of non-responders or how non-responders differed from participants. Loss to follow up not relevant as cross-sectional study.

Study ID	Janssen 2011 (This is a further analysis of data collected by three studies reviewed in the Independent Review)	Kuwano 2013	Yano 2013 (This is a further analysis of data collected by Kuwano 2013)	McBride 2013	Mroczek 2012	Paller 2014	Pohl 2012	Taylor 2013a
	(48% responded); no differences in annoyance were found between this group and the study participants. Loss to follow up not relevant as cross-sectional study.							
Recall bias?	Given the nature of the survey it is implausible that participants would have been blinded to its purpose.	Given the nature of the survey it is implausible that participants would have been blinded to its purpose.	Given the nature of the survey it is implausible that participants would have been blinded to its purpose.	Uncertain. Participants were blinded to study purpose in original survey but authors acknowledge participants possibly unblinded in present survey due to publicity associated with original survey.	No information is provided about whether participants were blinded to the purpose of the study. Unknown whether respondents influenced by renting their land for wind farm construction and use.	Information bias is likely, as the self-reported distance from the nearest wind farm was grossly underestimated. No blinding was possible.	Yes. The study purpose was not masked and an incentive to take part was offered, so responder bias may have been enhanced.	Uncertain. The study purpose was not masked. Findings stronger for perceived noise exposure, rather than calculated noise exposure, which could suggest recall bias.
Confounding? (other factors that could affect the outcomes)	Age, sex, noise sensitivity, economic benefit, visibility of wind turbine, and living in rural and flat terrain were adjusted for in	No information provided by authors about addressing confounders. Another factor that could affect the outcomes is that	No information provided by authors about addressing confounders.	Socioeconomic and geographic matching and adjustment by length of residence were undertaken. Detail about	Plausible confounders that were not addressed include socio-economic status, occupation, chronic diseases and risk	Some collected demographic information (education, income, marital status) were not used for adjustment in	Multiple potential confounders were considered in the analysis, but others, such as socio-economic status (SES) were not.	Discussion of confounders was limited, and no adjustments were provided on likely confounders such as employment,

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	models used in the study. However, data on some other potentially important confounders, such as socioeconomic status, medical status, other potential sources of annoyance and country, were either not collected or adjusted for in the analyses. Therefore, confounding may have affected the results, as annoyance can be influenced by a wide range of lifestyle, demographic, health and environmental factors.	there is potential for misclassification of exposure (duration of exposure not quantified).		recruitment, selection and matching not provided, but plausible confounders not addressed in previous (and nor presumably this) report include age, education, chronic disease and risk factors for chronic disease, occupation, employment, background noise, and turbine visibility.	factors for chronic diseases.	analyses, and so could have affected the outcomes. Other potential sources of confounding likely to have affected the results are the health outcomes, such as quality of life, symptomatology, sleep and life satisfaction as they are influenced by a very wide range of health, demographic, lifestyle and environmental factors.		economic benefit from wind turbines etc.
Chance?	There was only one outcome (although this was for annoyance both inside and outside, so there were two variables) and only one exposure measure (L*den*).	No statistical tests for differences were performed.	Possibility of spurious significant associations arising by chance cannot be excluded as multiple statistical tests were conducted. No mention of	Statistical tests for differences were performed; however there was no mention of statistical adjustments for multiple testing.	Possibility of spurious significant associations arising by chance cannot be excluded as multiple statistical tests were conducted. No mention of	Large number of analyses likely to have been undertaken given the number of wind farms, outcome measures and their component variables. No	Possibility of spurious significant associations arising by chance cannot be excluded as multiple statistical tests were conducted.	Possibility of spurious significant associations arising by chance cannot be excluded as multiple statistical tests were conducted.

Study ID	Janssen 2011 (This is a further analysis of data collected by three studies reviewed in the Independent Review)	Kuwano 2013	Yano 2013 (This is a further analysis of data collected by Kuwano 2013)	McBride 2013	Mroczek 2012	Paller 2014	Pohl 2012	Taylor 2013a
	Thus there was not an excessive number of analyses in the paper, which reduces the potential for chance to explain the associations found.		statistical adjustments for multiple testing.		statistical adjustments for multiple testing.	correction for multiple comparisons was undertaken. Thus, chance cannot be excluded as an explanation for at least some of the associations found.		
Overall quality of the study to determine whether wind farms cause adverse health effects?	The design of this pooled study had some strengths over much of the other published epidemiological wind turbine research, such as having a clear and limited set of specific objectives, the large sample size of 1820 participants, acceptable recruitment rates (at least for the two Swedish studies, rather than the Dutch study), robust exposure metrics based on measured data and high quality	There was no difference between exposure and control groups in reported satisfaction with living environments. More exposed group respondents reported wind turbine, road traffic and 'other' noise as the most annoying in their environment, and trouble sleeping due to (non-specified) noise. However the reliability of the results are limited by the overall quality of the study	Though directionality of dose-response measurements are as expected (i.e. the prevalence and severity of annoyance increased with increasing sound level), the study was cross-sectional in design and so does not permit definitive conclusions regarding causation and health outcomes, in this case annoyance due to wind turbine noise. In addition, bias is likely due to	There was little difference evident in WHOQOL scores among exposed residents in 2010 and 2012. In the current survey, exposed residents scored significantly lower than (2012) control residents in the physical domain (p = 0.043). Answers to the amenity questions indicated no significant difference in scores over time, however there was a significant decrease in amenity in the 2012 control group compared with the	Cross-sectional design does not permit conclusions regarding causation between quality of life and wind farms. The finding that QOL was inversely related to distance of home from a wind farm was unconvincing given the lack of data regarding responders living near wind farms receiving rent from wind farm operators. Due to major potential confounders not being considered, and the potential	The study design had some strengths, however other aspects, including the execution, were poor. The very low participation rates, the use of some non-validated instruments (e.g. symptom reporting and the Wind Turbine Syndrome (WTS) index), lack of data on potentially important confounders weakened the quality of the study. In addition, most health outcomes did not appear to	This study was cross-sectional in design. This does not permit any conclusions regarding causation and health outcomes, in this case annoyance, from wind turbines. However, the results are consistent and the findings of the research robust. This study has limited capacity to inform the assessment of wind turbine obstruction markings as a cause of adverse health effects.	Perception of noise, rather than actual noise exposure, is important in predicting symptoms of ill-health. This relationship is stronger in those who have personality characterised by negative affect, and intolerance of negative emotion and events. However this finding is not convincing given the low response rate, lack of description of non-responders and use of

Study ID	Janssen 2011 (This is a further analysis of data collected by three studies reviewed in the Independent Review)	Kuwano 2013	Yano 2013 (This is a further analysis of data collected by Kuwano 2013)	McBride 2013	Mroczek 2012	Paller 2014	Pohl 2012	Taylor 2013a
	reporting in the paper. Conversely, there were some weaknesses, such as the cross-sectional design, using non-validated self-report outcome measures of annoyance and noise sensitivity, pooling data from three different studies from two different countries (with inevitable differences in methods used, although these are small) and lack of data on potentially important factors which may influence annoyance. Overall confidence in the results is considered moderate.	which is considered poor due to several aspects, including bias from self-reported outcomes, low recruitment rate and lack of statistical testing. The study design was cross-sectional which does not permit any conclusions about causation, and it is unclear whether the reported differences between control and exposed groups are associated with wind turbine noise. Generalisability of findings is likely limited due to over-recruitment of elderly residents, and cultural / contextual differences between Japan and Australia. This study has very	self-reported outcomes and recruitment method. Generalisability of findings is likely limited due to over-recruitment of elderly residents, and cultural / contextual differences between Japan and Australia. Overall, this study has very limited capacity to inform the assessment of wind turbine noise of adverse health effects.	2010 control group (p = 0.034). The overall quality of the study is considered poor due to, among other things, the high probability of recall bias, exposure and outcome misclassifications, and confounding. In addition, this study has a repeat cross-sectional design, it however does not permit definitive conclusions regarding causation and health outcomes. Therefore, this study has limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.	for recall and selection bias, and chance associations, this study has an overall poor quality rating. This study has very limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.	have a relationship with distance from a wind farm, and the two findings for which there appeared to be an association, could be explained by chance, bias or confounding. Therefore, it is unlikely that the findings of this study have any clear implications in relation to the question of proximity of wind farms and human health.		modelled noise exposure instead of actual measurements for relatively small wind turbines. In addition, the cross-sectional design does not permit any conclusions regarding causation and health outcomes. This study has limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.

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		limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.						

Table 1b – Results of Included Studies (Direct Evidence) and Commentary

Study ID	Results	Commentary (by Authors of this review)
Janssen 2011	In the adjusted models there was a small positive association between noise level and indoor annoyance. There was significant variability between the three studies, with lower annoyance in the Swedish studies. Visibility of the wind turbines had a considerably stronger positive effect than for the noise level, while self-reported noise sensitivity was only weakly associated with noise. Annoyance was found to be strongly reduced for economic benefit. A similar pattern of associations was found for outdoor annoyance. Repeating the analyses taking out those who did not benefit economically and not taking the individual study effects into account resulted in a steeper slope of the relationship between noise and annoyance for both indoors (B = 5.50) and outdoors (B = 5.48). Dose-response curves show that noise levels up to about 35 dB caused almost no annoyance for both indoors and outdoors. The authors estimated that an L*den* of 45 dB resulted in 12% annoyed participants indoors and 26% annoyed participants outdoors. It should be noted that the numbers of highly annoyed participants indoors and outdoors were very small (specific numbers not reported) and this, coupled with small numbers exposed above 45 dB, resulted in wide error bars at the higher noise levels. For both indoors and outdoors, a 1 dB increase in L*den* was estimated to increase annoyance by about three points on a 100-point scale. No confidence intervals or p-values given.	This paper, comprising pooled data from three European cross-sectional studies of wind turbine noise and annoyance, is a little stronger than most other Direct Evidence papers included in this review. In particular, participation rates were reasonable for two out of the three studies and noise measurement was robust. There were some weaknesses in the annoyance measurement and other factors, such as noise susceptibility, which were based on self-report and insufficient consideration of confounders. The most reliable conclusion from this study is that there is a small, but statistically significant association between self-reported annoyance and wind turbine noise. There is also a consistent dose-response relationship between increasing noise and increased annoyance. The relationship is similar for indoor and outdoor annoyance. The other interesting finding is that factors such as economic benefit and visibility are suggested to have a stronger effect on annoyance, reducing and increasing annoyance respectively.
Kuwano 2013	No statistical tests were reported for this study. According to the study authors, there appeared to be some difference between wind turbine site respondents and control area respondents in the satisfaction of quietness in their environmental surroundings. The authors also noted that more control site respondents reported no concerns with noise compared with wind turbine site respondents, and more wind turbine site respondents reported that wind turbines were the most annoying	This cross-sectional survey does not permit any reliable conclusions about causation and it is unclear whether the reported differences between control and exposed groups are associated with wind turbine noise. The aim of the study was to conduct a social survey of wind turbine noise using a questionnaire that had been developed to examine responses to environmental noise. The study compared an 'exposed' group of residents from sites with audible wind turbine noise and a

Study ID	Results	Commentary (by Authors of this review)
	sound in their environment. However, more wind turbine respondents also nominated road traffic noise or “other” noise as their most annoying noise, suggesting that the wind turbine areas surveyed may have a different overall noise profile compared with control areas. It appeared that somewhat more wind turbine site respondents reported trouble with sleep, but more wind turbine site respondents also did not answer this question. According to the authors, wind turbine noise respondents who had trouble sleeping were more likely to report noise as the reason; however what type of noise was not investigated and earlier questions indicated that this group were troubled more than control groups by other types of noise as well as wind turbine noise.	control group where no wind turbines were visible and no noise from turbines was audible. The survey design does not associate reported outcomes to measured wind turbine noise, and the overall noise profile of control areas and wind turbine areas may be systematically different in other ways. No data were reported to determine whether poorer sleep or greater annoyance could be attributable to the degree of noise exposure in the ‘exposed’ group. Lack of statistical testing makes it difficult to determine if differences between control and exposed groups are likely to be due to chance. The low recruitment rate indicates possibility for recruitment bias and over-recruitment of elderly residents limits generalisability to the broader population. The context of the survey is poorly described, but it is likely to be very different to the Australian context of wind turbine exposure, limiting generalisability to the Australian context. This study has very limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.
Yano 2013	This study presented annoyance-distance and annoyance-noise (LAeq) curves based on survey data which the authors describe as indicating the dose-response relationship between wind turbine exposure and annoyance response among nearby residents. While the specific p-values were not reported, the authors indicated that respondents were significantly more likely to be “more extremely annoyed than others” by wind turbines if they reported being “interested in environmental problems”, thought that “wind turbine generator was not a good method” and viewed them as “disturbing the landscape”. Self-reported “sensitivity to sound” was also associated with greater propensity to report being extremely annoyed by wind turbines. Annoyance at sites with sea wave sound was significantly lower than that at sites without, and the authors suggested this was because of masking of turbine noise by sea wave sound. There was no significant difference in exposure-annoyance relationships between colder and warmer areas.	The purpose of this cross-sectional survey was to investigate the effects of moderating factors of annoyance caused by wind turbine noise. This study does not permit any conclusions about causation because it cannot be determined that exposures precede outcomes. Self-reported exposures and outcomes are likely to be subject to reporting bias and recruitment bias is also likely. Overall noise profile of control areas is likely to be systematically different to wind turbine areas in ways other than presence of turbines. Over-recruitment of elderly residents limits generalisability to broader population. Although context is poorly described, differences between Japanese and Australian contexts likely limit generalisability to Australia. This study has very limited capacity to inform the assessment of wind turbine noise on adverse health effects.

Study ID	Results	Commentary (by Authors of this review)
McBride 2013	Two-year follow up of a previous cross-sectional survey carried out on individuals living within two kilometres of industrial wind turbines compared with a matched control group (Shepherd 2011). This study was conducted in the same community as the 2010 survey, but with a different sample. There was little difference evident in WHOQOL scores among exposed residents (Makara, NZ) in 2010 and 2012. In the current survey, exposed residents scored significantly lower (i.e. poorer) than control residents in the physical domain (Mann-Whitney U test $p = 0.043$). Examination of individual WHOQOL questions revealed that exposed residents scored significantly lower (i.e. poorer) on the question, "How satisfied are you with your health?" ($p = 0.020$). Answers to the amenity questions indicated no significant difference in scores over time, however, there was a significant decrease in amenity in the 2012 control group compared with the 2010 control group ($p = 0.034$).	This cross-sectional study was carried out to compare health-related quality of life (HRQOL) in both a community living within 2 km of a wind farm and a control group, with the results of a similar survey conducted two years earlier. Although it replicates the previous cross-sectional study in the same community, the study does not permit conclusions regarding causality. Therefore, it is unknown if the exposure preceded the self-reported health and amenity outcomes. Also, given that the outcomes are based on self-report, it is plausible that pre-existing opinions about the turbine installation in question, or about wind turbines in general, may have influenced participant recruitment and self-reported outcomes. While the overall health of the exposed group was self-reported as being significantly poorer than the control group in the 2012 dataset, this difference between groups was small and potentially influenced by factors other than exposure to the turbine, given that other confounders were not taken into account in the analysis. Follow up of individuals in comparison to communities would have been more beneficial. This study has limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.
Mroczek 2012	Quality of life (QOL) within all subscales was reported to be highest by the respondents living the closest to wind farms and lowest by those living farther than 1,500 m from a wind farm (and by those who did not know about the plans for construction of a wind farm in their neighbourhood). People living more than 1,500 m from a wind farm assessed their vitality (V) significantly lower than those living the closest distance from a wind farm ($p < 0.05$). Within the mental health (MH) subscale, the respondents living the closest distance from a wind farm assessed their QOL significantly higher compared to those living between 1,000 m to 1,500 m or more from a wind farm ($p < 0.05$ in both cases). The distance between a place of residence and a wind farm also had a statistically significant effect on QOL scores within the social functioning (SF) and the	This study was cross-sectional in design and does not permit any conclusions regarding causation between QOL and wind farms. The results of this study indicate that close proximity to wind farms does not result in a deterioration of QOL. However, the finding that QOL was inversely related to distance of home from a wind farm was unconvincing given the lack of data regarding responders living near wind farms receiving rent from wind farm operators. Other biases and confounders were not addressed and this study has limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.

Study ID	Results	Commentary (by Authors of this review)
	role functioning-emotional (RE) subscales ($p < 0.05$). A regression analysis found that various socio-demographic and health variables (including whether respondents worked, learned or had a farm) within the subscales had only limited influence on how respondents perceived their QOL.	
Paller 2014	A statistically significant association between the logarithm of distance and the Pittsburgh Sleep Quality Index (PSQI) was found when controlling for age, gender and county, with sleep improving with greater distance from the wind farm (adjusted R-Squared = 0.08 and $p = 0.01$ for the adjusted model were the only ways that these findings were presented). Among the eight Wind Turbine Syndrome (WTS) index variables, the relationship between vertigo and the logarithm of distance was statistically significant when controlling for age, gender and county, with vertigo worse among participants living closer to the wind farm (adjusted R-Squared = 0.11 and $p < 0.001$ for the adjusted model were the only ways that these findings were presented). Distance-response relationships were presented for those outcomes shown to be associated with the logarithm of distance (PSQI and vertigo) or close to being statistically significant (tinnitus $p = 0.08$). While no data were presented for a similar analysis of WTS index, it is stated in the text that there was no association with the logarithm of distance, but vertigo was one of the variables used in this index. There was no significant difference across each of the eight wind farms, and for each of the quartiles of distance from a wind farm, for the following outcomes: Physical Component Score (PCS) and Mental Component Score (MCS) of the SF-12, depression, Satisfaction With Life Scale (SWLS), Wind Turbine Syndrome (WTS) index, headache, irritability score, concentration problems, nausea, undue tiredness, tinnitus or sleep quality.	While the serious limitations in design, execution, analysis and presentation in this Master's Thesis make interpretation of these findings difficult, most health outcomes did not appear to have a relationship with distance from a wind farm. The two findings for which there appeared to be an association (poorer sleep quality and vertigo) could be explained by chance, bias or confounding. Therefore, it is unlikely that the findings of this study have any clear implications in relation to the question of proximity of wind farms and human health.

Study ID	Results	Commentary (by Authors of this review)
Pohl 2012	This study, which considered stress responses to aircraft obstruction markings on wind farms, found no evidence of substantial annoyance caused by the obstruction markings. According to the study authors, residents exposed to xenon lights reported more intense and multifaceted stress responses than those exposed to LED or colour markings on blades, however p-values were not reported. The authors also considered that synchronised navigation lights were found to be less annoying than non-synchronised lights under certain weather conditions, and that light intensity adjustment seemed to be advantageous. The respondents 'strain during the planning and construction phase' appeared to have a moderating on the relationship between research conditions (day marking, synchronisation, intensity adjustment, landscape scenery) and annoyance. The stress factor of a wind farm that was rated most annoying was changes to landscape scenery, followed by wind turbine noise. While p-values were not reported, the authors state that annoyance caused by night and day markings was significantly lower than these factors.	This study was cross-sectional in design. This does not permit any conclusions regarding causation and health outcomes, in this case annoyance, from wind turbines. However, the results are consistent and the findings of the research robust. The study has limited capacity to inform the assessment of wind turbine obstruction markings as a cause of adverse health effects.
Taylor 2013a	Respondents living in areas with low probability of hearing turbine noise had higher Positive Affectivity (mean = 2.86; SD = 1.05) than those living in areas with moderate (mean = 2.38; SD = 1.21) or high (mean = 1.97; SD = 1.04) probability of hearing turbine noise ($F_{2,118} = 6.40$; partial $g^2 = 0.10$; $p < 0.01$). Two-step hierarchical regression analyses were carried out to examine the moderating impact of Negative Oriented Personality (NOP) traits on the perceived noise loudness – reported symptom relationship. The simple slope analyses showed that the link between perceived loudness and symptoms reporting only occurred at high levels of discomfort intolerance (b = 3.954, t = 3.4815, p < 0.001) and emotional intolerance (b = 1.921, t = 1.677, p < 0.096). However, the simple slope analyses examining the link between perceived loudness and symptoms reporting did not reach significance at any level of Negative Affectivity.	This paper investigated whether any association between wind turbine noise and reporting of non-specific symptoms (NSS) was attributable to actual noise levels or an individual's perceptions of noise. The overall finding was that perception of noise rather than actual noise exposure is important in predicting symptoms of ill-health, and that this relationship is stronger in those who have personality characterised by Negative Affectivity and intolerance of negative emotion and events. However this finding is not convincing given the low response rate, lack of description of non-responders, and use of modelled noise exposure instead of actual measurements for relatively small wind turbines. The study has limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.

Study ID	Results	Commentary (by Authors of this review)
	A second series of five hierarchical regression analyses examined the interaction between calculated actual noise from the turbine and NOP traits on symptom reporting. Calculated actual wind turbine noise did not affect symptom reporting directly or interactively.	

Summary of studies of Supporting Evidence

Thirty citations, representing 26 unique studies, met the criteria for the Background, Mechanistic and Parallel Evidence components of the review (15 Background studies; six Mechanistic studies; five Parallel studies). Twenty-one of these studies were identified from the submissions (Submitted Literature) and five from the repeat systematic literature search. A summary of the characteristics of the included studies is provided in Table 2.

Since the identification of these studies depended on submissions received during the public consultation, and was thus not the result of a systematic search of the literature, their findings may not be representative of the complete body of evidence from published studies relevant to their topics. At best, these studies represent a snapshot of (mostly) recent research in this area.

Background Evidence

The fifteen studies were grouped according to the type of emission being investigated. Noise and infrasound accounted for seven and five studies, respectively. Shadow flicker, annoyance and electromagnetic field (EMF) were each the subject of one study. Collectively, the studies were concerned with measuring exposure levels from wind turbines and how these levels vary by distance and other characteristics (e.g. terrain, climate, etc.). The following question was addressed:

> For each such emission from wind turbines (i.e. noise, infrasound, flicker or EMR), what is the level of exposure from a wind turbine and how does it vary by distance and characteristics of the terrain separating a wind turbine from potentially exposed people?

1. Noise

Bockstael 2012 reported that factors which may influence annoyance from wind turbines were angular blade velocity, nacelle position (wind direction) and relative humidity. The fluctuation indicator, developed in the study, was related to noise with “not at all annoyed” at noise levels in the low 40 dB(A) range to “extremely annoyed” at the high 90 dB(A) range. Level of exposure from a wind turbine in the study was 42.8 dB(A) at 17 rotations of the blade and measured levels were slightly higher than the calculated levels.

Doolan 2013 reported measurements made at 2.5 km and 8 km from a wind turbine. Measurements were in the 10 Hz to 30 Hz frequency band and the broadband up to 1000 Hz, using three metrics to assess exposure to overall noise. Overall noise levels were found to be low and at the level of detectability and ranged from 39 dB(Unweighted) to 67 dB(Unweighted) and 30 dB(A) to 34 dB(A) for broadband noise. For the 10 Hz to 30 Hz band the noise level ranged from 36 dB(Unweighted) to 66 dB(Unweighted). No link could be made between the noise data and the operation of the wind turbine. Three subsequent publications reporting on this study (Zajamsek 2013a, 2013b, 2014) refined the recording technique proposed by Doolan by additional microphones and measurement locations. Local wind speed was found to be more important for annoyance at the house 2.5 km from the turbine than at 8 km. At 8 km distance, time of day was found to be more important for annoyance than wind speed and direction.

A report by the EPA South Australia in 2013 (EPA SA 2013) for the Waterloo Wind Farm measured both audible noise and infrasound at six locations 1.3 km to 7.6 km from the wind farm. Audible noise was detected at two homes but at very low levels. For downwind conditions the levels outside of the residences were 29 dB(A) to 39 dB(A), compared with 27 dB(A) to 30 dB(A) measured during upwind conditions outside of the residences. The recommended evening and night time limit of 20 dB(A) was met for 99% of the time (inside of the residences) when the wind turbines were in operation. Extensive information was provided regarding variation of G, A and C-weighted noise by wind speed, direction and shutdown periods.

Evans 2013 reported on pre-operational and operational low frequency noise (LFN) and infrasound at the Macarthur wind farm. A-weighted and un-weighted sound levels for LFN were measured indoors at two farms 1.8 km and 2.7 km from the wind farm. Measurements undertaken at three operating conditions (no turbines, 105 and 140 turbines), and the effects of varying hub height and wind direction speeds were assessed. Almost all noise levels were below 30 dB(A) with only seven ten-minute periods out of 23 nights of monitoring exceeding the low frequency noise criteria developed by the UK Department for Environment, Food and Rural Affairs (DEFRA). No information was provided regarding attenuation by distance.

The study by Møller 2011 was an extensive noise survey of LFN from 48 wind turbines to assess penetration into indoor spaces. Factors investigated included effects from wind speed, directivity, sound insulation of the building, noise versus turbine size, ground reflections, distance from turbine, window configuration (open or closed) and atmospheric effects. Different factors may increase or decrease sound at the receiver with wind speed, directivity, distance and turbine size all potentially increasing noise. The authors state: "The minimum distance, where a 35 dB limit is complied with, varies considerably between the large turbines, even when the turbines are relatively equal in size (2.3–3.6 MW). The distance varies from slightly over 600 m to more than 1200 m."

Schiff 2013 investigated outdoor LFN at five measurement locations near 84 wind turbines in rural western New York state. Two control sites were chosen, but data from one control site were discarded. Data were provided on the predicted variation of noise with distance as reported in the pre-construction environmental impact assessment, e.g. if distance to three nearest turbines was 663 m, 813 m, and 856 m (location A) then the noise level was 38 dBA, compared to 48 dBA where the three nearest turbines were located at 219 m, 427 m and 666 m (location D). Extensive results were presented for the measured change in noise level for different wind speeds at 10-minute intervals. At measurement location A, the un-weighted low frequency noise levels were 48.7 dB at 1m/sec and 64.7 dB at 7m/sec wind speed. The A-weighted measurements at location A were 33.2 dB(A) and 44.8 dB(A) for wind speeds of 1 m/sec and 7 m/sec respectively. At location D the noise levels were slightly higher, but lower at the other three locations. The noise exposure at the five receptor locations was generally ordered by the distances to nearby turbines. No information was provided regarding the effects of terrain or wind direction.

A consultant report by Walker 2012 (also reported in Schomer 2013) provides details of LFN measurements at three homes at distances between 0.4 km and 5.6 km from wind farms. Extensive ten-minute measurement results were reported, with 50 dB in the frequency range 16 Hz to 25 Hz, measured at the residence located 1280 feet (0.4 km) from a wind turbine. Information regarding variation in terrain and distance separating wind turbine from residences was limited. Although the distances to various turbines were reported, only overall turbine noise at each home was reported.

2. Infrasound

The EPA SA 2013 report included infrasound results for various wind speeds and wind directions, both inside and outside of residences at the six locations. For downwind conditions, the levels outside of the residences were 61 dB(G) to 64 dB(G), compared with 51 dB(G) to 58 dB(G) inside of the residences. The infrasound levels for upwind conditions ranged from 54 dB(G) to 59 dB(G) outside of the residences, compared with 45 dB(G) to 50 dB(G) inside the residences.

In Evans 2013 the measured infrasound levels during the operational monitoring stage typically ranged from 40 dB(G) to 70 dB(G), increasing as the wind speed at the site increased (as was observed during the pre-operational and interim stages). All measured infrasound levels during the operational stage remained below the assessment criterion of 85 dB(G), with the vast majority of data points significantly lower than the criterion. No information was provided regarding variation with distance.

Møller 2011 only briefly discusses the effects of propagation of infrasound from wind turbines and gives some variation in sound due to distance. These results are 69.1 dB(G) at 629 m and 58 dB(G) at 822 m for turbines between 2.3 MW and 3.6 MW.

Schiff 2013 reported infrasound measurement results at five locations near 84 wind turbines in rural western New York. At the most affected location (location D), the un-weighted infrasound level increased from 53.4 dB with wind speeds of 1 m/sec to 82.8 dB for wind speeds of 7 m/sec. No information for wind direction, terrain or distance was presented.

Turnbull 2012 describe limited information related to wind farm infrasound and variation in distance. Infrasound levels reported for the Clements Gap wind farm were as follows: 72 dB(G) at 85m; 67 dB(G) at 185 m and 61 dB(G) at 360 m. Further results were reported for Cape Bridgewater wind farm: 66 dB(G) at 100 m and 63 dB(G) at 200 m. These levels of infrasound are all inaudible to humans.

Walker 2012 (also reported in Schomer 2013) reported measurements of infrasound at three homes at varying distances from a wind farm. Extensive ten-minute measurement results were reported for the second residence (1280 feet from the nearest turbine), with a sound level of 76 dB detected both indoors and outdoors for the frequency harmonics in the 0.7 Hz to 5.6 Hz range. Information regarding variation in terrain and distance separating wind turbines from residences was limited.

3. Flicker

The report by Brinckerhoff 2011 related to the effects of shadow flicker where effects are only likely to occur within 10 times the rotor diameter of wind turbines. Factors that may affect shadow flicker are window widths in receiving houses, uses of affected rooms, intervening topography and intervening vegetation. No quantitation of these factors was provided.

4. Electromagnetic radiation

The report by McCallum 2014 described EMF measurements in the proximity of 15 vestas 1.8MW wind turbines. Results reported for three operational scenarios: high wind, low wind and shut-off. The levels reported were described in the abstract as follows: “Magnetic field levels detected at the base of the turbines under both the ‘high wind’ and ‘low wind’ conditions were low (mean = 0.9 mG; n = 11) and rapidly diminished with distance, becoming indistinguishable from background within 2 m of the base. Magnetic fields measured 1 m above buried collector lines were also within background (≤ 0.3 mG). Beneath overhead 27.5 kV and 500 kV transmission lines, magnetic field levels of up to 16.5 mG and 46 mG, respectively, were recorded. These levels also diminished rapidly with distance. None of these sources appeared to influence magnetic field levels at nearby homes located as close as just over 500 m from turbines, where measurements immediately outside of the homes were ≤ 0.4 mG.”

5.Vibration

Styles 2005 described ultra-low vibration amplitudes generated by wind farms for variation in wind speed, distance and mode of propagation. Clear harmonic components at multiples of 0.5 Hz were observed at 0.5 Hz to 7.5 Hz, at levels up to 250 nanometres per second, which were clearly vibrations from a wind turbine. Vibrations could be detected in excess of 10 km from a turbine, but amplitudes were very low.

Several studies (Maschke 2007; Qibai 2004; van Renterghem 2013; Tickell 2012) presented no new data regarding shadow flicker, EMR or variation of wind turbine noise in relation to characteristics, such as wind speed, distance or terrain.

Mechanistic Evidence

This section addresses the following question:

> Is there basic biological evidence that make it plausible that wind turbines cause adverse health effects?

There is some evidence from laboratory studies in psychology that positive and negative media reports and information exert a measurable effect on people's self-reported symptoms, mood and perceived wellbeing in response to laboratory-synthesised infrasound emissions (Crichton 2013; Crichton 2014). Although these studies were based on relatively small sample sizes, and in both cases subjects were university students, this is unlikely to negate the overall finding that psychological expectations can influence perception of effects of laboratory-synthesised wind farm exposures on wellbeing. This is broadly consistent with the findings of Chapman 2013 where, in a historical analysis of public complaints about wind turbine installations, the authors found that 15 of the 18 wind farms (83%) which have seen complainants have experienced local opposition from anti-wind farm groups. Although this study relied on imprecise estimates of the exposed population(s), this would not be sufficient to negate the principal findings.

Background noise may induce annoyance and also affect cognitive task performance in experimental settings. Ruotolo 2012 reported that audible wind farm noise was associated with annoyance and poorer performance when undertaking demanding cognitive tasks. However, the authors also found that annoyance was reduced when wind farm noise was accompanied by simulated video images of the wind farm. It is difficult to interpret the relevance of the findings to the present question but it seems likely that visual cues may be influential in certain noise-related effects and tends to support a psychogenic pathway.

It is important to note that Ruotolo 2012, Crichton 2013 and Crichton 2014 are all experimental studies that used small numbers of university students as participants. It is unclear how generalisable these results are to a broader population, and also whether these laboratory findings would apply in real world situations.

There has been very little research in community settings that helps to answer the question of whether wind turbine emissions could plausibly cause human health effects. Taylor 2013b reported the results of a cross-sectional noise and opinion survey among people living near micro wind turbine installations. Although this survey found an association between turbine noise and self-reported wellbeing and attitudes, the recruitment rate was extremely low (and this postal survey was likely subject to recruitment bias as well as retrospective/recall biases) and therefore its generalisability is questionable. Furthermore, being a cross-sectional study, the causality of relationships observed is difficult to determine. Kelley 1987 describes a method of gathering and organising opinion data about low frequency noises and for establishing thresholds of annoyance. Given that the published study included only seven participants, whose representativeness in relation to the general population was ill-defined, the specific thresholds reported in this paper are not considered likely to be a useful indicator of general community tolerance. This method could be applied to gauge community tolerance in a specific community, but the published example is unlikely to be representative of communities exposed to wind farms in general so its applicability to the present question is limited.

Taken as a whole, these studies of Mechanistic Evidence in humans did not find biological pathways by which wind turbine emissions might cause adverse health effects. However, they do indicate that wind turbine exposures may be associated with annoyance and that influences from the surrounding socio-cultural environment, such as media reports and local community attitudes, may influence how people perceive wind turbines and whether they attribute health effects to them.

Parallel Evidence

This section addresses the following question:

> Is there evidence from research into other circumstances of human exposure to physical emissions that wind turbines produce, that make it plausible that wind turbines cause adverse health effects?

Experimental laboratory studies of exposure to low frequency noise in general have indicated that low frequency noise can affect annoyance, cognitive task performance, mood and sleep quality (Persson Waye 1997; Persson Waye 2001; Smith 2013). The remarks above in relation to the generalisability of experimental laboratory studies to broader populations and real world situations also apply to these studies. In addition, experimental exposures to synthesised low frequency noise (Persson Waye 1997; Persson Waye 2001) are unlikely to be equivalent with wind farm noise, and experimental exposure to simulated railway train pass vibration and noise (Smith 2013) would be expected to have very different characteristics. Therefore the applicability of this literature to the question of wind farm emissions is uncertain.

Other experimental evidence suggests that exposure to negative media reports about EMF exposure associated with Wi-Fi can induce symptoms via a 'nocebo' effect (Witthoft 2013). In this study, subjects perceived symptoms, related worries about EMF and reported anxiety, even during sham exposure. They also reported that the effect appeared to be magnified by an anxious disposition. Although the experimental design had some limitations, the main finding remains credible and agrees broadly with the psychological experimental literature described above, which suggests that psychogenic effects may be induced by expectations.

A cross-sectional survey of Taiwanese aerospace workers and noise exposure (Chao 2012) used echocardiography and audiometry to test the association between low frequency workplace noise and hearing loss and cardiac function. The authors concluded that hearing loss was greater for workers exposed to low frequency noise and that abnormality of left ventricular filling, as shown by an abnormal echocardiographic E/A ratio, was also higher in workers exposed to low frequency noise than that of the non-exposed control group. The study is of limited applicability because industrial noise exposure is most unlikely to be comparable to wind farm noise emissions. The generally poor scientific quality of this study also limits its value, e.g. selection of workers and how these were categorised into the three exposure groups was not described and potential confounders were not evaluated. In addition, the mechanism of how low frequency noise could affect left ventricular function is not clear from this study.

In summary, the Parallel Evidence included here indicates that low frequency noise in general may be perceived to be annoying, and may influence mood and performance on cognitive tasks in experimental laboratory situations. Although the experimental studies of Persson Waye were not specific to residential exposure to wind farm low frequency noise, similar effects may be plausible for wind farm exposures, particularly given their general consistency with the findings of other studies (Chapman 2013;

Crichton 2013; Crichton 2014; Ruotolo 2012). It is therefore plausible that external influences, such as media reports, community attitudes and even landscape visibility characteristics, could influence annoyance and exert psychogenic effects on subjective perception of health outcomes among those who believe they are exposed.

Evidence suggesting lower performance on demanding cognitive tasks in experimental laboratory settings is difficult to interpret; it is unclear if such effects, observable under experimental conditions, would also apply to real world settings. Given that the findings of reduced performance on cognitive tasks in laboratory settings tended to be accompanied by reports of annoyance and/or negative mood, it is possible that effects on performance are of psychogenic origin.

Conclusions of studies of Background Evidence

The Mechanistic studies do not provide reliable evidence that wind turbine emissions cause adverse health effects by biological pathways. However, they do indicate that exposure may be associated with annoyance, and that sociocultural factors, such as media and community attitudes, may influence people's perception of wind turbines and whether they attribute adverse health effects to them. The Parallel Evidence suggests that in experimental laboratory situations, low frequency noise may be perceived to be annoying and may influence mood and the ability to perform cognitive tasks. These findings may be plausible for wind turbine exposures. However, as with Mechanistic Evidence, external influences, such as media reports, community attitudes and landscape visibility characteristics, may also influence annoyance and exert psychogenic effects on subjective perception of health outcomes among those who believe they are exposed.

Table 2 – Characteristics of Included Studies (Background, Mechanistic and Parallel Evidence)

Background Evidence

Brinckerhoff 2011	Design	Exposure	Outcome	Limitations
Shadow Flicker				
Aim To update the evidence base regarding shadow flicker effects by stakeholder consultation survey and a review of international guidance material and academic literature. Shadow flicker modelling methods were also reviewed.	UK government report on shadow flicker including reviews of international guidance, and scientific literature, stakeholder survey and assessment of current methodologies used in the wind farm industry.	Large onshore wind turbines (approximately 500 kW upwards).	Stakeholder questionnaire survey results. Results of guidance and literature review. Results of review of shadow flicker modelling methods. Stakeholder questionnaires were completed by local planning authority (n = 17), developers and consultants (n = 14).	Poor response rate: the industry questionnaire was sent out to 178 company members on the mailing list of the industry association Renewable UK, only 14 responses obtained. Representativeness of industry stakeholders unknown. Two respondents were owners of wind turbines, four respondents were operators, and one respondent was involved in technical operations.
Results Review of other literature suggested that the health effects of shadow flicker show that light variations at frequencies below 2.5 Hz are unlikely to cause disturbances (generally wind turbine rotation frequency is 0.3-1 Hz). The report concluded that the frequency of shadow flickering associated with wind turbines is such that it should not cause a significant risk to health. Limited evidence suggests possible association between wind turbine flicker and epileptic seizures. In the UK, approximately 0.5% of the population suffers from epilepsy, and 3.5% to 5% of epileptics are susceptible to photosensitivity. However, the proportion of susceptible individuals (photo-sensitive epileptics who are specifically sensitive to low frequency flicker, i.e. 2.5 Hz to 3 Hz) is extremely small (less than 5% of photosensitive epileptics). The psychological and nuisance impact of shadow flicker does not constitute harassment, however under specific conditions of increased physical or mental demand and long-term exposure cumulative effects might meet criteria for significant nuisance. Stakeholder consultation indicated that shadow flicker has not been a widespread problem in the industry, yielding few complaints, generally resolved by implementing turbine shut down strategies. Mitigation measures which have been employed by operational wind farms, have proved very successful, to the extent that shadow flicker cannot be considered a major issue in the UK. Current pre-development site design measures to minimise shadow flicker also appear to have been successful. Current general recommendations to assess shadow flicker impacts within 130 degrees either side of north is considered acceptable, as is the 10 rotor diameter distance from the nearest property. However, the "one size fits all" approach may not be suitable at all latitudes.				

Review of computer shadow flicker modelling programs used by developers to assess shadow flicker indicated that the different shadow flicker modelling programs used produce similar results and because of simplification inherent in the modelling process (such as not considering wind speed and cloud cover variations), computer modelling produces 'worst case scenario' results and real-world experience is generally likely to be less extreme. Quantitative measures are also specified in some guidelines stating that shadow flicker should not exceed 30 hours per year or 30 minutes a day. Responses to questionnaires show that developers view such guidelines as problematic due to latitudinal variations of impact and believe mitigation measures would be a better option in addressing the problem. The most common mitigation measures across countries are careful site design and turbine shut down periods. Other measures include blind installation, landscaping and vegetation screening. **Conclusion** Authors concluded "It is considered that the frequency of the flickering caused by the wind turbine rotation is such that it should not cause a significant risk to health."

Bockstael 2012	Design	Exposure	Outcome	Limitations
Noise				
Aim To investigate the relationship between wind turbine noise annoyance and exposure indicators, operational characteristics and environmental variables.	Field research at a wind turbine site in the Flemish part of Belgium over a six-month period. Environmental noise monitoring and resident's annoyance survey. Wind turbine annoyance was investigated in relation to possible exposure indicators, operational characteristics and environmental variables. Three households provided periodic reports of experienced annoyance (five point scale from 'not at all' to 'extremely annoyed') via a web application. Eight households were originally recruited via door-knocking.	Three wind turbines rated at 2 MW. Following previous complaints turbines were restricted to 600 kW during the night period (7pm–7am). Noise measurements were taken from two points in the back yard of one house approximately 270 m from the closest wind turbine. Operational characteristics of the closest wind turbine (such as angular blade velocity, electricity production and wind speed at hub height) and meteorological data (such as temperature and relative humidity) were also observed. Participants were asked to report annoyance levels via a web application.	Participant reported annoyance.	Limited number of participants in residents' annoyance survey . Representativeness unclear. Likely recruitment bias. Periodicity/frequency of resident reports unclear. Likely reporting bias as one household only reported when they were annoyed and five non-respondents reported lack of annoyance as the reason for non-response.

Results
552 reports of annoyance-level were provided by three of the recruited eight resident households over a four-month period. Three of the non-responders were telephone interviewed, one was not annoyed and the remaining two were annoyed from time to time but did not report it. Difference in noise sensitivity between responders and non-responders was not significant ($p > 0.05$, Fisher's Exact Test). Predicted risk of annoyance was significantly related to blade velocity ($p < 0.0001$) and wind direction ($p < 0.001$). The risk of high annoyance increases with decreasing relative humidity ($p < 0.001$) from the air absorption effect on sound, a higher sound pressure level is expected with increasing humidity however is not consistent with observed decrease of annoyance, suggesting such an effect is not related to the propagation of sound but rather the weather. Annoyance was found to be associated with directionality, with higher annoyance determined by certain conditions of angular blade velocity together with wind direction. **Conclusion** Authors concluded that the current study confirms that annoyance due to wind turbine noise is complex and influenced by personal and contextual variables as well as noise production and propagation. The authors also recommend that because directionality plays a role in noise annoyance, more subtle steering protocols and operational restrictions based on wind direction and angular blade velocity might help to reduce noise annoyance without cost-effectiveness detriment.

Doolan 2013	**Design**	**Exposure**	**Outcome**	**Limitations**
Noise				
Zajamsek 2013a **Zajamsek 2013b** **Zajamsek 2014** **Aim** To describe a new methodology to record noise annoyance inside residences near wind farms (Doolan 2013). To present preliminary results from upgraded noise and annoyance recording systems (Zajamsek 2014).	Noise surveys. The noise and annoyance monitoring system was placed in one house at a distance of 2.5 km (capacity 111 MW) from the wind farm for Doolan 2013 and Zajamsek 2013b. In the reports by Zajamsek 2013a and Zajamsek 2014 the noise and annoyance monitoring were undertaken in two houses, one at 2.5 km (capacity 129 MW) and the second at 8 km from the same wind farm. Location: Waterloo Wind Farm, South Australia.	In Doolan 2013 measurements of the A, Z (unweighted) and C-weighted sound level, and both the octave bands and narrowband format with a frequency resolution of 2 Hz, were recorded. Doolan only used one microphone; the later Zajamsek reports measure multiple locations simultaneously with an array of three and four microphones.	Overall sound pressure level versus annoyance rating by the resident. Doolan 2013 used a ten-point annoyance scale. The later Zajamsek reports used only '*Very Annoyed", "Moderately Annoyed", "Slightly Annoyed" and "Not Annoyed".*	All four studies were small studies with only one or two houses and therefore only a handful of subjects reporting annoyance. The noise recording system cannot identify noise sources, however the resident self-reported characteristics of the noise and weather conditions. Studies did not have a weather station to track wind direction. Doolan 2013 did not have full information of on/off time of wind farm to compare with measurements. Doolan 2013 only monitored one microphone position at a time.

Results

Doolan 2013 reported that measurements showed an increase in the overall mean Z (unweighted) and C-weighted sound level with annoyance rating. However no increase was observed in the mean A-weighted sound level. Levels within the 10-30 Hz band were observed to increase with annoyance rating.

Zajamsek 2013a reported all levels in the infrasonic and low-frequency region were well below the median hearing thresholds, and are thus unlikely to be audible.

Zajamsek 2013b reported that the noise levels show some increase with annoyance, but there was also close correlation of noise with local wind speed. Narrowband spectral density analysis results indicated infrasonic “tones”, only when the resident was not annoyed and local wind speed was low.

Zajamsek 2014 reported 14 figures of detailed results for Residence A and Residence B. During the measurement period at Residence A, 20 self-reported annoyance measurements were taken with three rated as “Very Annoyed”, six as “Moderately Annoyed”, seven as “Slightly Annoyed” and four as “Not Annoyed”. At Residence B, eight self-reported annoyance measurements were taken with one rated as “Very Annoyed”, two as “Moderately Annoyed”, two as “Slightly Annoyed” and three as “Not Annoyed”.

Conclusion

Doolan 2013 concluded: “that a test case, a home near a wind farm, was presented to demonstrate the use of the proposed technique. No link can be made between the noise data and the operation of the turbines; however, the data presented gives an insight into the type and level of noise experienced by residents and that they personally attribute to wind turbines. Additionally, significant level variation was detected in the noise signals; however, no trend with annoyance was observed.”

Zajamsek 2013a concluded: “1. The *Leq*, 2 min is well correlated with local wind speed. 2. Noise levels in the infrasound and low-frequency bands are well below the *ISO226-2003* median perception threshold, making them unlikely to be audible by a person with normal hearing. 3. Annoyance measurements do not directly correlate with the highest noise levels. 4. Some measurements show peaks in the infrasonic and low-frequency bands. In one case, these peaks appear to be revealed when local wind speed drops to a low value. 5. Without information concerning the operational state of the wind farm, the wind farm cannot be confirmed as the source of noise at low-frequency. 6. Since tonal components appear at very low and infrasound frequencies their direction of arrival could not be resolved by arrays whose low frequency limits were 50 Hz and 85 Hz respectively. According to the small data set collected in this preliminary study, no further conclusions can be drawn.”

Zajamsek 2013b concluded: “1. The *Leq,* 2 min is well-correlated with the local wind speed. 2. Noise levels in the infrasound and low-frequency bands (below 50 Hz) are well below the *ISO226-2003* median perception threshold, making them unlikely to be audible by a person with normal hearing. 3. Annoyance ratings do partially correlate with the high *Leq,* 2 min noise levels. 4. The resident was not annoyed when the local wind speed was low and its direction was scattered. 5. Some measurements show peaks in the infrasonic and low-frequency bands. In one case, these peaks are revealed when the local wind speed drops to a low value.”

Zajamsek 2014 concluded: “The noise level measured in both homes was found to be controlled by local wind speed more than any other factor. The highest noise levels were measured in the low frequency and infrasonic range however the levels at these frequencies were below the median hearing threshold making them unlikely to be audible by a person with normal hearing. Annoyance was found to be related to noise level and local wind speed in the home located 2.5 km from the wind farm. However, at the home located 8 km from the wind farm, annoyance was not controlled by noise level. In this case, time of day seemed to be a more important factor.

When the local wind speed was at a very low level, with correspondingly low background noise levels, tones at harmonics of the blade pass frequency were measured inside both homes. These tones were however below the threshold of hearing.”

EPA SA 2013	Design	Exposure	Outcome	Limitations
Noise				
Aim To investigate the concerns of the community regarding noise from the Waterloo Wind Farm, South Australia.	Report of a two-month investigation into the noise environment in an area where health concerns have been expressed by residents near a wind farm. Two main study components: (a) noise and weather monitoring and (b) community diary component. Commonalities between described noises amongst residents, specific environmental conditions that are related to disturbances, presence of low frequency and infrasound noise were explored across six residential sites. Report also reviewed current EPA wind farm noise guidelines. Location: Waterloo Wind Farm, South Australia.	Situated atop a north–south ridge, and stretching for 18 km, the wind farm comprises 37 Vestas V90 3 MW wind turbine generators (WTG), each having a hub-height of 80 m, with the entire site having a rated generation capacity 111 MW. Noise and weather monitoring at six sites 1.3 km to 7.6 km from the wind farm in question. Community diaries were kept by volunteer residents in the local area.	Noise and weather monitoring at six locations (houses) from 1.3 km to 7.6 km away from a wind farm. • Audio noise and infrasound (0.25 Hz to 20 Hz) were monitored (indoor and outdoor) at two of the houses. • Audio noise only (12.5 Hz to 20 Hz) was monitored (indoor and outdoor) at three of the houses. • Audio noise (12.5 Hz to 20 Hz) was measured (outdoor only) at one house. Six ten-minute shutdown periods took place in order to measure background noise levels. Operational and meteorological data were obtained from the wind farm operator. Weekly noise diaries were collected from residents; including information on perceived characteristics of noise, start time and end time.	Monitoring program was focused on homes of residents who had expressed concerns about noise. Noise diary data provided by residents of monitored homes, along with two other volunteering neighbouring residents (total of six sites with analysis of diaries and noise levels in Appendix C to Appendix H). Diaries often disagreed. Responder bias likely but triangulation with measured data is a rational way to analyse the diary data.

Results
Noise events attributable to the wind farm were periodically audible at four houses, but at very low levels, forming a minor component of the overall noise environment. No attributable noise events were found at the two remaining houses. Where detected, wind farm noise was within EPA noise guidelines for wind farms. Specific wind farm operating and weather conditions generated more low frequency noise, and this was consistent with noise diary data collected from the community. Noise diary data reported a 'rumbling' noise effect at certain times which respondents attributed to the wind farm, however investigators could only detect this effect on amplification and could not attribute it to wind farm operations and at times it coincided with wind farm shutdown periods. Typically the effect was recorded under downwind conditions when the local background noise was low, notably at low local wind speeds. Background noise resulting from local winds and other noise sources was shown to contribute to increases in low frequency noise that were comparable with, or higher than, contributions from the wind farm. A 'blade pass frequency' infrasound component was detected at levels significantly below the accepted audibility threshold (85 dB(G)) in the homes where infrasound was monitored. Low frequency noise characters found in this study would not normally be audible to typical listeners, however sensitive residents in this quiet environment may perceive it and this could cause annoyance to some people if exposed for prolonged periods. This type of noise was identified at three residences when audio recordings were amplified. **Conclusion** Authors concluded "Analysis of acoustic data and audio records measured at the township and east sites did not show evidence for noise that may have been associated with wind farm operations.… Noise impact from the wind farm, where detectable, was found to comply with the conditions of the development of approval and the baseline criterion of 40 dB(A)."

Evans 2013	**Design**	**Exposure**	**Outcome**	**Limitations**
Noise				
Aim To compare measured infrasound (noise at frequencies lower than 20 Hz) and low frequency noise (noise from frequencies of 10 Hz to 160 Hz) levels between the measurement stages and to relevant	Noise monitoring survey in response to concerns raised by some community members. Indoor measurement of infrasound (< 20 Hz) and low frequency noise (10 Hz to 160 Hz) at two homes near a wind farm at pre-operational and operational time periods (1.8 km and 2.7 km from nearest turbine). Measurements of infrasound and low frequency noise were	A wind farm of 140 x 3 MW WTG monitored during wind farm's pre-operational phase (Sept 2012), during full operation (March-April 2013) and at an intermediate time when 105 out of 140 WTGs were operational (Nov-Dec 2012). Infrasound and low frequency noise levels at three operating conditions: • No WTGs operating	Differences in infrasound and low frequency noise measurements compared during the three time periods described.	Two homes near the wind farm were monitored. Rationale for selection of these dwellings was not described in detail and recruitment of home owners was not described, however the rationale for the survey was that it was in response to concerns raised by some community members, therefore presumably the two sites were homes of concerned residents. Possible bias in selection of

assessment criteria.	compared with relevant Australian noise guidelines. Location: Macarthur Wind Farm, Victoria.	• 105 operating WTGs • 140 operating WTGs Noise measurements included: • Infrasound assessment • Low frequency noise • Linear sound pressure measurements		monitoring sites.
Results No differences in infrasound levels at both residences were observed during the differing measurement periods (taking into account variables such as wind direction), with almost all results below 85 dB(G) assessment criteria. Low frequency noise measurements showed an increase in noise levels at 63 Hz and above during the operational stages (105 WTGs and 140 WTGs) at one of the residences. Of these increases seven ten-minute periods out of 23 nights of monitoring exceeded the criteria, although this was likely to be influenced by local wind noise. **Conclusion** Authors concluded "Overall, this assessment has demonstrated that infrasound and low frequency noise levels from [the wind farm] are compliant with relevant assessment criteria at the two nearby residences. No change in infrasound levels was identified relative to the pre-operational monitoring. An increase in low frequency noise levels at frequencies of 63 Hz and above was measured at each of the residences for particular conditions and may be a result of noise from [the wind farm]".				

Møller 2011	Design	Exposure	Outcome	Limitations
Noise				
Aim To describe the spectrum of noise associated with large wind turbines and in particular the role of low frequency sound and infrasound. As stated in the Introduction, "…the hypothesis that the spectrum moves toward lower	Accoustical noise survey conducted in Denmark. Noise spectrum assessment of wind turbines of different sizes. Differences in noise emissions of 48 small and large wind turbines were analysed. A measurement of low frequency sound insulation to exterior sound across ten rooms in typical houses was also undertaken to assess the penetration of wind turbine noise.	Noise data from 48 WTGs were included. Noise from four large prototype turbines (> 2 MW) was measured. The effect of wind speed on noise was also measured. Previously collected noise measurement data from seven other similarly large turbines and 37 smaller turbines (< 2 MW) were obtained from the Danish EPA. All turbines were three-blade WTGs with the rotor to the upwind side of the tower.	Estimation of indoor sound penetration of homes in the vicinity of WTGs was made by discounting outdoor sound pressure levels to take into account the attenuation of noise by the house structure.	Problems with background noise limited the sound insulation evaluation of indoor spaces and the resultant statistical model was based on fewer measurements than planned. Assessment of indoor sound insulation method was focused on house façades and did not include noise exposure via other noise paths (e.g. roof, back of house etc.) which would be exposed to WTG noise, especially relevant for

frequencies for increasing turbine size is investigated."		Low-frequency noise penetration into indoor spaces was modelled based on sound insulation evaluation of ten rooms in five average Danish houses which were exposed to artificial noise via an outdoor loudspeaker.		low frequency sound. Assumptions made in the outdoor free-field sound pressure level calculations that could lead to highly variable low frequency sound predictions. Modelling assumes house windows closed, which limits generalisability to warmer climates. Assumptions in models may not apply in all atmospheric conditions (e.g. when there is a temperature inversion or low-level jets).

Results

Large wind turbines emitted more low frequency noise (2.3-3.6 MW) than small turbines (≤2 MW), which was statistically significant. The difference equates to a one-third octave difference in noise pitch of large vs small turbines. Therefore, as turbines become larger it is expected that more low frequency sound will be generated by wind turbine installations.

Due to air absorption, low frequency noise becomes more pronounced when outdoor sound pressure levels are taken into account (higher frequency sound is absorbed more than low frequencies). Indoor low frequency noise levels are influenced by sound insulation in the measured room, position of a room and turbine characteristics. Infrasound emitted by WTGs was found to be well below the threshold of hearing, even in immediate vicinity of WTGs where infrasound is imperceptible.

The minimum distance at which noise levels comply with a 35 dBA limit varies considerably between the large turbines, even when the turbines are relatively equal in size (2.3 MW to 3.6 MW). The distance varies from slightly over 600 m to more than 1200 m. It was found that the noise from WTG increases with wind speed, but levels out or even decreases above 7–8 m/sec.

Conclusion

Authors concluded that the spectrum of wind turbine noise moves down in frequency with increasing turbine size. The relative amount of low frequency noise is greater for large WTGs (2.3 MW to 3.6 MW) than for smaller WTGs (< 2 MW). Because distance attenuates higher frequencies more readily, low frequencies are more pronounced outdoors over distances relevant to neighbouring houses. Therefore the low frequency part of the spectrum plays an important role in the noise at nearby dwellings. The authors state that the turbines do emit infrasound (sound below 20 Hz), but levels are low when human sensitivity to these frequencies is accounted for. Even close to the turbines, the infrasonic sound pressure level is much below the normal hearing threshold, and infrasound is thus not considered as a problem with turbines of the investigated size and construction. The authors regard infrasound from WTGs of the kind investigated not to be problematic because the sound pressure levels of infrasound renders it imperceptible, even at close range. Under certain atmospheric conditions WTG noise may be more annoying, however more research is needed into this hypothesis.

van Renterghem 2013	Design	Exposure	Outcome	Limitations
Noise				
Aim (Not explicit in paper.) A listening experiment investigating annoyance, recognition and detection of WTG noise.	Investigated annoyance, recognition and detection of wind turbine noise through a listening experiment in which 50 participants with normal hearing ability were exposed to differing noise recordings. Noise recordings included an operating wind turbine, highway noise, local traffic noise and mixed recordings (i.e. wind turbine noise with local traffic noise).	Part 1 involved samples being played during a quiet leisure activity. Part 2 asked participants to identify the sample containing wind turbine noise in a paired comparison test. Participants were asked to rate their annoyance levels for the differing noise exposure and to identify the types of noise they believe were included in the recordings (blinded to the purpose of the study during these measurements). Participants were then exposed to the mixed recording and asked to detect the wind turbine sound. Sound recordings of a 1.8 MW wind turbine operating at 22 rpm, highway noise and local road traffic noise (unmixed and mixed). Recordings were adjusted to L_{Aeq} 40 dB(A) to simulate indoor sound pressure levels.	Participants were asked to rate their annoyance after exposure to six audio recordings at 7.5 minutes each. Recognition responses to the six recordings and detection responses to the mixed recordings (wind turbine noise with other noise). A short questionnaire assessed participant attitude in relation to renewable energy.	Measuring annoyance levels using a short exposure time (7.5 minutes per recording) may not provide a clear indication of the prolonged exposure that residents experience. Small and non-representative sample and the selection of participants was not described. The test group could be categorised as having a positive to neutral attitude in relation to renewable energy.
Results Under the conditions of Part 1, pure wind turbine noise gave very similar annoyance rating as unmixed highway noise at the same equivalent level, while annoyance by local traffic noise was significantly higher. The detection limit of wind turbine noise in the presence of highway noise was estimated to be as low as a signal to noise ratio of -23 dBA. The larger the signal-to-noise ratio, the larger the fraction of the participants that were able to identify the sample containing the wind turbine noise. When mixed with local road traffic, such a				

detection limit could not be determined. The findings support that noticing the sound could be an important aspect of wind turbine annoyance at the low equivalent levels typically observed indoors in practice. Participants recorded a similar annoyance level between highway noise only and pure wind turbine noise. Significant differences were observed between the annoyance ratings to local road traffic compared with wind turbine noise and highway noise, with local road traffic annoyance levels the highest. **Conclusion** Authors concluded that this experiment supports previous observations that retrospective annoyance for WTG noise is greater than for highway noise at an equivalent noise level and that this difference is mediated by higher perception of noise level, emotional and/or cognitive processes. It was also found that traffic noise and WTG noise were perceived similarly when the noise source was not known beforehand, however in focused listening, WTG noise is sufficiently distinctive to allow detection even at low signal-to-noise ratios. Therefore, the authors concluded that focusing, triggered by more general knowledge of the presence of wind turbines, could increase annoyance. Some individuals were shown to recognise more readily WTG noise, even if its presence was not revealed beforehand.

Schiff 2013	Design	Exposure	Outcome	Limitations
Noise				
Aim To increase the understanding of potential noise issues related to industrial wind turbine operation in New York State, by examining the outcome of a recent wind project.	Environmental noise survey of five sites, 219 m to 663 m from operating 1.5 MW WTGs in a large wind farm project and two control sites (> 4.6 km removed). Each site was monitored for four days in summer, winter and autumn. Infrasound and low-frequency sound were also evaluated, wind conditions permitting.	Wind farm of 84, 1.5 MW WTGs. Outdoor noise measured on rural residential land parcels as far from buildings and roads as practicable within the selected land parcel. In some cases this resulted in monitoring location being closer to the nearest WTG than the dwelling on the land parcel in question. Meteorological data (weather, wind speed, wind direction, and temperature) were logged over concurrent periods at one of the central receptor locations.	n/a, environmental noise survey.	Only five measurement locations. One control site's data were discarded for summer and autumn monitoring campaigns. Therefore only winter monitoring had both control locations. Selection of residences for monitoring was not described. Justification of the 4.6 km distance for control residences was not provided. Indoor monitoring was not undertaken. Siting of outdoor monitoring (away from dwellings, sometimes closer to WTG than dwelling) may not accurately represent real human exposure. Sizes of land parcels in question were not defined, therefore the

				distances involved were not clear.

Results

Certain monitoring locations may have slightly exceeded 50 dBA, the local limit for wind turbine noise, though the assumed conditions associated with the standard may not have been exactly replicated in the study.

Measured results were within +/- 2 dB of a pre-development study model on an overall long-term basis, though individual measurements in the study were as high as +/- 5 dB of pre-development model. This would indicate that noise exposure could vary by up to 5 dB compared to model estimates.

Noise exposure was consistent between the autumn and winter campaigns, but overall A-weighted and low frequency noise was slightly lower during the summer campaign, suggesting that sound propagation differs depending on the season.

Conclusion

Authors concluded "measured sound levels at most locations exceeded the corresponding background location sound level by substantial and audible margins especially in moderate to high winds." Measured ground level wind speed tended to be marginally lower than that extrapolated from the 10 m wind mast, indicating that ground-level masking of turbine noise may sometimes be less than expected. Certain monitor locations may have slightly exceeded the 50 dBA local limit for wind power noise at the residence building itself. Measured background noise at an individual site was up to 5 dB lower than the pre-development survey, which amalgamated six different sites into one data set. Finally, the measured results were within a ± 2 dB margin of the pre-development study model on an overall long term basis, but for each individual measurement campaign this margin was as high as ± 5 dB.

Qibai 2004	Design	Exposure	Outcome	Limitations
Infrasound				
Aim To study the physiological and psychological effects of infrasound on persons.	Laboratory study. The physiological and psychological impact of exposure to infrasound was measured in ten university students (four female, four male; aged 22-28).	Ten participants were split into two exposure groups (A & B) with two females and three males per group. Group A was exposed to infrasound of 4.10 Hz at 120 dB for one hour and Group B was exposed to 2.14 Hz at 110 dB for one hour.	Blood pressure and heart rate were measured three times at two-minute intervals before exposure and after one hour of exposure. Subjective feelings and reactions were measured using a short questionnaire after exposure.	Small sample drawn from university student population which is not representative of the general population. Representativeness and generalisability questionable. Lack of baseline or pre-exposure questionnaire. Lack of a validated questionnaire instrument.

Results No results which provide information about exposure to WTG outputs. Physiological and psychological effects of infrasound appeared as changes in heart rate, blood pressure and subjective reactions. All participants reported feeling uncomfortable during exposure. Eight of the ten participants compared the feeling during exposure to travelling in a vehicle or train and nine of ten reported pressure in the ears. For all participants from Group A and B, at least one change of more than 10% was observed in at least one measurement (systolic pressure, diastolic pressure, heart rate). Group A showed an increase in systolic and diastolic pressure in four of the five participants. Heart rate also increased for four of the five participants, with one participant showing no change. Group B showed an increase in systolic and diastolic pressure for all participants. Heart rate also increased for four of the five participants. No major differences were observed between the two exposure groups. **Conclusion** Authors concluded "Different individuals have different responses to infrasound and the change ratio of blood pressure and heart rate are also different. By comparing physiological and psychological effects of infrasound on persons in two different infrasound conditions, we find that there are not obvious differences." No conclusions relevant to exposure to WTGs.				

Styles 2005	**Design**	**Exposure**	**Outcome**	**Limitations**
Infrasound				
Aim To identify the characteristic frequencies and mode of propagation of seismic vibrations from wind turbines and develop a model for the integrated seismic vibration at the Eskdalemuir seismological array facility which will be created by any distribution of wind farms.	Measurement of seismic and infrasound disturbances in vicinity of several Scottish wind farms in order to model and estimate the likely impact of a proposed large wind farm on the nearby British Geological Survey (BGS) seismological array.	Measurements were made by sensitive seismometers at 100 m, 50 m and 20 m. LFN was measured with digital seismographs with a bandwidth of 0.2 Hz to 64 Hz and acoustic noise was measured around a wind turbine.	To what extent would proposed wind farms be expected to transmit vibration into the ground such that would interrupt the operations of the nearby seismological array.	No limitations, other than possible uncertainty over applicability to other locations.
Results The researchers were able to detect low-frequency sound waves at considerable distances away from a wind farm under the right atmospheric conditions with highly sensitive seismometers. The authors recommended exclusion distances around nearby BGS seismological array based on the probability of interference from the transmission of vibration from wind turbines to the ground. The vibration levels about which this study was concerned were below the limit of human sensation because this study was not concerned				

with human effects, but with possible effects on the highly sensitive Eskdalemuir seismological array used by the British Ministry of Defence for international detection of nuclear test explosions. **Conclusion** Authors concluded “By considering the present ambient background experienced at the monitoring site it has been possible to set a noise budget which is permissible at Eskdalemuir without compromising its detection capabilities. … [the measurements] have demonstrated that at least 1.6 GW of planned capacity can be installed and have developed software tools which allow the Ministry of Defence and planners to assess what further capacity can be developed against criteria established by this study”.

Tickell 2012	**Design**	**Exposure**	**Outcome**	**Limitations**
Infrasound				
Aim To review recent papers describing low-frequency, infrasound and amplitude-modulation noise from wind turbines, and whether low-frequency and infrasound from wind farms is a real measureable issue.	A narrative review of recent publications.	No noise measurements collected. Sound levels reported from various reviewed studies.	For low frequency noise from wind turbines, a comparison of findings from published studies. For modulation sound levels from wind turbines, sound levels at different distances from five wind turbines from a study by Miyazaki 2011.	Non-systematic review, completeness of coverage and representativeness of cited papers is questionable.
Results Figure 1: Comparison of low frequency hearing thresholds with Wind Turbine Sound Levels at low frequencies from five studies. The figure showed that for the frequency range below 25 Hz, which includes the infrasonic range, the sound levels from the five wind turbines were less than the threshold of hearing – for frequencies less than 20 Hz, this difference was at least 10 dB and increased with reducing frequency. The measurement distances ranged from 44 m to 77 m. Figure 2: Sound levels of reference distances from five wind turbines from a study published in 1990, showed that the rotor trailing edge was a source of high noise emission. Figure 3: Results of predicted sound levels at increasing distances from a 2.5 MW wind turbine, for overall sound levels and modulation depth, indicating that while the overall sound pressure level decreased with distance, the modulation depth was consistent with distance. **Conclusion** Author agreed with findings of a reference that an objective external sound level for residential receivers should be 60 dB(C) for night-time. Author suggested that amplitude modulation should be considered as an addition to predicted overall sound level at receiver locations for comparisons with environmental noise quality objectives.				

Turnbull 2012	Design	Exposure	Outcome	Limitations
Infrasound				
Aim Reports a new acoustical methodology for measuring infrasound.	Methodological evaluation of a monitoring method for infrasound (specifically a means of minimising influence of wind on microphone). Measurements within a test chamber below the ground surface were used to compare infrasound at two South Australian wind farms (Clements Gap Wind Farm and Cape Bridgewater Wind Farm) and in the vicinity of a beach, coastal cliff, city and power station, using the same measurement methodology.	Infrasound from wind farms and other sources. Environmental noise measured against the infrasound audibility threshold limit of 85 dB(G).	Measured levels of infrasound from wind turbines and other natural sources.	Modelling is lacking. All measurements reported in Table 2 for various sources are at different distances, making comparisons unclear. Limited reporting of variations in infrasound levels due to different atmospheric conditions.

Results

Infrasound levels inside the underground chamber were the same as those of the signal generator.

Levels of infrasound were similar at a beach, in the vicinity of a coastal cliff and close to wind turbines. The proposed measurement method used in the study illustrates that the infrasound generated from wind turbines is well below the audibility threshold level. The reduction of signal strength during transmission of 6 dB per 'doubling distance' from a turbine was adequately demonstrated. The infrasound noise level generated by wind turbines is similar to urban and costal environments and other engineered noise sources.

The measured levels of infrasound from the wind turbines and all other natural and engineered sources were well below the 85 dB(G) threshold of audibility. The measured levels included a significant contribution of infrasound from the wind farm at 100 m, but at a distance of 200 m from the wind farm the infrasound from the other sources was at similar levels, e.g. 74 dB(G) at 350 m from a gas-fired power station and 63 dB(G) at 200 m from the Cape Bridgewater Wind Farm.

Conclusion

Authors concluded "The measured level of infrasound within the wind farms is well below the audibility threshold and similar to that of urban and coastal environments and near other engineered noise sources… The method shows that for wind turbines, the level of infrasound is well below the audibility threshold of 85 dB(G). An attenuation rate of 6 dB per doubling of distance from a single turbine. Infrasound is prevalent in urban and coastal environments at similar levels to the level of infrasound measured close to a wind turbine".

Walker 2012	Design	Exposure	Outcome	Limitations
Infrasound				
Schomer 2013 **Aim** To present information from an investigation of infrasound and low frequency noise performed at Shirley wind farm in Brown county Wisconsin in December 2012. Schomer 2013 To propose the hypothesis that very low frequency wind turbine noise emissions may induce motion sickness in susceptible persons, as the same inner ear organs may be central to both conditions.	An environmental noise monitoring survey undertaken for litigation purposes. Symptoms were also collected and this was cross-sectional. Low frequency noise (LFN) and infrasound measurements at three residences (indoor and outdoor) in varying proximity to wind turbines (0.3 km to 2.1 km). Data were collected by five investigators from four firms of consultants. Schomer 2013 A survey among 50 (of 275) people residing within 5000 feet of the closest wind farm in Shirley, Wisconsin who described adverse effects after introduction of the wind turbines. Selection criteria further restricted to a sub-subset of two (out of five) people exhibiting motion sickness symptoms who meet the following criteria: i) about half or more of their symptoms must be motion sickness symptoms; ii) the overall symptoms must be severe enough that the people abandon their homes (or equivalent); iii) the motion sickness symptoms must include nausea; and iv) the motion sickness symptoms must play a	Wind farm consisting of eight wind turbines. Measurements made at three homes abandoned by owners due to health complaints attributed WTG health effects. Primary measurements were made at the three abandoned residences on consecutive days by four consulting firms. Sound pressure was measured using a custom designed multi-channel data acquisition system in the time domain at a sampling rate of 4000/sec where all signals were collected under the same clock. At each residence, a multi-channel recorder was connected to an outside wind-speed anemometer and a microphone; others channels of the recorder were connected to microphones inside each residence that were situated in various rooms including basements, living or great rooms, office or study, kitchens and bedrooms (observations were based upon coherence calculations for indoor and outdoor microphones). Data collected at Residence 2	Indoor and outdoor sound pressure measurements and spectral data were taken at three unoccupied homes near wind turbines in a Wisconsin wind farm. Investigators' observations of perceived low frequency noise and infrasound at the test locations. Investigators' observations of any health effects (own) during and after the 3-4 day monitoring periods. Detection of infrasonic pressure modulations from the wind turbine to the residence. Reports on any health issues experienced by neighbours (nausea, dizziness and headache).	Focused on a single wind farm with a history of high levels of community dissatisfaction and complaint. Measurements taken from homes which were abandoned because of concerns or complaints attributed to WTGs. No measurements of occupied homes. The decision was made not to measure acoustic data at a control home far away from the wind farm site, despite its intention in the original survey design. Emphasis on the consultants' self-reported perception of noise and health symptoms during the period of monitoring. Limited due to small sample size and lack of blinding. Schomer 2013 Small sample size and lack of blinding. Unlikely to be representative and response and recall biases likely. Recruitment rate low and likely subject to recruitment bias. Noise data from only one residence were used in the analyses, as that residence was "tested during a time when significant power was being generated", whereas the wind

	prominent role in the subject's overall response to wind turbine noise. (The following reported effects were tested: whether effects were similar from one space to another, were independent of the rotor, and were not related to audible sound.)	were measured with 58% of turbine power, but < 58% during measurement periods at Residence 1 and Residence 3 (so only data from Residence 2 was used). Neighbour reports and physiological effects including nausea, dizziness and headache were documented.		turbine operator "was not generating much power during the measurements" at the other two residences. Much of report is speculative in nature, discussing hypotheses and possible mechanisms.
Results Walker 2012 Infrasound attributable to WTGs was detected above background at the residence closest to the nearest turbine. One of the investigators (R Rand) incurred symptoms during the survey and on this basis, suggested that nauseogenicity is a factor at Shirley. The other four investigators did not report any symptoms. Infrasound was measured at very low frequencies (0.7 Hz) but was inaudible. Schomer 2013 Most residents do not hear WTG sound and annoyance reportedly not present. Physical symptoms reported similar to motion sickness among some respondents (10%). **Conclusion** Walker 2012 concluded that analysis of measurements showed that only very low frequencies are detectable throughout the houses and that they are related to the blade passing frequency of the nearby wind turbines. Schomer 2013 concluded that respondents reporting symptoms of motion sickness (apparently without noise annoyance) also report susceptibility to motion sickness. Therefore, the authors concluded that sensitivity to motion sickness and sensitivity to WTG emissions are likely related among a small fraction of those exposed.				

Maschke 2007	**Design**	**Exposure**	**Outcome**	**Limitations**
Annoyance				
Aim Using data from the LARES survey, neighbour noise annoyance was surveyed as an adverse housing condition and its	Analysis of cross-sectional survey data from a WHO European housing and health survey (LARES Survey). LARES collected data in eight European cities to evaluate the effects of housing conditions on health.	Noise exposure not measured; 'noise annoyance' rather than actual noise was the independent variable of interest and this was collected by questionnaire. Neighbour noise was assessed by four items: neighbour flat noise; stairwell noise; children playing in	Housing and neighbourhood satisfaction were collected by questionnaire completed by one household member. Health data were collected by questionnaire from each household member. Self-reported medical diagnoses of hypertension, depression and	Cross-sectional design limits ability to determine causality. Reverse-causality is plausible. Dependent and independent variable data both self-reported. Over-reporting of health effects by noise-annoyed respondents would lead to over-estimation of risk

relation to reported medically diagnosed illnesses was evaluated.	The present paper reports analysis of self-reported annoyance from neighbour noise over the previous 12 months and self-report of 15 different health conditions over the previous 12 months.	building; noises within dwelling. Total score was categorised as no annoyance, moderate, severe.	migraine.	estimates. Reverse causality is also possible if poor health is associated with poorer noise tolerance and/or higher duration of exposure as a result of increased time at home. Unclear how health data were collected for children but likely by proxy which would be subject to proxy response bias, particularly problematic if the proxy respondents were also respondents in their own right, which seems likely.

Results

For adults, a dose-effect relationship was observed between annoyance induced by neighbours and self-reported hypertension ($p = 0.007$). The p-value following adjustment for risk factors was 0.018. Self-reported depression was greater with higher annoyance by neighbour noise, suggesting a dose response relationship ($p = 0.005$; $p = 0.041$ adjusted for socio-economic state, risk factors, general environment and housing factors). Self-reported migraine was also higher ($p = 0.001$; $p = 0.022$ adjusted for risk factors, general environment and housing factors). A significant increased risk of self-reported arthritis was recorded for elderly people who indicated moderate chronic annoyance by neighbour noise, but this trend was not significant for severe neighbour noise annoyance. Increased risk of reported bronchitis in children was associated with chronic noise annoyance ($p = 0.002$; $p = 0.004$ following adjustment for socio-economic state).

Conclusion

Authors concluded: “The results of the survey confirmed the thesis that neighbour noise effects health via long lasting severe annoyance. Neighbour noise induced annoyance is therefore a highly underestimated risk factor for healthy housing.” Authors recommended that chronic severe annoyance induced by neighbour noise be classified as a serious health risk for adults. Likewise, the authors recommended that children be classified as a risk group. Epidemiological confirmation is needed of neighbour noise affecting health via long lasting severe annoyance, for both cardiovascular and respiratory symptoms.

McCallum 2014	Design	Exposure	Outcome	Limitations
Electromagnetic Field (EMF)				
Aim To characterise EMF in the vicinity of an active wind farm in Ontario, to address the heightened anxiety by some around electromagnetic field, wind turbines and human health.	Environmental monitoring survey of EMF in vicinity of wind turbines.	EMF measured in the proximity of 15 vestas 1.8 MW wind turbines, two substations, both buried and overhead collector and transmission lines and nearby homes.	EMF measurements were collected under three operational scenarios to characterise potential EMF exposure. Operational scenarios were high wind (generating power), low wind (drawing power from the grid but not generating power) and shut off (not generating power).	Static monitoring rather than personal monitoring may not reflect actual personal exposure.

Results

Limited levels of EMF measured around the wind farm suggested that human exposure to EMF from wind turbines is insignificant in comparison to common household exposures.

Location of exposure	mG
Background levels of EMF (shut off scenario)	0.2 mG to 0.3 mG
*Base of turbines (at high wind and low wind)	mean = 0.9 mG; n = 11
Buried collector lines (1 m above)	≤ 0.3 mG
Beneath overhead transmission lines	16.5 mG and 46 mG
**Nearby homes (outside – 500 m away)	≤ 0.4mG

* all diminished with distance ** sources did not appear to influence level

EMF exposure was not unique to the wind farm, exposure was lower than common electrical devices (common household items) and was below human health regulatory guidelines.

Conclusion

Authors concluded "The results suggest that there is nothing unique to wind farms with respect to EMF exposure. Magnetic field levels in the vicinity of wind turbines were lower than those produced by many common household electrical devices and well below any existing regulatory guidelines with respect to human health".

Mechanistic Evidence

Chapman 2013	Design	Exposure	Outcome	Limitations
Mechanistic Evidence				
Aim To test four hypotheses relevant to psychogenic explanations of the variable timing and distribution of health and noise complaints about wind farms (WF) in Australia.	Historical audit. Information on the commencement of turbine operation, number of turbines operating, average turbine size and the megawatt (MW) capacity of each wind farm was located from public sources, such as wind farm websites. Information about complainants, including date first complaint occurred, adverse effects on health and sleep or annoyance of turbine sound among residents in the vicinity of operating wind farms, and occurrence of anti-WF activity in the local area were requested from the wind farm owners. Additional information was collected from: 1. Submissions made to three government enquiries on wind farms. 2. Daily media monitoring records supplied to the Clean Energy Council by a commercial monitoring company from August 2011 to January 2013. 3. Personal correspondence to the	Companies provided estimates of the number of residents currently living within 5 km of each wind farm – either estimates of the number of individuals or the number of houses.	Proportion of WFs with complaints. Proportion of residents in vicinity of operating WFs who complained. Proportion of WFs with a history of complaints consistent with claims that turbines cause acute effects. Date/Period of first complaints.	Population estimates included children, who would be unlikely to complain to a regulatory body regarding wind farms. The primary source of information on complaints was from the WF operators. Estimates of resident numbers relied in some cases on estimates made using Google Earth images and so precise numbers of residents living within the 5 km boundary were not available.

	authors about complainants who had complained via a legal case.			

Results

1. Hypothesis 1 – Many WFs would have no history of complaints: 33 of 51 WFs (18/34 of larger wind farms and 15/17 of small farms), with an estimated 21,633 residents living within 5 km of turbines, and had operated for a cumulative total of 267 years, had never been subject to health or noise complaints. Small total capacity farms were less likely to have complainants (88% vs 53%, $\chi^2 = 6.18$, 1df, $p = 0.013$). 18 WFs (35.3%) received at least one complaint since operation started, 16 of which were larger WF (≥ 10 MW). Distribution of WFs which have ever received complaints is highly variable across Australia (there have been no complaints in TAS or WA).

2. Hypothesis 2 – There would be a small proportion of complaining residents: 129 out of 32,789 individuals residing within 5 km of WFs complained about noise or health effects. 94 (of 129) were from residents living near 6 WFs. 124 (of 129) represented 1 in 100 of the surrounding 12,366 residents living near large WFs (> 1 MW).

3. Hypothesis 3 – Few WFs would have any history of complaints consistent with claims that turbines cause acute effects: six WFs saw complaints commence at times ranging from two months to 13.5 years after turbine operation. 12 WFs had either on-going complaints continue from before the WFs commenced operation or within the first month.

4. Hypothesis 4 – Most complaints would date from 2009 or later, when anti-WF groups began to publicise alleged health effects. 69% of WFs began operating prior to 2009, 90% of complaints were received after this date. 15 of 18 WFs (83%) that have seen complainants have experienced local opposition from anti-WF groups.

Conclusion

Authors concluded "the historical and geographical variations in complaints are consistent with psychogenic hypotheses that expressed health problems are communicated diseases with nocebo effects likely to play an important role in the aetiology of complaints".

Crichton 2014	Design	Exposure	Outcome	Limitations
Mechanistic Evidence				
Aim To test the following hypotheses: (a) that high-expectancy would be associated with increased symptom reporting (number and intensity), (b) that high expectancy participants would be more likely to report	A sham controlled double blind provocation study in which 54 university students (34 female, 20 male) were randomly assigned to groups of high expectancy and low expectancy that infrasound causes specific symptoms.	Participants from each group were shown the relevant expectancy video – high expectancy video (of symptomatic experiences due to wind farm) or low expectancy video (of scientific position on lack of symptoms from infrasound) and then exposed in a standards-compliant listening room to ten minutes of infrasound and ten minutes of sham infrasound (no sound) in a counterbalanced design. Participants were told	Subjects were asked about health effects of wind turbine sound at baseline and after video viewing. Self-reported physical symptoms, 12 specified to be typical of infrasound and 12 less typical, were elicited before and during each ten-minute exposure session. A total symptom score was calculated for each rating period. Blood pressure and heart rate were monitored.	Minimal information on the spectrum and amplitude of the auditory stimulus. Small sample drawn from university student population which is not representative of the general population. Unclear whether blood pressure and heart rate were monitored pre-exposure to determine whether there was variation between the randomly assigned

symptoms described as typical of infrasound exposure and (c) that there would be no effect of actual infrasound exposure on reported symptoms.		both sessions were infrasound and experimenter was blinded to the order of exposure. Sound transmitted during exposure sessions 40 dB at 5 Hz (no other information given).		groups. Comparatively low level of exposure to infrasound given some levels measured in residence close to wind farms – e.g. 60 dB or higher.

Results

When given information about the expected physiological effect of infrasound reported symptoms, participants' self-reported symptoms aligned with that information, during exposure to both infrasound and sham infrasound.

Number and intensity of symptoms in the high intensity group increased from the baseline level during both real and sham infrasound whereas there was little or no increase in either during exposure, whether real or sham, in the low expectancy group. A mixed model ANCOVA found a significant main effect of expectancy group on both symptom change ($p < 0.01$) and symptom intensity ($p < 0.01$). The high expectancy group expressed greater concern regarding the health effects of sound generated by wind turbines than the low expectancy group $p < 0.001$. Heart rate and blood pressure did not change materially during exposure to infrasound in either expectancy group ($p = 0.09$ to $p = 0.9$).

Conclusion

Authors concluded that "Results suggest psychological expectations could explain the link between wind turbine exposure and health complaints".

Crichton 2013	Design	Exposure	Outcome	Limitations
Mechanistic Evidence				
Aim To investigate whether positive expectations about infrasound can produce a reduction in reported symptoms and health in response to exposure to wind farm noise.	An experimental study in which 60 undergraduate students (39 female, 21 male) were randomly assigned to positive or negative expectation groups.	Participants from each group were shown TV footage of either negative health effects associated with infrasound produced by wind turbines or therapeutic effects associated with infrasound. Participants from each group were then exposed to audible wind farm sound (43 dB) and infrasound (9 Hz, 50.4 dB) and audible wind farm sound (43 dB) for two seven-minute listening sessions.	Participants' symptoms and mood were assessed using a seven-point Likert scale. This questionnaire was filled in at baseline and during each exposure period.	Self-reported outcomes. Small sample drawn from university student population which is not representative of the general population.

Results

During exposure to audible wind farm sound and infrasound, self-reported symptoms and mood were strongly influenced by the type of expectations. Negative expectation participants experienced a significant increase in symptoms and a significant deterioration in mood, while positive expectation participants reported a significant decrease in symptoms and significant improvement in mood.

Evaluation of perceived health impacts of infrasound exposure showed 90% of the positive expectation group reported an improvement in physical symptoms after the listening sessions had concluded compared to 10% of the negative group ($p < 0.001$). Consistently, 77% of the negative expectation group reported a worsening of symptoms during exposure, compared to 10% of the positive group ($p < 0.001$).

Conclusion

Authors concluded "that expectations can influence symptom and mood reports in both positive and negative directions. The results suggest that if expectations about infrasound are framed in more neutral or benign ways, then it is likely reports of symptoms or negative effects could be nullified".

Kelley 1987	**Design**	**Exposure**	**Outcome**	**Limitations**
Mechanistic Evidence				
Aim To identify metrics or descriptors for low frequency community annoyance for wind turbine noise applications.	Experimental study. Seven volunteer evaluators took part in the experiment. The group consisted of three women and four men aged from early twenties to early sixties.	Low frequency noise (LFN) generated by sub-woofer speaker in room next to a second room used as a listening room by the evaluators.	Comparison of noise annoyance ratings for six different metrics for low frequency noise. Annoyance results for the following: • A-weighted noise level • C-weighted noise level • G_1 (Less than 20 Hz) • G_2 (Less than 20 Hz) • LSL which reflects three LFN influences • LSPL which is similar to LSL	Small study with only seven participants. Participant selection not described and representativeness unclear. Generalisability to general population may be limited. Final recommendation involves complicated procedure for community annoyance evaluation.

Results

Establishment of an interior noise annoyance scale. This was achieved by using the annoyance of the evaluators and described in Table 4. Table 4 results indicate that LSL and C metrics were ranked equal highest as efficiency metrics, with LSPL and G_1 equal second, G_2 third and A-weighted ranked 4^{th}.

Table 5. INTERIOR LF ANNOYANCE-LEVEL CRITERIA EMPLOYING THE LSL AND C METRICS

	Threshold Annoyance		Unacceptable Perception Threshold		Annoyance Stimuli	
	LSL	C	LSL	C	LSL	C
Class	(dB)		(dB)		(dB)	
Nonimpulsive, periodic random	58	68	65	75	68	77
Periodic impulsive source	53	63	57	67	60	68
Random periodic source	59	67	68	76	70	78

Conclusion

The authors describe a methodology for describing worst-case low frequency wind turbine noise based on the LSL and C metrics. The derived levels can then be compared with Table 5 (above) to assess the interior annoyance potential.

Ruotolo 2012	Design	Exposure	Outcome	Limitations
Mechanistic Evidence				
Aim To assess impact of a wind farm on individuals by means of a virtual audio-visual methodology to stimulate biologically plausible individual-environment interactions. To	Laboratory trial (unblinded). 93 university students aged 19-34 years (51 females). There were no control subjects.	Subjects were exposed to recorded noise and/or video representing a wind farm at 20 m, 100 m, 250 m and 600 m. Noise was recorded at an Italian wind farm. Visual stimuli were reproduced using a 3D graphic tool to represent WTGs at these distances and a control condition representing the same landscape without WTGs. There were three	While exposed to noise and/or video conditions, subjects performed tasks assessing verbal fluency, short-term verbal memory, counting backwards and distance estimations (egocentric and allocentric). After exposure, participants were asked to report their degree of visual and noise annoyance using standard assessment methods	Subjects recruited from university student population, not representative of general population. Few details about subject characteristics reported. Plausible confounders such as socio-economic status or health status were not controlled. Given that experimental subjects were university students, generalisability to people living

disentangle the effects of auditory and visual components on cognitive performances and subjective evaluations, unimodal (audio or visual) and bimodal (audio-visual) conditions were compared).		experimental conditions: (1) audio + video, (2) audio only, (3) video only.	(ISO/TS15666).	near wind farms is questionable. Generalisability to Australian context is also questionable. Noise levels (dBA) and power output of WTGs in question were not provided so comparisons with other studies are problematic. Generalisability of annoyance resulting from brief exposure in a laboratory context is unlikely to be generalisable to annoyance which may result from long-term residential exposure.

Results

Results indicated that proximity to wind farm noise was associated with poorer performance in executive control (backwards counting) and semantic memory (verbal fluency) tasks, consistent with previous similar research on different types of environmental noise (e.g. commuter train noise). The performance in executive control improved as distance from the WF increased ($p = 0.009$). Semantic memory was influenced by distance from the WF ($p < 0.001$) as well as distance and noise sensitivity ($p < 0.001$). Short-term verbal memory was not influenced by the exposures. Presence of a visual representation of a wind farm may have a negative effect on performance of certain cognitive tasks but a mitigating effect on perceived noise annoyance.

Conclusion

Authors concluded that the mitigating effect of visual cues on perception of annoyance underscores the importance of complex modelling when undertaking environmental impact assessments in order to simulate as closely as possible the multisensory human-environment interaction, for which Immersive Virtual Reality may be a useful tool.

Taylor 2013b	Design	Exposure	Outcome	Limitations
Mechanistic Evidence				
Aim To present the findings of a study of measured noise from small wind installations and the effect of individual	A cross-sectional environmental noise and opinion survey of residents living near micro and small wind turbine installations. 138 residents (age ranging from 20-95; 74 male, 62 female; two unknown) living within 500 m	A computer model together with L_{Aeq} noise measurements, were used to generate sound maps in the vicinity of 12 micro (0.6 kW) and small (5 kW) wind turbine installations. Measures of frequency spectra and indication	Participants were asked about perceived noise intrusion, attitudes towards wind power, mood, general health, personality traits and demographic details via the postal questionnaire.	Postal survey, potential selection bias (analysis by occupational groups showed no significant differences between occupational groups). Authors reported that demographic characteristics of participants were checked and

personality traits on noise perception.	of one of 12 micro or small wind turbines participated in the study via postal questionnaire. 1327 households were contacted (response rate of 10.86%).	of key frequencies were documented.		found to be representative of the relevant wider populations, however the results were not described. The study is open to retrospective and recall biases. Cross-sectional study, limited ability to determine causality.

Results

The survey showed that the most commonly perceived noises are 'swooshing' and 'humming', the presence of which may be inferred from the measured frequency spectra.

Negative attitude to wind turbines was associated with increased perception of noise ($p = 0.001$) from nearby turbines and perception of more noise was associated with increased levels of general symptoms reported ($p = 0.014$). It could not be determined if noise perception causes negative attitude or if negative attitude enhances noise perception. Respondents who could see a turbine from their dwelling did not have a significantly more negative attitude to wind turbines ($p = 0.993$). Individuals' personalities influenced attitudes towards wind turbines, noise perception and symptom reporting.

At one of the installations, sound levels were higher at all frequencies when the turbines were switched on. There was a peak in the turbine spectrum at around 160-500 Hz, which was higher than the blade pass frequency mechanism. Therefore, the authors concluded that the peak was due to mechanical noise at the turbine hub as a result of electromechanical equipment. At the highest frequencies, a large difference was observed between the two sets of data with the turbines increasing the LAeq by almost 20 dB(A) at 10 kHz (reference sound pressure value 2×10^{-5} Pa for all values).

Conclusion

Authors concluded "it has been found that an individual's level of positive and negative affectivity best explain the variance in attitude to wind turbines and noise perception. It has also been demonstrated that attitude to wind turbines has a significant effect on noise perception and that noise perception has a significant effect on symptom reporting."

Parallel Evidence

Chao 2012	Design	Exposure	Outcome	Limitations
Parallel Evidence				
Aim To clarify health effects in maintenance	Cross-sectional study. 213 Taiwanese aerospace maintenance workers divided into three groups according to	Each group exposed to different noise exposure. LFN (n = 64) or General Noise (GN) (n = 89) or no Noise (control group) (n = 60).	Evaluation of working environment: determination of source noise. Noise exposure of LFN group was	Noise measurements in the work-areas are poor, only spot measurements and not noise dosimetry. The audiometry is

workers exposed to low frequency and/or general noises. To understand the relationship between the variations of workers' echocardiographic E/A ratio and LFN.	occupational noise exposure.	Noise exposure was assessed by spot measurements in the workplace.	98 dB(A) compared to the GN group of 92 dB(A). In the low frequency range (20-500 Hz) the LFN group were exposed to 96 dB(Lin) compared to less than 80 dB(Lin) for the GN group. Biological monitoring: hearing evaluation; electrocardiographic E/A ratio.	questionable since the authors only reported a "background" level in the room that was "lower than 40 dB(A)". Correct background measurements for audiometry require different maximum backgrounds for specific frequencies. Selection of workers was not described. Classification of workers to exposure categories was not fully described. Potential confounders were not evaluated. Authors identify as a limitation that there is "room for improvement between the normality and pseudo normalisation LV filling of the E/A ratio echocardiography parameter."

Results

The abnormality rate of the echocardiography parameter E/A ratio within the LFN group was greater than both the GN and control group members. The abnormality of E/A ratio between the latter two groups did not show any difference.

Severe dysfunction cases (E/A ratio > 3) only occurred in LFN group members. The hearing loss caused by LFN exposure was more severe at higher frequencies, 4 kHz and 6 kHz and the loss of hearing could reach above 40 dB.

Authors reported: "…for the LFN group, the averaged value of the E/A ratio echocardiography parameter was found to be greater than 1.5 (which is the standard for grade of the JACC classification). The abnormality rate of the E/A ratio (E/A > 2) was found to be close to 31% in LFN group members, which was much higher than that of the GN and control groups. …[H]earing loss for the LFN and GN groups became serious at higher frequencies, especially at 4k [Hz] and 6k [Hz] where the hearing loss of the LFN group reached 40 dB, and was 10 dB higher than that of GN group. …[T]here was a 20 dB higher hearing loss in the LFN group when compared with the control group."

Conclusion

Authors concluded "Low frequency noise has a tremendous effect on human health both psychologically and physically."

Persson Waye 1997	Design	Exposure	Outcome	Limitations
Parallel Evidence				
Aim To assess evaluating effects of LFN on performance. Of special interest was to study objective and subjective effects on performance involving cognitive aspects over time.	Laboratory pilot study of 14 students with self-reported sensation of eardrum pressure after exposure to a LFN.	The study involved two exposure conditions: (1) predominantly mid frequency character (mid frequency noise) and (2) predominantly low frequency character (LFN). Participants performed three computerised cognitive tests in the mid frequency or LFN condition alternatively. The first two cognitive tests were performed together with a secondary task (intended to create an interactive environment which led to a competition of cognitive resources).	Questionnaires were used to evaluate subjective symptoms, effects on mood and estimated interference with test results due to temperature, light and noise. Mood was measured pre-test and post-test. Post-test questionnaire was on subjective symptoms that had earlier been found to be associated with LFN (e.g. headache, pressure, fatigue) and symptoms were not previously found to be associated with LFN (e.g. eye irritation).	Only subjective effects were investigated. Small sample drawn from university student population which is not representative of the general population. Volunteers were pre-screened and included or excluded from the testing based on self-reported sensation of eardrum pressure following exposure to LFN, further limiting the representativeness of the study to the general population. Analyses had very low power, and subsequently non-significant effects and trends were reported.

Results

Subjects reported greater interference of task performance for LFN than mid frequency noise ($p < 0.05$). Exposure to LFN resulted in lower 'social orientation' ($p < 0.05$) (i.e. less agreeable, less co-operative) and tendency to lower 'pleasantness' ($p = 0.07$) (more bothered, less content), compared to the mid-frequency noise. Response times during the last part of the test were longer in the LFN exposure condition. The difference in annoyance between the LFN and the mid-frequency noise was not statistically significant ($p = 0.19$).

Conclusion

Authors concluded "that the LFN was estimated to interfere more strongly with performance. The results also gave some indication that cognitive demands were less well coped with under the LFN condition. This effect was especially pronounced in the last parts of the test, which indicates that the effects appear over time. The relation between the reduced activity and response time, which was especially pronounced in the low frequency noise condition, may also indicate that increased fatigue was of importance for the results."

Persson Waye 2001	Design	Exposure	Outcome	Limitations
Parallel Evidence				
Aim: To study the possible interference of LFN on performance and annoyance.	Experimental study testing the impact of LFN exposure (ventilation noises) on cognitive performance and self-reported annoyance. 32 young adults (male = 13, female = 19, mean age = 23 years, SD = 2.6 years) with high or low sensitivity to noise in general or specifically to LFN took part in the study. Participants' sensitivity to noise in general and specifically LFN assessed by questionnaire. Participants underwent a hearing test, and only those with normal hearing (< 20 dB HL) included. Participants took part in two test sessions, on separate days.	This study involved exposure to two ventilation noise conditions: • predominantly low frequency content noise (in the frequency of 31.5 Hz to 125 Hz generated using a digital sound processor system, with the third octave band centred at 31.5 Hz and amplitude-modulated at a frequency of 2 Hz). • flat frequency content noise (control, recorded noise from a ventilation installation) Both conditions had a sound pressure level of 40 dBA.	Change in performance of various tasks designed to involve different levels of mental processing: Task I – simple reaction-time task Task II – short-term memory task Task III – proof-reading task Task IV – computerised verbal grammatical reasoning task Participants' self-reported reactions were also collected by questionnaire. Saliva samples taken to assess stress and cortisol levels were measured. Questionnaire measuring perceived stress and energy.	Small sample size (n = 32), particularly when sub-divided into groups by sensitivity to general and LFN. "Noise sensitivity" was not clearly defined and evaluated by questionnaire with no other information provided. Participants were young with normal hearing, were recruited by public advertising and were paid. Possible recruitment bias but detailed demographics of subjects were not provided. Participants' literacy and numeracy was not reported.

Results

Exposure to LFN condition resulted in poorer performance on some aspects of cognitive tasks and LFN appeared to impair working capacity more than reference noise. LFN was associated with reduced number of errors identified per line read in a proof-reading task and reduced improvement over time during the verbal grammatical reasoning task. Subjects rated LFN more annoying than reference noise and also considered LFN impaired working capacity more than reference noise. No associations were found between noise and other symptoms. Subjects reported a higher degree of annoyance and impaired working capacity when working exposed to LFN. Impaired working capacity and annoyance due to LFN were significantly correlated to subjective outcomes, such as a feeling of pressure on the head, tiredness, and lack of concentration. Three-way interaction in response time between noise, phase and LFN sensitivity ($p < 0.05$).

- subjects with high-sensitivity to LFN decreased their response time considerably during reference noise, but only slightly during LFN (reverse observed for subjects low-sensitive to LFN).

- subjects with high-sensitivity to noise in general decreased their response time during LFN, but only slightly during reference noise (subjects low-sensitive only decreased their response time during reference noise).

Effects were more pronounced among subjects classified as sensitive to low-frequency noise and to noise in general. Noise-sensitive subjects reported more annoyance and impaired working capacity, particularly low-frequency sensitive individuals.

- tendency to a two-way interaction in reaction-time between noise and sensitivity to noise in general ($p = 0.051$); subjects with high-sensitivity to noise in general had a somewhat longer reaction-time during the LFN condition compared to the reference noise condition, whereas low-sensitivity subjects had similar reaction times during both noise conditions. **Conclusion** Authors concluded "…the quality of work performance and perceived annoyance may be influenced by the continuous exposure to LFN at commonly occurring noise levels."

Smith 2013	Design	Exposure	Outcome	Limitations
Parallel Evidence				
Aim To ascertain the increasing vibration amplitude, associated with passing railway trains, on sleep disturbance.	Laboratory study of 12 participants to investigate the impact of increasing vibration amplitudes (horizontal vibrations) simulating passing freight trains on individuals sleep disturbance (sleep parameters) and heart rates (cardiovascular response).	Participants slept for six consecutive nights in a laboratory. Beginning with one night of habituation, followed by one night of controlled sleep followed by four nights of randomised order exposure. Exposure nights considered of 36 pass by train simulations, varying vibration level (noise only, low (W_d Weighted maximum acceleration 0.0058 m/sec^2), moderate (0.0102 m/sec^2), high (0.0204 m/sec^2)) between nights.	Questionnaires measured subjective sleep indicators (including tiredness and stress) completed at both morning and evening. Sleeping parameters were obtained through use of polysomnography (PSG). Heart rate activity was recorded during the night period through use of a single ECG. Breathing measurements were also obtained. An EEG was used to establish artefacts and wake stages to be excluded from the heart rate analysis, due to prior unforeseen technical limitations due to unsuitability for task.	Laboratory environment may not accurately replicate real-world exposures. Small study group (n = 12) and young age (20-29 years) limits generalisability. Unable to draw a conclusion regarding the impacts of the individual train's characteristics, including rise time and event duration.
Results Quality of sleep was seen to decrease significantly with the increased level of vibration ($p = 0.033$, $F(3,7) = 6.1$), participants felt increasingly disturbed by the vibrations with increasing amplitudes ($p = 0.002$, $F(3,8) = 16.2$). Levels of stress were increased the evening after a night of increased vibration (previous night) ($p = 0.048$). Specific sleep parameters showed clear influence of the applied vibration and this effect was significant in subscales of poor sleep, difficultly falling asleep and tiredness in the				

morning (each $p < 0.05$). In contrast participants' rating of being disturbed by noise did not change significantly with increasing vibration amplitude ($p = 0.626$). An overall heart rate increase was observed during an increased amplitude of vibration ($p = 0.054$, $F(3,4) = 7.3$). With increasing vibration, a decrease in latency was found and an increase in amplitude of heart rate, as well as a reduction in sleep quality and sleep disturbance, was observed. **Conclusion** Authors concluded that "individuals are able to differentiate between train induced vibration and train induced noise during the night and that train induced vibration and LFN has a negative effect on their self-reported sleep quality, causes subjective sleep disturbance and is accompanied by heart rate increase. The effects increase with greater vibration amplitude. The results suggest that individuals living near to railway lines and thus subjected to the accompanying noise and vibration exposure are at risk for having their sleep impaired. This may lead to reduced concentration and daytime functioning in the short term and impaired health in long term."

Witthoft 2013	Design	Exposure	Outcome	Limitations
Parallel Evidence				
Aim To test whether exposure to a media report promoting a link between Wi-Fi and symptoms would influence symptom attribution during sham Wi-Fi exposure.	'Between-groups' experiment. 147 university students randomly assigned to experimental (watch a television report about the adverse health effects of Wi-Fi, n = 76) or control groups (report of the same length but relating to the security of mobile phone data transmission, n = 71). Positively skewed symptom reports and questionnaire data were log-transformed where necessary; effects of television report on concerns about EMF tested using linear regression analysis; t-tests to test the difference in symptom scores before and after sham exposure.	Exposure to either a television report (genuine report aired on UK television) about the adverse health effects of Wi-Fi or a control film. Subsequently exposed to a 'sham' Wi-Fi signal (15 minutes). Exposure equipment (antenna mounted on a headband, seemingly connected to a Wi-Fi router and laptop) was attached to the participant's head.	Symptoms were assessed with a modified state version of the checklist for symptoms in daily life (CSD) following the sham exposure. Secondary outcomes measures included worries regarding the health effects of EMF, attributing symptoms to the sham exposure and increases such as perceived sensitivity to EMF. Perceived EMF sensitivity was evaluated using EMF version of the Sensitive Soma Assessment Scale (SSAS). Worries about the health effects of EMF measured using Modern Health Worries Scale (MHW-R). State of anxiety was assessed using State Trait Anxiety Inventory (STAI-6), somatisation was	Did not use a 'no exposure' control condition and therefore cannot definitively rule out the nocebo effect, however authors argue that nocebo is unlikely given the magnitude of the effects found and the consistency with *a priori* expectations. Symptoms reports were influenced by the demand characteristics of the study rather than the actual symptom experience. There was a lack of baseline measurement resulting in a lack of ability to relate inference between film and symptom report. Sample drawn from university student population which is not representative of the general population.

			assessed using Patient Health Questionnaire (PHQ-15) and somatosensory amplification was assessed using Somatosensory Amplification Scale (SSA).	Participants were paid for their involvement in the study. Study did not systematically assess the current and previous medical and psychiatric conditions of participants, therefore cannot rule out the possibility that these factors might have influenced results.

Results

82 of the 147 participants (56%) reported symptoms which were attributed to the sham exposure. The film shown to the experimental group found: EMF related worries (B = 0.19; P = 0.019)* were strongest in people with high levels of anxiety state; post sham exposure symptoms were found among participants with high pre-existing anxiety (B = 0.22; P = 0.008)*; the likelihood of symptoms being attributed to the sham exposure among people with high anxiety (B = 0.31; P = 0.001)*; and the likelihood of people who attributed their symptoms to the sham exposure believing themselves to be sensitive to EMF (B = 0.16; P = 0.049)*

*B = Beta

Conclusion

Authors concluded that "Media reports about the adverse effects of supposedly hazardous substances can increase the likelihood of experiencing symptoms following sham exposure and developing apparent sensitivity to it."

References

Included studies – Direct Evidence

Janssen 2011	Janssen S, Vos H, Eisses A, Pedersen E. A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources. *Journal of the Acoustical Society of America*. *2011*;130(6):3746.
Kuwano 2013	Kuwano S, Yano H, Kageyama T. Social survey on community response to wind turbine noise in Japan. *42nd International Congress and Exposition on Noise Control Engineering*; 15-18 September 2013; Innsbruck, Austria; 2013.
	Yano T, Kuwano S, Kageyama T, Sueoka S, Tachibana H. Dose-response relationships for wind turbine noise in Japan. *42nd International Congress and Exposition on Noise Control Engineering*; 15-18 September 2013; Innsbruck, Austria; 2013.
McBride 2013	McBride D, Shepherd D, Welch D. A longitudinal study of the impact of wind turbine proximity on health related quality of life. *42nd International Congress and Exposition on Noise Control Engineering*; 15-18 September 2013; Innsbruck, Austria; 2013.
Mroczek 2012	Mroczek B, Kurpas D, Karakiewicz B. Influence of distances between places of residence and wind farms on the quality of life in nearby areas. *Annals of Agricultural and Environmental Medicine: AAEM*. 2012;19(4):692-6.
Paller 2014	Paller C. Exploring the association between proximity to industrial wind turbines and self-reported health outcomes in Ontario, Canada: University of Waterloo; 2014.
Pohl 2012	Pohl J, Hubner G, Mohs A. Acceptance and stress effects of aircraft obstruction markings of wind turbines. *Energy Policy*. 2012;50:592-600.
Taylor 2013a	Taylor J, Eastwick C, Wilson R, Lawrence C. The influence of negative oriented personality traits on the effects of wind turbine noise. *Personality and Individual Differences*. 2013;54(3):338-43.

Included studies – Background, Mechanistic and Parallel Evidence

Bockstael 2012	Bockstael A, Dekoninck L, Can A, Oldoni D, De Coensel B, Botteldooren D. Reduction of wind turbine noise annoyance: an operational approach. *Acta Acustica united with Acustica*. 2012;98(3):392-401.
Brinckerhoff 2011	Brinckerhoff P. Update of UK Shadow Flicker Evidence Base. Department of Energy and Climate Change, 2011.
Chao 2012	Chao PC, Yeh CY, Juang YJ, Hu CY, Chen CJ. Effect of low frequency noise on the echocardiographic parameter E/A ratio. *Noise Health*. 2012;14(59):155-8.
Chapman 2013	Chapman S, St George A, Waller K, Cakic V. The pattern of complaints about Australian wind farms does not match the establishment and distribution of turbines: support for the psychogenic, 'communicated disease' hypothesis. *PloS One*. 2013;8(10):e76584.

Crichton 2013	Crichton F, Dodd G, Schmid G, Gamble G, Cundy T, Petrie KJ. The power of positive and negative expectations to influence reported symptoms and mood during exposure to wind farm sound. *Health Psychology*. 2013;DOI: 10.1037/hea0000037.
Crichton 2014	Crichton F, Dodd G, Schmid G, Gamble G, Petrie KJ. Can expectations produce symptoms from infrasound associated with wind turbines? *Health Psychology*. 2014;33(4):360-4.
Doolan 2013	Doolan C, Moreau D. An on-demand simultaneous annoyance and indoor noise recording technique. *Acoustics Australia*. 2013;41(2):141-5.
	Zajamsek B, Doolan CJ, Moreau DJ, Hansen K. Simultaneous indoor low-frequency noise, annoyance and direction of arrival monitoring. *5th International Conference on Wind Turbine Noise*; 28-30 August 2013; Denver. [Zajamsek 2013a]
	Zajamsek B, Moreau D, Doolan C, Hansen K. Indoor infrasound and low-frequency noise monitoring in a rural environment. *Acoustics*; 17-20 November 2013; Victor Harbor, SA. [Zajamsek 2013b]
	Zajamsek B, Moreau DJ , Doolan CJ. Characterising noise and annoyance in homes near a wind farm. *Acoustics Australia*. 2014;42(1):14-9. [Zajamsek 2014]
EPA SA 2013	Environment Protection Authority SA. Waterloo Wind Farm environmental noise study, 2013.
Evans 2013	Evans T [Resonate Acoustics]. Macarthur Wind Farm, Infrasound & Low Frequency Noise, Operational Monitoring Results. Prepared for AGL Energy Limited, 2013.
Kelley 1987	Kelley N. A proposed metric for assessing the potential of community annoyance from wind turbine low-frequency noise emissions. *Windpower '87 Conference and Exposition*; 5-8 October 1987; San Francisco.
Maschke 2007	Maschke C, Niemann A. Health effects of annoyance induced by neighbour noise. *Noise Control Engineering Journal*. 2007;55:348–56.
McCallum 2014	McCallum LC, Whitfield Aslund ML, Knopper LD, Ferguson GM, Ollson CA. Measuring electromagnetic fields (EMF) around wind turbines in Canada: is there a human health concern? *Environmental Health: a global access science source*. 2014;13(1):9.
Møller 2011	Møller H, Pedersen C. Low-frequency noise from large wind turbines. *Journal of the Acoustical Society of America*. 2011;129(6):3727–44.
Persson Waye 1997	Persson Waye K, Rylander R, Benton S, Leventhall HG. Effects on performance and work quality due to low frequency ventilation noise. *Journal of Sound Vibration*. 1997;205(4):467-74.
Persson Waye 2001	Persson Waye K, Bengtsson J, Kjellberg A, Benton S. Low frequency noise "pollution" interferes with performance. *Noise Health*. 2001;4(13):33-49.
Qibai 2004	Qibai C, Shi H. Technical contribution: An investigation on the physiological and psychological effects of infrasound on persons. *Low Frequency Noise, Vibration and Active Control*. 2004;23(1):71–6.
Ruotolo 2012	Ruotolo F, Senese VP, Ruggiero G, Maffei L, Masullo M, Iachini T. Individual reactions to a multisensory immersive virtual environment: The impact of a wind farm on individuals. *Cognitive Processing*. 2012;13(Suppl 1):S319-S23.

Schiff 2013	Schiff MT, Magari SR, Smith CE, Rohr AC. Field evaluation of wind turbine-related noise in western New York State. *Noise Control Engineering Journal*. 2013;61(5):509-19.
Smith 2013	Smith MG, Croy I, Ogren M, Persson Waye K. On the influence of freight trains on humans: a laboratory investigation of the impact of nocturnal low frequency vibration and noise on sleep and heart rate. *PloS One*. 2013;8(2):e55829.
Styles 2005	Styles P, Simpson I, Toon S, England R, Wright M. Microseismic and infrasound monitoring of low frequency noise and vibrations from wind farms – Recommendations on the siting of wind farms in the vicinity of Eskdalemuir, Scotland. Applied and Environmental Geophysics Research Group, Earth Sciences and Geography, School of Physical and Geographical Sciences, Keele University, Staffordshire, UK, 2005.
Taylor 2013b	Taylor J, Eastwick C, Lawrence C, Wilson R. Noise levels and noise perception from small and micro wind turbines. *Renewable Energy*. 2013;55:120-27.
Tickell 2012	Tickell C. Low frequency, infrasound and amplitude modulation noise from wind turbines: some recent findings. *Acoustics Australia*. 2012;40(1):64-6.
Turnbull 2012	Turnbull C, Turner J, Walsh D. Measurement and level of infrasound from wind farms and other sources. *Acoustics Australia*. 2012;40(1):45.
van Renterghem 2013	Van Renterghem T, Bockstael A, De Weirt V, Botteldooren D. Annoyance, detection and recognition of wind turbine noise. *The Science of the Total Environment*. 2013;456-457:333-45.
Walker 2012	Walker B, Hessler G, Hessler D, Rand R, Schomer P. Cooperative measurement survey and analysis of low-frequency and infrasound at the Shirley Wind Farm. Wisconsin Public Service Commission, 2012.
	Schomer P, Erdreich J, Boyle J, Pamidighantam P. A proposed theory to explain some adverse physiological effects of the infrasonic emissions at some wind farm sites. *5th International Conference on Wind Turbine Noise*; 28-30 August 2013; Denver.
Witthoft 2013	Witthoft M, Rubin GJ. Are media warnings about the adverse health effects of modern life self-fulfilling? An experimental study on idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF). *Journal of Psychosomatic Research*. 2013;74(3):206-12.

Additional references

Miyazaki 2011	Miyazaki T, Kono K, Inoue Y, Nakao T, Kato H, Matsuzaki H, Sakino H, Shiraishi H. Noise characteristics generated form wind turbine generators. *Proceedings of Inter-Noise 2011*; 4-7 September 2011; Osaka, Japan.
Shepherd 2011	Shepherd D, McBride D, Welch D, Dirks KN, Hill EM. Evaluating the impact of wind turbine noise on health-related quality of life. *Noise Health*. 2011;13(54):333-9.
Whitfield Aslund 2013	Whitfield Aslund ML, Ollson CA, Knopper LD. Projected contributions of future wind farm development to community noise and annoyance levels in Ontario, Canada. *Energy Policy*. 2013;62:44-50.

Appendix 1 – Systematic Review Questions

SRQ1. Distance

Is there any reliable evidence of an association between distance from wind turbines and adverse health effects? If so:

a. How strong is this association?

b. How does the strength of this association relate to distance from wind turbines?

c. Might this association be explained by: (i) chance, (ii) bias, or (iii) confounding?

SRQ2. Audible noise

Is there any reliable evidence of an association between audible noise (greater than 20 Hz) from wind turbines and adverse health effects? If so:

a. How strong is this association?

b. How does the strength of this association relate to level of exposure to audible noise from wind turbines?

c. Might this association be explained by: (i) chance, (ii) bias, or (iii) confounding?

SRQ3. Infrasound and low-frequency noise

Is there any reliable evidence of an association between infrasound and low frequency noise (less than 20 Hz) from wind turbines and adverse health effects? If so:

a. How strong is this association?

b. How does the strength of this association relate to level of exposure to infrasound/inaudible noise from wind turbines?

c. Might this association be explained by: (i) chance, (ii) bias, or (iii) confounding?

SRQ4. Shadow flicker

Is there any reliable evidence of an association between shadow flicker (photosensitivity greater than 3 Hz) from wind turbines and adverse health effects? If so:

a. How strong is this association?

b. How does the strength of this association relate to level of exposure to shadow

flicker from wind turbines?

c. Might this association be explained by: (i) chance, (ii) bias, or (iii) confounding?

SRQ5. Electromagnetic radiation

Is there any reliable evidence of an association between electromagnetic radiation from wind turbines and adverse health effects? If so:

a. How strong is this association?

b. How does the strength of this association relate to level of exposure to electromagnetic radiation from wind turbines?

c. Might this association be explained by: (i) chance, (ii) bias, or (iii) confounding?

Appendix 2 – Database search strategies

Searches were first run on 19 March 2014 (#2) and repeated on 7 May 2014 (#4)

Databases	Set	Query	Hits
PubMed	#1	((wind[all fields] AND (turbine*[all fields] OR farm[all fields] OR farms[all fields] OR tower*[all fields] OR energy[all fields] OR technology[all fields] OR energy generating resources[MeSH] OR electric power supplies[MeSH])) OR wind turbine syndrome[all fields] OR Wind power[all fields])	4225
	#2	#1 AND ("2012/10/01"[Date - Entrez] : "3000"[Date - Entrez])	460
	#3	((wind[all fields] AND (turbine*[all fields] OR farm[all fields] OR farms[all fields] OR tower*[all fields] OR energy[all fields] OR technology[all fields] OR energy generating resources[MeSH] OR electric power supplies[MeSH])) OR wind turbine syndrome[all fields] OR Wind power[all fields])	4292
	#4	#3 AND ("2014/03/19"[Date - Entrez] : "3000"[Date - Entrez])	35
EMBASE via embase.com	#1	wind OR 'wind'/exp AND (turbine* OR tower* OR farm OR farms OR 'energy generating resources'/exp OR 'energy generating resources' OR 'electric power supplies'/exp OR 'electric power supplies OR power OR 'technology'/exp OR technology OR 'power supply'/exp OR 'power supply' OR 'energy resource'/exp OR 'energy resource') OR 'wind turbine syndrome' OR 'wind power'/exp	4471
	#2	#1 AND [26-9-2012]/sd	619
	#3	wind OR 'wind'/exp AND (turbine* OR tower* OR farm OR farms OR 'energy generating resources'/exp OR 'energy generating resources' OR 'electric power supplies'/exp OR 'electric power supplies' OR power OR 'technology'/exp OR technology OR 'power supply'/exp OR 'power supply' OR 'energy resource'/exp OR 'energy resource') OR 'wind turbine syndrome' OR 'wind power'/exp	3962
	#4	#3 AND [19-3-2014]/sd	61
Cochrane Library	#1	"wind turbine" or "wind tower" or "wind farm" or "wind power" or "wind renewable energy" or "wind power plant" or "wind technology" or "wind energy" or "wind resource"	1
	#2	Limit 2012-3000	0
	#3	"wind turbine" or "wind tower" or "wind farm" or "wind power" or "wind renewable energy" or "wind power plant" or "wind technology" or "wind energy" or "wind resource"	1
	#4	Limit 2012-3000	0
PsycINFO via OVID	#1	(Wind and (turbine or tower or farm or power or "renewable energy" or "power plant" or technology or energy or resource)).mp.	196
	#2	limit 1 to yr="2012 -Current"	40
	#3	(Wind and (turbine or tower or farm or power or "renewable energy" or "power plant" or technology or energy or resource)).mp.	198
	#4	limit 3 to yr="2014 -Current"	8

Web of Science	#1	TS=((wind NEAR (turbine* OR tower* OR farm* OR power* OR "renewable energy" OR "power plant*" OR technolog* OR energy OR resourc*)) OR "wind turbine syndrome") AND TS=(health OR welfare OR well-being OR human OR noise OR glint OR flicker OR “electromagnetic radiation”) Timespan = 2012-2014	778
	#2	Refined by: WEB OF SCIENCE CATEGORIES: (ENERGY FUELS OR ENGINEERING INDUSTRIAL OR IMMUNOLOGY OR ENGINEERING ELECTRICAL ELECTRONIC OR ENGINEERING MECHANICAL OR MATERIALS SCIENCE MULTIDISCIPLINARY OR ENGINEERING CIVIL OR ACOUSTICS OR BIOTECHNOLOGY APPLIED MICROBIOLOGY OR MICROBIOLOGY OR ENVIRONMENTAL SCIENCES OR OPHTHALMOLOGY OR OPTICS OR OTORHINOLARYNGOLOGY OR MECHANICS OR PATHOLOGY OR ENVIRONMENTAL STUDIES OR PHARMACOLOGY PHARMACY OR MATERIALS SCIENCE CHARACTERIZATION TESTING OR PLANNING DEVELOPMENT OR PRIMARY HEALTH CARE OR PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH SCI OR ECOLOGY OR ENGINEERING ENVIRONMENTAL OR ENGINEERING MULTIDISCIPLINARY OR MULTIDISCIPLINARY SCIENCES OR PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH OR ORNITHOLOGY OR DERMATOLOGY OR MEDICINE RESEARCH EXPERIMENTAL OR BIOCHEMICAL RESEARCH METHODS OR ONCOLOGY OR CONSTRUCTION BUILDING TECHNOLOGY OR DEVELOPMENTAL BIOLOGY OR MEDICINE GENERAL INTERNAL OR CARDIAC CARDIOVASCULAR SYSTEMS OR BIOLOGY OR PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH SSCI OR ENGINEERING BIOMEDICAL OR ENGINEERING CHEMICAL)	619
	#3	TS=((wind NEAR (turbine* OR tower* OR farm* OR power* OR "renewable energy" OR "power plant*" OR technolog* OR energy OR resourc*)) OR "wind turbine syndrome") AND TS=(health OR welfare OR well-being OR human OR noise OR glint OR flicker OR “electromagnetic radiation”) Timespan = 2014	82
	#4	Refined by: WEB OF SCIENCE CATEGORIES: (ENERGY FUELS OR ENGINEERING MECHANICAL OR ENGINEERING CIVIL OR ACOUSTICS OR ECOLOGY OR ENGINEERING ELECTRICAL ELECTRONIC OR ENVIRONMENTAL SCIENCES OR BIOTECHNOLOGY APPLIED MICROBIOLOGY OR MEDICAL INFORMATICS OR MEDICINE RESEARCH EXPERIMENTAL OR MULTIDISCIPLINARY SCIENCES OR ENVIRONMENTAL STUDIES OR ONCOLOGY OR PUBLIC ENVIRONMENTAL OCCUPATIONAL HEALTH OR ENGINEERING MULTIDISCIPLINARY)	70

Appendix 3 – Background Review Questions

BQ1. What are wind turbines and wind farms?

BQ2. By what specific physical emissions might wind turbines cause adverse health effects?

BQ3. For each such emission, what is the level of exposure from a wind turbine and how does it vary by distance and characteristics of the terrain separating a wind turbine from potentially exposed people?

BQ4. Is there basic biological evidence, or evidence from research into other circumstances of human exposure to physical emissions that wind turbines produce, that make it plausible that wind turbines cause adverse health effects?

BQ5. Is there any direct research evidence that exposure to wind turbines is associated with adverse health effects?

BQ6. If there is evidence that exposure to wind turbines is associated with adverse health effects:

a. Is there evidence that there are confounding factors or effect modifiers that might explain the association of wind turbines with adverse health effects? Such as but not necessarily limited to:

i. visibility of turbines

ii. financial gain from the siting of turbines

iii. community participation in decision making on the siting of turbines

iv. age and design of turbines?

Appendix 4 – Citations from the repeat literature search

Reasons for exclusion

1 = not publicly available in English

2 = not based on systematically collected data relevant to wind farms and human health

3 = does not look at human exposure to wind farm emissions

4 = exclusively selects participants only because they had reported health effects

5 = does not compare participants with different levels of exposure to wind turbines

6 = does not explain how the data were collected

7 = does not report on one or more health (or health-related) outcomes

8 = does not analyse the results

9 = citation was considered (and either included or excluded) for the Independent Review

CITATION	REASON
Adcock J, Delaire C, Griffin D. A Review of the Draft NSW Planning Guidelines: Wind Farms. *Acoustics Australia*. 2012;40(1):72-8.	9
Alimohammadi I, Sandrock S, Gohari MR. The effects of low frequency noise on mental performance and annoyance. *Environmental Monitoring and Assessment*. 2013;185(8): 7043-51.	2, 3
Alway P. Wind Farm Noise. *Acoustics Australia*. 2013;41(3):195.	2 [letter]
Ammar M, IEEE. Flicker Emission of Distributed Wind Power: A Review of Impacts, Modeling, Grid Codes and Mitigation Techniques. New York: IEEE; 2012.	7
Ammar M, Joos G. Impact of Distributed Wind Generators Reactive Power Behavior on Flicker Severity. *IEEE Transactions on Energy Conversion*. 2013;28(2):425-33.	7
Angulo I, de la Vega D, Grande O, Cau N, Gil U, Wu YY, et al. Empirical Evaluation of the Impact of Wind Turbines on DVB-T Reception Quality. *IEEE Transactions on Broadcasting*. 2012;58(1):1-9.	7
Baath LB. Noise spectra from wind turbines. *Renewable Energy*. 2013;57:512-9.	5, 7
Bakker RH, Pedersen E, van den Berg GP, Stewart RE, Lok W, Bouma J. Impact of wind turbine sound on annoyance, self-reported sleep disturbance and psychological distress. *Science of the Total Environment*. 2012;425:42-51.	9
Barnard M. Issues of wind turbine noise. *Noise & Health*. 2013;15(63):150-2.	2, 5 [letter]
Baxter J, Morzaria R, Hirsch R. A case-control study of support/opposition to wind turbines: Perceptions of health risk, economic benefits, and community conflict. *Energy Policy*. 2013;61:931-43.	2, 3, 7
Bidwell DC. The structure and strength of public attitudes towards wind farm development. *Dissertation Abstracts International Section A: Humanities and Social Sciences*. 2012;72(7-A):2598.	7
Bilski B. Factors Influencing Social Perception of Investments in the Wind Power Industry with an Analysis of Influence of the Most Significant Environmental Factor - Exposure to Noise. *Polish Journal of Environmental Studies*. 2012;21(2):289-95.	9
Bockstael A, Dekoninck L, Can A, Oldoni D, De Coensel B, Botteldooren D. Reduction of Wind Turbine Noise Annoyance: An Operational Approach. *Acta Acustica united with Acustica*. 2012;98(3):392-401.	Background Evidence
Bolin K, Almgren M, Ohlsson E, Karasalo I. Long term estimations of low frequency noise levels over water from an off-shore wind farm. *Journal of the Acoustical Society of America*. 2014;135(3):1106.	7

CITATION	REASON
Adcock J, Delaire C, Griffin D. A Review of the Draft NSW Planning Guidelines: Wind Farms. *Acoustics Australia*. 2012;40(1):72-8.	9
Bolin K, Kedhammar A, Nilsson ME. The Influence of Background Sounds on Loudness and Annoyance of Wind Turbine Noise. *Acta Acustica united with Acustica*. 2012;98(5):741-8.	7
Bowdler D. Wind turbine syndrome – an alternative view. *Acoustics Australia*. 2012;40(1):67-71.	9
Broner N. Special issue wind turbine noise. *Acoustics Australia*. 2012;40(1):5-83.	7
Camp S. The steep and the tearful: a New Zealand perspective of wind turbine noise. *Acoustics Australia*. 2012;40(1):57-8.	7
Chapman S, St George A, Waller K, Cakic V. The pattern of complaints about Australian wind farms does not match the establishment and distribution of turbines: support for the psychogenic, 'communicated disease' hypothesis. *PLoS One*. 2013;8(10):e76584.	5
Chapman S, St George A. How the factoid of wind turbines causing 'vibroacoustic disease' came to be 'irrefutably demonstrated'. *Australian and New Zealand Journal of Public Health*. 2013;37(3):244-9.	5 [review]
Chapman S. Wind Turbine Noise Editorial ignored 17 reviews on wind turbines and health. *BMJ*. 2012;344:1.	9
Chourpouliadis C, Ioannou E, Koras A, Kalfas AI. Comparative study of the power production and noise emissions impact from two wind farms. *Energy Conversion and Management*. 2012;60:233-42.	7
Crichton F, Dodd G, Schmid G, Gamble G, Cundy T, Petrie KJ. The power of positive and negative expectations to influence reported symptoms and mood during exposure to wind farm sound. *Health Psychology*. 2013. [Epub ahead of print 25/11/2013]	Mechanistic Evidence
Crichton F, Dodd G, Schmid G, Gamble G, Petrie KJ. Can expectations produce symptoms from infrasound associated with wind turbines? *Health Psychology*. 2014;33(4):360-4.	Mechanistic Evidence
Deignan B, Harvey E, Hoffman-Goetz L. Fright factors about wind turbines and health in Ontario newspapers before and after the Green Energy Act. *Health, Risk and Society*. 2013;15(3):234-50.	3, 5, 7
Doolan CJ, Moreau DJ. An on-demand simultaneous annoyance and indoor noise Recording Technique. *Acoustics Australia*. 2013;41(2):141-5.	Background Evidence
Ejdys J, Broniewicz E. Impact of wind power plants on acoustic climate. *Przeglad Elektrotechniczny*. 2012;88(3A):199-202.	7
Enbom H, Enbom IM. Infrasound from wind turbines: an overlooked health hazard. *Lakartidningen*. 2013;110(32-33):1388-9.	2
Evans T, Cooper J. Comparison of predicted and measures wind farm noise levels and implications for assessments of new wind farms. *Acoustics Australia*. 2012;40(1):28-36.	7
Farboud A, Crunkhorn R, Trinidade A. 'Wind turbine syndrome': fact or fiction? *Journal of Laryngology and Otology*. 2013;127(3):222-6.	2 [review]
Groth TM, Vogt C. Residents' perceptions of wind turbines: An analysis of two townships in Michigan. *Energy Policy*. 2014;65:251-60.	7
Haggett C. The Social Experience of Noise from Wind Farms. *Learning from Wind Power: Governance, Societal and Policy Perspectives on Sustainable Energy*. 2012:153-73.	2, 7 [book chapter]
Hanning CD, Evans A. Wind turbine noise. Authors' reply to Chapman. *BMJ*. 2012;344:1.	9
Hanning CD, Evans A. Wind turbine noise. *BMJ*. 2012;344:2.	9
Hume KI, Brink M, Basner M. Effects of environmental noise on sleep. *Noise & Health*. 2012;14(61):297-302.	2 [review]
Jeffery RD, Krogh C, Horner B. Adverse health effects of industrial wind turbines. *Canadian Family Physician/Médecin de Famille Canadien*. 2013;59(5):473-5.	2, 3, 5

CITATION	REASON
Adcock J, Delaire C, Griffin D. A Review of the Draft NSW Planning Guidelines: Wind Farms. *Acoustics Australia*. 2012;40(1):72-8.	9
Jeffery RD, Krogh CM, Horner B. Industrial wind turbines and adverse health effects. *Canadian Journal of Rural Medicine/Journal Canadien de la Médecine Rurale*. 2014;19(1):21-6.	6 [review]
Jianu O, Rosen MA, Naterer G. Noise Pollution Prevention in Wind Turbines: Status and Recent Advances. *Sustainability*. 2012;4(6):1104-17.	7
Katsaprakakis DA. A review of the environmental and human impacts from wind parks. A case study for the Prefecture of Lasithi, Crete. *Renewable and Sustainable Energy Reviews*. 2012;16(5):2850-63.	7
Kontogianni A, Tourkolias C, et al. Planning globally, protesting locally: Patterns in community perceptions towards the installation of wind farms. *Renewable Energy*. 2014;66:170-7.	7
Koulouras G, Alves-Pereira M, et al. Letter to the Editor re: 'How the factoid of wind turbines causing 'vibroacoustic disease' came to be 'irrefutably demonstrated'. *Scientific World Journal*. 2014;38(2):191-2.	2, 4, 5
Kurpas D, Mroczek B, Karakiewicz B, Kassolik K, Andrzejewski W. Health impact of wind farms. *Annals of agricultural and environmental medicine: AAEM*. 2013;20(3):595-604.	2, 5, 6 [review]
Larsson C, Ohlund O. Amplitude modulation of sound from wind turbines under various meteorological conditions. *Journal of the Acoustical Society of America*. 2014;135:67-73.	7
Lee GS, Cheong C, Shin SH, Jung SS. A case study of localization and identification of noise sources from a pitch and a stall regulated wind turbine. *Applied Acoustics*. 2012;73(8):817-27.	7
Lee S, Lee S, Lee S. Numerical modeling of wind turbine aerodynamic noise in the time domain. *Journal of the Acoustical Society of America*. 2013;133(2):El94-100.	5, 7
Leung DYC, Yang Y. Wind energy development and its environmental impact: A review. *Renewable and Sustainable Energy Reviews.* 2012;16(1):1031-9.	7
Maffei L, Iachini T, Masullo M, Aletta F, Sorrentino F, Senese VP, et al. The effects of vision-related aspects on noise perception of wind turbines in quiet areas. *International Journal of Environmental Research and Public Health*. 2013;10(5):1681-97.	7
Maille ME, Saint-Charles J. Social cohesion in a community divided by a wind farm project. *Human Ecology Review*. 2012;19(2):83-98.	5
McCallum LC, Whitfield Aslund ML, Knopper LD, Ferguson GM, Ollson CA. Measuring electromagnetic fields (EMF) around wind turbines in Canada: is there a human health concern? *Environmental Health*. 2014;13(1):9.	Background Evidence
McDonald NC, Pearce JM. Community Voices: Perspectives on Renewable Energy in Nunavut. *Arctic*. 2013;66(1):94-104.	2, 3, 5, 7
Moynihan MJ. Wind energy presents new challenges for worker health and safety. *Workplace Health & Safety*. 2013;61(5):232.	2, 3, 5, 7
Mroczek B, Kurpas D, Karakiewicz B. Influence of distances between places of residence and wind farms on the quality of life in nearby areas. *Annals of Agricultural and Environmental Medicine: AAEM*. 2012;19(4):692-6.	Direct Evidence
Mulvaney KK, Woodson P, Prokopy LS. Different shades of green: a case study of support for wind farms in the rural Midwest. *Environmental Management.* 2013;51(5):1012-24.	3, 5, 7
Nilsson ME, Bolin K, Bluhm G. [Wind power noise is not an infrasound problem]. *Lakartidningen*. 2013;110(42):1877.	1
Nissenbaum MA, Aramini JJ, Hanning CD. Effects of industrial wind turbine noise on sleep and health. *Noise & Health*. 2012;14(60):237-43.	9

CITATION	REASON
Adcock J, Delaire C, Griffin D. A Review of the Draft NSW Planning Guidelines: Wind Farms. *Acoustics Australia*. 2012;40(1):72-8.	9
Ollson CA, Knopper LD, McCallum LC, Whitfield-Aslund ML. Are the findings of "Effects of industrial wind turbine noise on sleep and health" supported? *Noise & Health*. 2013;15(63):148-50.	2, 5, 7 [letter]
Parks JM, Theobald KS. Public engagement with information on renewable energy developments: The case of single, semi-urban wind turbines. *Public Understanding of Science*. 2013;22(1):49-64.	2, 5, 7
Pohl J, Hubner G, Mohs A. Acceptance and stress effects of aircraft obstruction markings of wind turbines. *Energy Policy*. 2012;50:592-600.	Direct Evidence
Read DL, Brown RF, Thorsteinsson EB, Morgan M, Price I. The theory of planned behaviour as a model for predicting public opposition to wind farm developments. *Journal of Environmental Psychology*. 2013;36:70-6.	7
Roberts JD, Roberts MA. Wind turbines: is there a human health risk? *Journal of Environmental Health*. 2013;75(8):8-13, 6-7.	2
Ruotolo F, Senese VP, Ruggiero G, Maffei L, Masullo M, Iachini T. Individual reactions to a multisensory immersive virtual environment: The impact of a wind farm on individuals. *Cognitive Processing*. 2012;13(Suppl 1):S319-S23.	Mechanistic Evidence
Schiff MT, Magari SR, Smith CE, Rohr AC. Field evaluation of wind turbine-related noise in western New York State. *Noise Control Engineering Journal*. 2013;61(5):509-19.	Background Evidence
Seltenrich N. Wind turbines: a different breed of noise? *Environmental Health Perspectives*. 2014;122(1):A20-5.	2, 5
Shepherd D. Wind farms and health: who is fomenting community anxieties? *Medical Journal of Australia*. 2012;196(2):108.	9
Siler-Evans K, Azevedo IL, Morgan MG, Apt J. Regional variations in the health, environmental, and climate benefits of wind and solar generation. *Proceedings of the National Academy of Sciences of the United States of America*. 2013;110(29):11768-73.	7
Takahashi Y. Present situation and research task on the assessment of psychological effects caused by low-frequency noise. *Nihon Eiseigaku Zasshi*. 2013;68(2):88-91.	1
Taylor J, Eastwick C, Lawrence C, Wilson R. Noise levels and noise perception from small and micro wind turbines. *Renewable Energy*. 2013;55:120-7.	Mechanistic Evidence
Taylor J, Eastwick C, Wilson R, Lawrence C. The influence of negative oriented personality traits on the effects of wind turbine noise. *Personality and Individual Differences*. 2013;54(3):338-43.	Direct Evidence
Tickell C. Low Frequency, Infrasound and amplitude modulation noise from wind farms: some recent findings. *Acoustics Australia*. 2012;40(1):64-6.	Background Evidence
van Renterghem T, Bockstael A, De Weirt V, Botteldooren D. Annoyance, detection and recognition of wind turbine noise. *Science of the Total Environment*. 2013;456-457:333-45.	Background Evidence
Whitfield Aslund ML, Ollson CA, Knopper LD. Projected contributions of future wind farm development to community noise and annoyance levels in Ontario, Canada. *Energy Policy*. 2013;62:44-50.	2

Appendix 5 – Submitted literature

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Access Economics. Listen hear! The economic impact and cost of hearing loss in Australia. Access Economics Pty Ltd, 2006.	Exclude	Not related to exposures or outcomes related to wind farms
Acoustic Group. Peer review of environmental noise assessment Collector Wind Farm 42.5006.R1:ZSC. The Acoustic Group, 2013.	Exclude	Not based on new (or new analysis of) systematically collected data
Alves-Pereira M, Branco NA. Letter to the Editor - How the factoid of wind turbines causing 'vibroacoustic disease' came to be 'irrefutably demonstrated'. *Aust NZ J Public Health*. 2013;38(2):191-92.	Exclude	Letter; refers to previously published findings
Alves-Pereira M, Castelo Branco NA. Vibroacoustic disease: biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signalling. *Progress in biophysics and molecular biology*. 2007;93(1-3):256-79.	Exclude	Already considered and either included or excluded from the Independent Review
AMA. AMA Position Statement Wind Farms and Health: Australian Medical Association; 2014.	Exclude	Position statement; not based on new (or new analysis of) systematically collected data
Ambrose SE, Rand RW, Krogh CME. Falmouth, Massachusetts wind turbine infrasound and low frequency noise measurements Inter-noise 2012; 19-22 August; New York City, NY 2012.	Exclude	Summary of previously published paper
Ambrose SE, Rand RW, Krogh CME. Wind Turbine Acoustic Investigation: Infrasound and Low-Frequency Noise A Case Study. *Bull Sci Technol Soc*. 2012.	Exclude	Case study only; not based on new (or new analysis of) systematically collected data
Ambrose SE, Rand RW. The Bruce McPherson Infrasound and Low Frequency Noise Study Adverse Health Effects Produced By Large Industrial Wind Turbines Confirmed. 2011.	Exclude	Measurements at one turbine; not based on new (or new analysis of) systematically collected data
Andreucci F, Atzori D, Baratta C, Betti R. Correlation between people perception of noise from large wind turbines and measured noise levels. 5th International Conference on Wind Turbine Noise 28-30 August 2013; Denver.	Exclude	Conference abstract only
Arra I, Lynn H. Literature review 2013: Association between wind turbine noise and human distress. 2013.	Exclude	Review of previously published articles and presents no original findings not already considered in the Independent Review and this update. Provides no additional evidence on the likely level of exposure to emissions, Mechanistic data or any Parallel data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Association of Australian Acoustical Consultants. Wind farm position statement. Undated.	Exclude	Position statement; not based on new (or new analysis of) systematically collected data
Aughey, A, Transcript of evidence: Hearing before the Select Committee on Wind Farm Developments in South Australia (2013).	Exclude	Legal proceedings; not based on new (or new analysis of) systematically collected data
Australian Wind Energy Assoc. Wind farming, electromagnetic radiation and interference, Fact Sheet No. 10. Canberra: Australian Greenhouse Office; undated.	Exclude	Fact sheet; not based on new (or new analysis of) systematically collected data
Australian Wind Energy Assoc. Wind farms and noise, Fact Sheet No. 6. Canberra: Australian Greenhouse Office; undated.	Exclude	Fact sheet; not based on new (or new analysis of) systematically collected data
Babisch W. Updated exposure-response relationship between road traffic noise and coronary heart diseases: a meta-analysis. *Noise Health*. 2014;16(68):1-9.	Exclude	Does not provide additional evidence of likely level of emissions produced by wind farms, no Mechanistic evidence and no Parallel Evidence
Bakker H, Bennett D, Rapley B, Thorne R. Seismic effect on residents from 3 MW wind turbines. 3rd International Meeting on Wind Turbine Noise; 17-19 Jun; Aalborg Denmark 2009.	Exclude	Conference abstract
Barnard M. [RS] Issues of wind turbine noise. *Noise Health*. 2013;15(63):150-2.	Exclude	Letter; not based on new (or new analysis of) systematically collected data
Bell A. Annoyance from wind turbines: role of the middle ear muscles. *Acoustics Aust*. 2014;40:60.	Exclude	Letter, not based on new (or new analysis of) systematically collected data
Bell A. How do middle ear muscles protect the cochlea? Reconsideration of the intralabyrinthine pressure theory. *J Hearing Sci*. 2011;1(2):9-23.	Exclude	Not related to wind farms
Berglund B, Lindvall T, Schwela D. Guidelines for community noise. WHO, 1999.	Exclude	Guidelines; not based on new (or new analysis of) systematically collected data
Berglund B, Lindvall T. Community noise. *Arch Center Sens Res*. 1995;2(1):1-195.	Exclude	Not based on new (or new analysis of) systematically collected data
Bernert RA, Joiner TE. Sleep disturbances and suicide risk: A review of the literature. *Neuropsychiatr Dis Treat*. 2007;3(6):735-43.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data; no analysis of results and no exposures of any relevance to wind turbines
Bilski B. Factors influencing social perception of investments in the wind power industry with analysis of the most significant environmental factor - noise. *Pol J Environ Stud*. 2012;21(2):289-95.	Exclude	Already considered and either included or excluded from the Independent Review
Black O. Submission to Planning Hearing, Illinois USA. 2009.	Exclude	Legal proceedings; not based on new (or new analysis of) systematically collected data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Branco NA, Alves-Pereira M. Vibroacoustic disease. *Noise Health*. 2004;6(23):3-20.	Exclude	Narrative paper; not based on new (or new analysis of) systematically collected data
Branco NA. Low frequency noise: A major risk factor in military operations. RTO AVT Symposium on Ageing Mechanisms and Control; 8-11 October 2001; Manchester, 2001.	Exclude	Narrative review not based on new (or new analysis of) systematically collected data; no analysis of results
Bray W. Relevance and applicability of the Soundscape concept to physiological or behavioural effects caused by a noise at very low frequencies which may not be audible. Acoustical Society of America 164th Meeting; 26 October 2012; Kansas City 2012.	Exclude	Conference abstract
Brinckerhoff P. Update of UK Shadow Flicker Evidence Base. Department of Energy and Climate Change.	Background Evidence	Government report; shadow flicker exposure data
Bronzaft AL. The noise from wind turbines: Potential adverse impacts on children's well-being. *Bull Sci Technol Soc*. 2011;31:256.	Exclude	Already considered and either included or excluded from the Independent Review
Buck S, Palo S, Moriarty P. Application of phased array techniques for amplitude modulation mitigation. 5th International Conference on Wind Turbine Noise 28-30 August 2013; Denver.	Exclude	Conference abstract
Canada Health. Canadian handbook on health impact assessment: Vol. 1. The basics. 2004.	Exclude	Guidelines; not based on new (or new analysis of) systematically collected data
Cappuccio FP, Cooper D, D'Elia L, Strazzullo P, Miller MA. Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. *Eur Heart J.* 2011;32(12):1484-92.	Exclude	No evidence on likely level of exposure to emissions produced by wind farms; no Mechanistic or Parallel Evidence as covers no environmental exposures relevant to wind farms
Chao PC, Yeh CY, Juang YJ, Hu CY, Chen CJ. Effect of low frequency noise on the echocardiographic parameter E/A ratio. *Noise Health*. 2012;14(59):155-8.	Parallel Evidence	Occupational study of low frequency noise compared with a general noise group and a control group
Chapman S, St George A, Waller K, Cakic V. [RS] The pattern of complaints about Australian wind farms does not match the establishment and distribution of turbines: support for the psychogenic, 'communicated disease' hypothesis. *PloS one*. 2013;8(10):e76584.	Mechanistic Evidence	Collation of complaints from residents around wind farms obtained from a variety of sources
Chapman S, St George A. [RS] How the factoid of wind turbines causing 'vibroacoustic disease' came to be 'irrefutably demonstrated'. *Aust NZ J Public Health*. 2013;37(3):244-9.	Exclude	No evidence on likely level of exposure to emissions produced by wind farms; no Mechanistic or Parallel Evidence
Chapman S. Can wind farms make people sick? 2010; Available from: http://blogs.crikey.com.au/croakey/2010/02/23/can-wind-farms-make-people-sick-simon-chapman-investigates/.	Exclude	Not based on new (or new analysis of) systematically collected data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Chapman S. Factoid forensics: Have “more than 40” Australian families abandoned their homes because of wind farm noise? In press.	Exclude	Not based on new (or new analysis of) systematically collected data
Chapman S. Psycho-social mediators of reported annoyance and putative health-related symptoms associated with wind turbines: a discussion starter. Presentation to NHMRC Scientific Forum. 2011.	Exclude	Not based on new (or new analysis of) systematically collected data
Chapman S. Response to S. Laurie critique of PLOS ONE article. [NB correct title to be inserted]. 2013.	Exclude	Letter; not based on new (or new analysis of) systematically collected data
Cherry Tree Farm Pty Ltd v Mitchell SC (Includes Summary) (Red Dot) [2013] VCAT 1939. Victorian Civil and Administrative Tribunal; 2013.	Exclude	Legal proceedings; not based on new (or new analysis of) systematically collected data
Chief Medical Officer of Health. Report: The potential health impact of wind turbines. Ontario, Canada: Ontario Agency for Health Protection and Promotion, Ontario Ministry of Health and Long-Term Care, Council of Ontario Medical Officers of Health, 2010.	Exclude	Guidelines; not based on new (or new analysis of) systematically collected data
Cidras J, Feijoo A, Carillo Gonzalez C. Synchronization of asynchronous wind turbines. *IEEE Transact Power Syst*. 2002;17:1162-69.	Exclude	Not based on new (or new analysis of) systematically collected data
Colby WD, Dobie R, Leventhall G, Lipscomb DM, McCunney RJ, Seilo MT, et al. Wind turbine sound and health effects: An expert panel review. Washington DC: American Wind Energy Association and Canadian Wind Energy Association, 2009.	Exclude	Already considered and either included or excluded from the Independent Review
Colby WD. Presentation to Nova Scotia Department of Energy. 2010.	Exclude	Not based on new (or new analysis of) systematically collected data
Cole PN, Krogh CME. Wind turbine facilities’ perception: A case study from Canada. 5th International Conference on Wind Turbine Noise 28 - 30 August 2013; Denver.	Exclude	Conference abstract
Cooper SE. Peer review comments: South Australian EPA and Resonate Acoustics "Infrasound levels near windfarms and in other environments. The Acoustic Group, 2013.	Exclude	Opinion; not based on new (or new analysis of) systematically collected data
Cooper SE. Technical note: wind farm noise - An ethical dilemma for the Australian Acoustical Society? *Acoustics Aust*. 2012;40(2):139.	Exclude	Not based on new (or new analysis of) systematically collected data
Crichton F, Dodd G, Schmid G, Gamble G, Cundy T, Petrie KJ. The power of positive and negative expectations to influence reported symptoms and mood during exposure to wind farm sound. *Health Psychol*. 2013.	Mechanistic Evidence	Experimental study of expectations to wind farm sound
Crichton F, Dodd G, Schmid G, Gamble G, Petrie KJ. Can expectations produce symptoms from infrasound associated with wind turbines? *Health Psychol*. 2014;33(4):360-4.	Mechanistic Evidence	Double blind study of infrasound in university students

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Cummings J. The variability factor in wind turbine noise. 5th International Conference on Wind Turbine Noise 28 - 30 August 2013; Denver.	Exclude	Conference abstract
Dadali VA, Svidovyĭ VI, Makarov VG, Gor'kova LB, Kuleva VA, Pavlova RN, Tarasova OV, Timofeeva VM. [Effects of infrasound and protective effect ofadaptogens in experimental animals]. *Gig Sanit*. 1992 Jan;(1):40-3. Russian.	Exclude	Not publicly available in English; animal study
David A, Thorne B. Underpinning methodology to derive stand-off distances from a wind farm. 20th International Congress on Sound & Vibration; 7-11 July 2013; Bangkok, Thailand.	Exclude	Not based on new (or new analysis of) systematically collected data
Deignan B, Harvey E, Hoffman-Goetz L. [RS] Fright factors about wind turbines and health in Ontario newspapers before and after the Green Energy Act. Health, *Risk & Society* 2013;15(3).	Exclude	Not based on new (or new analysis of) systematically collected data, as based on newspaper reports
DeLacy PB, McCann M. Wind projects and land value. 2012.	Exclude	Not based on new (or new analysis of) systematically collected data
Delaney JA, Suissa S. The case-crossover study design in pharmacoepidemiology. *Statistical Methods in Medical Research*. 2009;18(1):53-65.	Exclude	Not relevant to exposure to wind farm emissions and not based on new (or new analysis of) systematically collected data
den Tandt A. Wind Turbine Syndrome: Is infrasound the cause? *The Daily Observer*. 2011.	Exclude	Newspaper article; not based on new (or new analysis of) systematically collected data
Dept Health Victoria. Wind farms, sound and health: Community information. Melbourne: Department of Health of Victoria, 2013.	Exclude	Guidelines; not based on new (or new analysis of) systematically collected data
Dept Health Victoria. Wind farms, sound and health: Technical information. Melbourne: Department of Health of Victoria, 2013.	Exclude	Guidelines; not based on new (or new analysis of) systematically collected data
Devine-Wright P. Beyond NIMBYism: towards an integrated framework for understanding public perceptions of wind energy. *Wind Energy*. 2005;8:125-39.	Exclude	Not based on new (or new analysis of) systematically collected data
Doolan C, Moreau D. [RS] An on-demand simultaneous annoyance and indoor noise recording technique. *Acoustics Aust*. 2013;41(2):141-45.	Background Evidence	Paper presenting a new annoyance and noise monitoring technique
Doolan CJ, Moreau DJ, Brooks L. Wind turbine noise mechanisms and some concepts for its control. *Acoustics Aust*. 2012;40(1):7-13.	Exclude	Not based on new (or new analysis of) systematically collected data
Doolan CJ. A review of wind turbine noise perception, annoyance and low frequency emission. *Wind Engineering*. 2013;37(1):97-104.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data or analysis.
Enbom H, Enbom I. Infrasound from wind turbines - an overlooked health risk. *Swedish Med J*. 2013;110:1388-89.	Exclude	Commentary; not based on new (or new analysis of) systematically collected data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Engineering H. Low frequency noise and infrasound associated with wind turbine generation systems, A literature review. Ontario Ministry of Environment, 2010.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data
enHealth. The health effects of environmental noise - other than hearing loss. Commonwealth of Australia, 2004.	Exclude	Not based on new (or new analysis of) systematically collected data
Environment Protection Authority SA. Waterloo Wind Farm environmental noise study. 2013.	Background Evidence	Noise survey
Erickson v. Ministry of the Environment Environmental Decision Case Nos 10-121, 10-122. Environmental Review Tribunal; 2011.	Exclude	Legal case; not based on new (or new analysis of) systematically collected data
European Wind Energy Technology Platform. Strategic research agenda market deployment strategy from 2008 to 2030. Annex B: State-of-the-art and current insufficiencies. 2008.	Exclude	Not based on new (or new analysis of) systematically collected data
Evans A. Wind farms and health. 2014.	Exclude	Opinion piece; not based on new (or new analysis of) systematically collected data
Evans T, Cooper J, Lenchine V. Infrasound levels near windfarms and in other environments. Environment Protection Authority South Australia, 2013.	Exclude	Already considered and either included or excluded from the Independent Review
Evans T [Resonate Acoustics]. Macarthur Wind Farm, Infrasound & Low Frequency Noise, Operational Monitoring Results. Prepared for AGL Energy Limited 2013.	Background Evidence	Wind turbine noise monitoring survey
Falmouth Health Department. Letter to Massachusetts Department of Public Health. 2012.	Exclude	Letter; not based on new (or new analysis of) systematically collected data
Farboud A, Crunkhorn R, Trinidade A. [RS] 'Wind turbine syndrome': fact or fiction? *J Laryngol Otol*. 2013;127(3):222-6.	Exclude	Narrative review with no analysis of results and no evidence on likely level of exposure to wind farm emissions
Gabriel J, Vogl S. Amplitude modulation and complaints about wind turbine noise. 5th International Conference on Wind Turbine Noise 28 - 30 August 2013; Denver.	Exclude	Conference abstract
Gardner A, Statement to VCAT Cherry Tree Hearing: Hearing before the Victorian Civil Administrative Tribunal (24 October, 2013).	Exclude	Legal proceedings; not based on new (or new analysis of) systematically collected data
Glegg S, Baxter SM, Glendinning AG. The prediction of broadband noise from wind turbines. *J Sound Vibration.* 1987;118(2):217-39.	Exclude	Testing a prediction model, so not based on new (or new analysis of) systematically collected data
Grosveld F. Prediction of broadband noise from horizontal axis wind turbines. *J Propulsion Power*. 1985;1(4):292-99.	Exclude	Testing a prediction model, so not based on new (or new analysis of) systematically collected data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Hanning CD, Evans A. Wind turbine noise. *BMJ.* 2012;344:e1527.	Exclude	Already considered and either included or excluded from the Independent Review
Hansen K, Henrys N, Hansen C, Doolan C, Moreau D. Wind farm noise -what is a reasonable limit in rural areas? Acoustics 2012; 21-23 November 2012; Fremantle, Western Australia.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data, no analysis of results
Harrison J. Wind turbine noise. *Bull Sci Technol Soc*. 2011;31:256.	Exclude	Already considered and either included or excluded from the Independent Review
Harry A. Wind turbines, noise and health: Self published; 2007.	Exclude	Not based on new (or new analysis of) systematically collected data
Havas M, Colling D. Wind turbines make waves: Why some residents near wind turbines become ill. *Bull Sci Technol Soc*. 2011;31:414.	Exclude	Not based on new (or new analysis of) systematically collected data
Hayes-Mackenzie. Report on wind farms (Drafts 1 and 3). 2006.	Exclude	Not based on new (or new analysis of) systematically collected data.
Health and Welfare Canada. Achieving health for all: A framework for health promotion. 1986.	Exclude	Guidelines; not based on new (or new analysis of) systematically collected data
Health Canada. Community noise annoyance. 2005.	Exclude	Fact sheet; not based on new (or new analysis of) systematically collected data
Health Canada. Health Canada wind turbine noise and health study design consultation. 2014; Available from: http://www.hc-sc.gc.ca/ewh-semt/consult/_2013/wind_turbine-eoliennes/index-eng.php.	Exclude	Not based on new (or new analysis of) systematically collected data
Higgins J. Wind farms: A blessing or a scam. *The Australian*. 4 May 2012.	Exclude	Newspaper article; not based on new (or new analysis of) systematically collected data
Howe Gastmeier Capnik Ltd [HGC Engineering]. Wind turbines and sound: Review and best practice guidelines. Prepared for the Canadian Wind Energy Association, 2007.	Exclude	Guidelines; not based on new (or new analysis of) systematically collected data
Horner B, Jeffery RD, Krogh CME. Literature reviews on wind turbines and health: Are they enough? *Bull Sci Technol Soc*. 2011;31:339.	Exclude	Already considered and either included or excluded from the Independent Review
Horner B, Krogh CME, Jeffery RD. Audit report: literature reviews on wind turbine noise and health. 5th International Conference on Wind Turbine Noise 28 - 30 August 2013; Denver.	Exclude	Conference abstract
Howe Gastmeier Chapnik Limited. Low frequency noise and infrasound associated with wind turbine generator systems: A literature review. Mississauga, Ontario, Canada: Ministry of the Environment, 2010.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Hubbard H. Noise induced house vibrations and human perception. *Noise Control Engineer J*. 1982;19(2):49-55.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data
Huson L. Expert Evidence at VCAT Cherry Tree Hearing: Hearing before the Victorian Civil Administrative Tribunal (24 October, 2013).	Exclude	Legal proceedings; not based on new (or new analysis of) systematically collected data
Huson L. Amplitude modulation case study at the Leonards Hill Wind Farm, Victoria, Australia. Institute of Acoustics meeting, Wind Turbine Noise; 20 March 2014; Newport, Wales.	Exclude	Only one dwelling, so not based on new (or new analysis of) systematically collected or analysed data
Iser D. Survey on wind power station effects. Submission to NHMRC. 2004.	Exclude	Already considered and either included or excluded from the Independent Review
Ising H, Braun C. Acute and chronic endocrine effects of noise: Review of the research conducted at the Institute for Water, Soil and Air Hygiene. *Noise Health*. 2000;2(7):7-24.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data
Jakobsen J. Infrasound emission from wind farms. *J Low Freq Noise V A*. 2005;24(3):145-55.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data
James R. Wind turbine infra and low-frequency sound: Warnings signs that were not heard. *Bull Sci Technol Soc*. 2012;32 no. 2 (2):108-27.	Exclude	Not based on new (or new analysis of) systematically collected data
Janssen S, Vos H, Eisses A, Pedersen E. A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources. *J Acoust Soc Am. 2011*;130(6):3746.	Direct Evidence	Excluded from the Independent Review, but reconsidered at request of the Reference Group.
Jeffery RD, Krogh CME, Horner B. [RS] Adverse health effects of industrial wind turbines. *Can Fam Phys*. 2013;59:921-25.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data
Jeffery RD, Krogh CME, Horner B. Adverse health effects of industrial wind turbines [Letter to the editor]. *Can Fam Phys*. 2013;59:921-25.	Exclude	Letter; not based on new (or new analysis of) systematically collected data
Jeffery RD, Krogh CME, Horner B. Industrial wind turbines and adverse health effects. *Can J Rural Med*. 2014;19(1):21-6.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data
Kaiser S, Fröhlingsdorf M. Wuthering heights: The dangers of wind power. *New York Times*. 2007.	Exclude	Newspaper article; not based on new (or new analysis of) systematically collected data
Katayama N, Takata G, Miyake M, Nanahara T. Theoretical study on synchronization phenomena of wind turbines in a wind farm. *Elec Engineer Japan*. 2006;155:9-18.	Exclude	Not based on new (or new analysis of) systematically collected data
Keith SE, Michaud DS, Bly SHP. A proposal for evaluating the potential health effects of wind turbine noise for projects under the Canadian Environmental Assessment Act. *J Low Freq Noise V A*. 2008;27:253-65.	Exclude	Already considered and either included or excluded from the Independent Review

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Kelley N. A proposed metric for assessing the potential of community annoyance from wind turbine low-frequency noise emissions. Windpower '87 Conference and Exposition; October 5-8, 1987; San Francisco.	Mechanistic Evidence	Laboratory study with sound simulations
Kelley ND, Hemphill RR, McKenna HE. Methodology for assessment of wind turbine noise generation. *J Solar Energy Engineering*. 1982;104:112-20.	Exclude	Narrative review of a measurement method, not based on new (or new analysis of) systematically collected data
Kelley ND, McKenna HE, Hemphill RR, Etter CL, Garrelts RL, Linn NC. Acoustic noise associated with the MOD-1 Wind Turbine: Its source, impact, and control Colorado: Solar Energy Research Institute, 1985.	Exclude	Extensive measurements of two wind turbines in response to complaints; questionable whether based on new (or new analysis of) systematically collected data
Knopper LD, Ollson CA. Health effects and wind turbines: a review of the literature. *Environ Health*. 2011;10:78.	Exclude	Already considered and either included or excluded from the Independent Review
Krogh C. Industrial wind turbine development and loss of social justice? *Bull Sci Technol Soc*. 2011;31:321.	Exclude	Not based on new (or new analysis of) systematically collected data
Krogh CME, Gillis L, Kouwen N, Aramini J. WindVOiCe, a self-reporting survey: Adverse health effects, industrial wind turbines, and the need for vigilance monitoring. *Bull Sci Technol Soc*. 2011;31:334.	Exclude	Already considered and either included or excluded from the Independent Review
Krogh CME, Jeffery RD, Aramini J, Horner B. Annoyance can represent a serious degradation of health: wind turbine noise a case study. Inter-noise 2012; 19-22 August 2002; New York City, NY.	Exclude	Not based on new (or new analysis of) systematically collected data
Krogh CME, Jeffery RD, Aramini J, Horner B. Wind turbine noise perception, pathways and effects: a case study. Inter-noise 2012; 19-22 August 2002; New York City, NY.	Exclude	Not based on new (or new analysis of) systematically collected data
Krogh CME, Jeffery RD, Aramini J, Horner B. Wind turbines can harm humans: a case study. Inter-noise 2012; 19-22 August 2002; New York City, NY.	Exclude	Not based on new (or new analysis of) systematically collected data
Krogh CME, Morris J, May M, Papadopoulos G, Horner B. Trading off human health: Wind turbine noise and government policy. 5th International Conference on Wind Turbine Noise 28-30 August 2013; Denver.	Exclude	Conference abstract
Krogh CME. Open submission: Risk of harm to children and industrial wind turbines. Health and social-economic impacts in Canada, Health Canada Wind Turbine Noise and Health Study. 2012.	Exclude	Not based on new (or new analysis of) systematically collected data
Kuwano S, Yano H, Kageyama T. Social survey on community response to wind turbine noise in Japan. 42nd International Congress and Exposition on Noise Control Engineering; 15-18 September 2013; Innsbruck, Austria.	Direct Evidence	Survey of annoyance related to wind turbine noise

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Lansink B. Case studies regarding 230kV and a 500kV industrial high voltage electrical power transmission corridors located in Ontario, Canada. Prepared by Lansink Appraisers and Consulting 2013.	Exclude	Not based on new (or new analysis of) systematically collected data
Lansink B. Case study, diminution in value, wind turbine analysis. Prepared by Lansink Appraisers and Consulting, 2012.	Exclude	Not based on new (or new analysis of) systematically collected data
Laratro A, Arjomandi M, Kelso R, Cazzolato B. A discussion of wind turbine interaction and stall contributions to wind farm noise. *J Wind Engin Industr Aerodynam*. 2014;127:1-10.	Exclude	Not based on new (or new analysis of) systematically collected data
Laurie S. A critical analysis of accuracy of the “complaints” data from the Chapman et al “nocebo” research. 2013.	Exclude	Not based on new (or new analysis of) systematically collected data
Leake J, Byford H. Officials cover up wind farm noise report. *The Sunday Times*. 13 December 2009.	Exclude	Newspaper article; not based on new (or new analysis of) systematically collected data
Leventhall G. Development of a course in computerised cognitive behavioral therapy aimed at relieving the problems of those suffering from noise exposure, in particular, exposure to low frequency noise (NANR 237). Queen’s Printer and Controller of HMSO, 2007.	Exclude	Not based on new (or new analysis of) systematically collected data
Leventhall G. Infrasound from wind turbines: Fact, fiction or deception. *Canadian Acoustics*. 2006;34:29-36.	Exclude	Not based on new (or new analysis of) systematically collected data
Leventhall G. Wind farms and human health. Presentation to NHMRC Scientific Forum. 2011.	Exclude	Conference presentation
Leventhall G. Wind turbines large small and unusual. 2009.	Exclude	Not based on new (or new analysis of) systematically collected data
Leventhall HG, Pelmear P, Benton S. A review of published research on low frequency noise and its effects. Department for Environment, Food and Rural Affairs, 2003.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data
Leventhall HG. Low frequency noise and annoyance. *Noise Health*. 2004;6:59-72.	Exclude	Not based on new (or new analysis of) systematically collected data
Leventhall HG. Wind turbine syndrome: An appraisal. Testimony before the Public Service Commission of Wisconsin (PSC Ref#121877 20). 2010.	Exclude	Legal case; not based on new (or new analysis of) systematically collected data
Lichtenhan JT, Salt AN. Amplitude modulation of audible sounds by non-audible sounds: understanding the effects of wind turbine noise. *J Acoust Soc Am*. 2013;133(5):3419.	Exclude	Animal study
Makarewicz R. Thump noise prediction. 5th International Conference on Wind Turbine Noise 28 - 30 August 2013; Denver.	Exclude	Conference abstract

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Maschke C, Niemann A. Health effects of annoyance induced by neighbour noise. *Noise Control Engineer J*. 2007;55:348-56.	Background Evidence	Analysis of self-reported annoyance from neighbour noise
Massachusetts Dept of Health. Wind turbine health impact study: Report of independent expert panel. Massachusetts Department of Environmental Protection, Massachusetts Department of Public Health, 2012.	Exclude	Not based on new (or new analysis of) systematically collected data
McBride D, Shepherd D, Welch D. A longitudinal study of the impact of wind turbine proximity on health related quality of life. 42nd International Congress and Exposition on Noise Control Engineering; 15-18 September 2013; Innsbruck, Austria.	Direct Evidence	Study of health-related quality of life in a community living near a wind turbine
McMurtry RY. Toward a case definition of adverse health effects in the environs of industrial wind turbines: Facilitating a clinical diagnosis. *Bull Sci Technol Soc*. 2011;31:316.	Exclude	Not based on new (or new analysis of) systematically collected data
McSwiggan D, Litttler T, Morrow D, Kennedy J. A study of tower shadow effect on fixed-speed wind turbines. Universities Power Engineering Conference; Padova 2008.	Exclude	Relevant to wind turbine performance rather than human exposures to wind farm noise or health outcomes
Michaud DS, Keith SE, McMurchy D. Noise annoyance in Canada. *Noise Health*. 2005;7(27):39-47.	Exclude	Not relevant to noise exposure
Mikołajczak J, Borowski S Marć-Pieńkowska J, Odrowąż-Sypniewska G, Bernacki Z, Siódmiak J, et al. Preliminary studies on the reaction of growing geese (Anser anser f. domestica) to the proximity of wind turbines. *Polish J Vet Sci*. 2013;16(4):679-86.	Exclude	Animal study
Minnesota Department of Health. Public health impacts of wind turbines. 2009.	Exclude	Not based on new (or new analysis of) systematically collected data
Møller H, Pedersen C. Low-frequency noise from large wind turbines. *J Acoust Soc Am*. 2011;129(6):3727-44.	Background Evidence	Noise survey of small and large wind turbines
Moller-Levet CS, Archer SN, Bucca G, Laing EE, Slak A, Kabiljo R, et al. Effects of insufficient sleep on circadian rhythmicity and expression amplitude of the human blood transcriptome. *Proc Natl Acad Sci USA*. 2013;110(12):E1132-41.	Exclude	Laboratory study; no evidence on exposures relevant to wind turbines; no Mechanistic and no Parallel data
Morris M. A comparison of wind turbine acoustic measurements and analysis, resident responses and wind farm power output during on-off testing at a South Australia wind farm. 2014.	Exclude	One wind turbine, so not based on new (or new analysis of) systematically collected data
Morris M. Waterloo case series preliminary report. 2013.	Exclude	Data from 2012 survey already included in Independent Review
Mroczek B, Kurpas D, Karakiewicz B. [RS] Influence of distances between places of residence and wind farms on the quality of life in nearby areas. *Ann Agric Environ Med*. 2012;19(4):692-6.	Direct Evidence	Identified as Direct Evidence in the updated literature search

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Munzel T, Gori T, Babisch W, Basner M. Cardiovascular effects of environmental noise exposure. *Eur Heart J*. 2014;35(13):829-36.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected or analysed data
National Research Council. Environmental impacts of wind-energy projects. Washington DC: National Academies Press; 2007.	Exclude	Narrative review concerned with environmental impacts
Navarette LM. Behavioral effects of wind farms on wintering sandhill cranes (Grus canadensis) on the Texas high plains [Thesis for the degree of Master of Science]: Texas Tech University; 2011.	Exclude	Animal study
Navarrete LM, Griffis-Kyle K, editors. Sandhill Crane (Grus canadensis) collisions with wind turbines in the Southern High Plains of Texas. North American Crane Workshop; in review.	Exclude	Animal study
NIEHS. Infrasound brief review of toxicological literature. National Institutes of Environmental Health Sciences, 2001.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected or analysed data
Niemann H, Bonnefoy X, Braubach M, Hecht K, Maschke C, Rodrigues C, et al. Noise-induced annoyance and morbidity results from the pan-European LARES study. *Noise Health*. 2006;8(31):63-79.	Exclude	No evidence on the likely level of exposure to emissions produced by wind farms
Nishimura K. The effects of infrasound on pituitary adreno-cortical response and gastric microcirculation in rats. *Journal of Low Frequency Noise and Vibration*. 1988;7(1):20-33.	Exclude	Animal study
Nissenbaum M, Aramini J, Hanning C. Adverse health effects of industrial wind turbines: A preliminary report. 10th International Congress on Noise as a Public Health Problem (ICBEN); 24-28 July 2011; London, UK.	Exclude	Already considered and either included or excluded from the Independent Review
Nissenbaum M. Letter to Secretary, Senate Environment & Communications committee inquiry into the renewable energy (wind farm noise) bill. 2012.	Exclude	Letter; not based on new (or new analysis of) systematically collected data
Nissenbaum MA, Aramini JJ, Hanning CD. Effects of industrial wind turbine noise on sleep and health. *Noise Health*. 2012;14(60):237-43.	Exclude	Already considered and either included or excluded from the Independent Review
NSW Dept Planning and Infrastructure. Major project assessment: Bodangora Wind Farm, Bodangora Central Western NSW MP10_0157. Sydney: 2013.	Exclude	Not based on new (or new analysis of) systematically collected data
NSW Dept Planning and Infrastructure. Major project assessment: Collector Wind Farm, Upper Lachlan Shire NSW Southern Tablelands MP10_0156. Sydney: 2013.	Exclude	Not based on new (or a new analysis of) systematically collected data
NSW Planning Assessment Commission. NSW Planning Assessment Commission determination report: Bodangora Wind Farm Project, Wellington LGA. Sydney: 2013.	Exclude	Not based on new (or new analysis of) systematically collected data
O'Sullivan C. Warning over wind turbine syndrome - Irish Deputy Chief Health Officer. Irish Examiner. 3 March 2014.	Exclude	Fact sheet; not based on new (or new analysis of) systematically collected data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Oerlemans S, Sijtsma P, Mendez Lopez B. Location and quantification of noise sources on a wind turbine. *J Sound Vibration*. 2007;299(4):869-83.	Exclude	Relevant to wind turbine performance rather than human exposures to wind farm noise or health outcomes
Oerlemans S. An explanation for enhanced amplitude modulation of wind turbine noise. Work Package A1. Renewable Energy, U.K. Wind turbine amplitude modulation: Research to improve understanding as to its cause and effect: Renewable Energy UK; 2013.	Exclude	Relevant to wind turbine performance rather than human exposures to wind farm noise or health outcomes
Ollson CA, Knopper LD, McCallum LC, Whitfield-Aslund ML. [RS] Are the findings of "Effects of industrial wind turbine noise on sleep and health" supported? *Noise Health*. 2013;15(63):148-50.	Exclude	Letter; not based on new (or new analysis of) systematically collected data
Oman C, Paloski WH, Young LR. In Memoriam F. Owen Black, M.D. *J Vestibular Res*. 2012;22:56.	Exclude	Not based on new (or new analysis of) systematically collected data
Paller C. Exploring the association between proximity to industrial wind turbines and self-reported health outcomes in Ontario, Canada: University of Waterloo; 2014.	Direct Evidence	Masters Thesis; association between proximity to wind turbines and self-reported health effects
Paller C, Bigelow P, Majowicz S, Law J, Christidis T. Wind turbine noise, sleep quality, and symptoms of inner ear problems. Poster. Symposium on Sustainability; 17 October; York University, Toronto, 2013.	Exclude	Duplicate data. Poster based on Science Masters Thesis by Paller C.
Pedersen E, Bakker R, Bouma J, van den Berg F. Response to noise from modern wind farms in the Netherlands. *J Acoust Soc Am*. 2009;126:634-43.	Exclude	Already considered and either included or excluded from the Independent Review
Pedersen E, Persson Waye K. Wind turbine noise, annoyance and self-reported health and well-being in different living environments. *Occup Environ Med*. 2007;64(7):480-86.	Exclude	Already considered and either included or excluded from the Independent Review
Pedersen E, Persson-Waye K. Perception and annoyance due to wind turbine noise--a dose-response relationship. *J Acoust Soc Am*. 2004;116(6):3460-70.	Exclude	Already considered and either included or excluded from the Independent Review
Persinger M. Infrasound, human health and adaptation: An integrative overview of recondite hazards in a complex environment. *Nat Hazards*. 2014;70(1):501-25.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected or analysed data
Persson Waye K, Bengtsson J, Kjellberg A, Benton S. Low frequency noise "pollution" interferes with performance. *Noise Health*. 2001;4(13):33-49.	Parallel Evidence	Experimental study of low frequency noise on cognitive performance and annoyance
Persson Waye K, Rylander R, Benton S, Leventhall HG. Effects on performance and work quality due to low frequency ventilation noise. *J Sound Vibration*. 1997;205(4):467-74.	Parallel Evidence	Laboratory pilot exposure study of 50 students
Persson-Waye K, Clow A, Edwards S, Hucklebridge F, Rylander R. Effects of nighttime low frequency noise on the cortisol response to awakening and subjective sleep quality. *Life Sci*. 2003;72:863-75.	Exclude	Already considered and either included or excluded from the Independent Review

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Phillips C. Properly interpreting the epidemiologic evidence about the health effects of industrial wind turbines on nearby residents. *Bull Sci Technol Soc*. 2011;31:303.	Exclude	Not based on new (or new analysis of) systematically collected data
Phipps R, Amati M, McCoard S, Fisher R. Visual and noise effects reported by residents living close to Manawatu wind farms: Preliminary survey results. 2007.	Exclude	Already considered and either included or excluded from the Independent Review
Pierpont N. Wind turbine syndrome and the brain. First International Symposium on the Global Wind Industry & Adverse Health Effects: Loss of Social Justice?; 30 October 2010; Picton, Ontario, Canada.	Exclude	Full conference paper; narrative review not based on new (or new analysis of) systematically collected or analysed data
Pierpont N. Wind turbine syndrome: a report on a natural experiment. Santa Fe, New Mexico: K-Selected Books; 2009.	Exclude	Already considered and either included or excluded from the Independent Review
PINCHE. Report WP7 Summary PINCHE policy recommendations. Policy Interpretation Network on Children's Health and Environment, 2002.	Exclude	Policy recommendations; not based on new (or new analysis of) systematically collected data
Pohl J, Faul F. Belästigung durch periodischen Schattenwurf von Windenergieanlagen. Kiel, Germany: Institut für Psychologie der Christian-Albrechts-Universität zu Kiel, 1999.	Exclude	Not in English
Portuguese Supreme Court ruling on wind turbines in Quinta. 2013.	Exclude	Legal proceedings; not based on new (or new analysis of) systematically collected data
Proceedings of the Fourth International Meeting on Wind Turbine Noise. Fourth International Meeting on Wind Turbine Noise; 2011; Rome, Italy.	Exclude	Whole conference proceedings; no specific abstract
Punch J, James R, Pabst D. Wind-turbine noise: what audiologists should know. *Audiology Today*. 2010;July/August:20-31.	Exclude	Not based on new (or new analysis of) systematically collected data
Punch J. Review of Crichton et al 2013.	Exclude	Commentary on a published paper; not based on new (or new analysis of) systematically collected data
Qibai C, Shi H. Technical contribution: An investigation on the physiological and psychological effects of infrasound on persons. *J Low Freq Noise, Vibr Active Control*. 2004;23(1):71-6.	Background Evidence	Laboratory study in university students
QLD Health. Coal seam gas in the Tara region: Summary risk assessment of health complaints and environmental monitoring data. 2013.	Exclude	Not based on new (or new analysis of) systematically collected data
Rand RW, Ambrose SE, Krogh CME. Occupational health and industrial wind turbines: A case study. *Bull Sci Technol Soc*. 2011;31:359.	Exclude	Not based on new (or new analysis of) systematically collected data
Reider S. Testimony Senate Energy and Natural Resources Committee.	Exclude	Legal proceedings; not based on new (or new analysis of) systematically collected data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Richarz W, Richarz H, Gambino T. Correlating very low frequency sound pulse to audible wind turbine sound. Fourth International Meeting on Wind Turbine Noise; 12-14 April 2011; Rome, Italy.	Exclude	Conference abstract
Robinson S. Mental health impacts of coal seam gas mining (a personal view). Submission to Inquiry into Coal Seam gas, NSW. 2011.	Exclude	Not based on new (or new analysis of) systematically collected data
Rushforth I, Moorhouse A, Styles P. A case study of low frequency noise assessed using DIN 45680 criteria. *J Low Freq Noise, Vibr Active Control*. 2002;21(4):181-98.	Exclude	Case study, not based on new (or new analysis of) systematically collected data
Salt AN, Hullar TE. Responses of the ear to low frequency sounds, infrasound and wind turbines. *Hear Res*. 2010;268(1-2):12-21.	Exclude	Narrative review; no evidence on noise or other emissions from wind turbines
Salt AN, Kaltenbach JA. Infrasound from wind turbines could affect humans. *Bull Sci Technol Soc*. 2011;31:296.	Exclude	Not based on new (or new analysis of) systematically collected data
Salt AN, Lichtenhan J. How does wind turbine noise affect people? *Acoustics Today*. 2014;10(1):20-8.	Exclude	Not based on new (or new analysis of) systematically collected data
Salt AN, Lichtenhan J. Perception-based protection from low-frequency sounds may not be enough. Inter-noise 2012; 19-22 August; New York City, NY.	Exclude	Animal study
Salt AN, Lichtenhan J. Responses of the ear to low frequency sounds, infrasound and wind turbines. Fourth International Meeting on Wind Turbine Noise; 12-14 April 2011; Rome, Italy.	Exclude	Narrative paper; not based on new (or new analysis of) systematically collected data
Salt AN, Lichtenhan JT, Gill RM, JJ. H. Large endolymphatic potentials from low-frequency and infrasonic tones in the guinea pig. *J Acoust Soc Am*. 2013;133:1561-71.	Exclude	Animal study
Salt AN. Can wind turbines be bad for you? Undated.	Exclude	Not based on new (or new analysis of) systematically collected data
Salt AN. Industrial wind farms generate infrasound. 2010; Available from: http://oto2.wustl.edu/cochlea/wt1.html.	Exclude	Not based on new (or new analysis of) systematically collected and analysed data
Schafer A. Macarthur wind energy facility preliminary survey. 2013.	Exclude	Not based on new (or new analysis of) systematically collected data
Schneider P. Cullerin Range Wind Farm Survey 2012.	Exclude	Not based on new (or new analysis of) systematically collected data
Schneider P. Cullerin Range Wind Farm Survey follow-up survey July - August 2013.	Exclude	Not based on new (or new analysis of) systematically collected data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Schomer P, editor. Can wind turbine sound that is below the threshold of hearing be heard? *Proceedings of Meetings on Acoustics*; 2013: Acoustical Society of America.	Exclude	Not based on new (or new analysis of) systematically collected data
Schomer P, Erdreich J, Boyle J, Pamidighantam P. A proposed theory to explain some adverse physiological effects of the infrasonic emissions at some wind farm sites. 5th International Conference on Wind Turbine Noise 28-30 August 2013; Denver.	Background Evidence	Full conference paper with some systematically collected noise data [Secondary publication to Walker 2012]
Schomer P, Parmidighantam P. A critical analysis of: wind turbine health impact study. Report of independent expert panel. *J Acoust Soc Am*. 2013;134:4096.	Exclude	Not based on new (or new analysis of) systematically collected data
SEDA. NSW wind atlas. Undated.	Exclude	Not based on new (or new analysis of) systematically collected data of relevance to wind turbine emissions or outcomes
Seltenrich N. [RS] Wind turbines: a different breed of noise? *Env Health Perspectives*. 2014;122(1).	Exclude	Not based on new (or new analysis of) systematically collected data
Seong Y, Lee S, Gwak DY, Cho Y, Hong J, Lee S. An experimental study on rating scale for annoyance due to wind turbine noise. 42nd International Congress and Exposition on Noise Control Engineering; 15-18 September 2013; Innsbruck, Austria.	Exclude	Laboratory study of wind turbine noise; validating noise metrics
Shain M. Public health ethics, legitimacy, and the challenges of industrial wind turbines: the case of Ontario, Canada. *Bull Sci Technol Soc*. 2011;31:256.	Exclude	Not based on new (or new analysis of) systematically collected data
Shepherd D, Billington R. Mitigating the acoustic impacts of modern technologies: Acoustic, health, and psychosocial factors informing wind farm placement. *Bull Sci Technol Soc*. 2011;31:389.	Exclude	Narrative paper; no evidence on noise or other emissions from wind turbines
Shepherd D, Hanning C, Thorne B. Windfarms. In: Jørgensen S, editor. Encyclopedia of environmental management: Taylor & Francis; 2012.	Exclude	Not based on new (or new analysis of) systematically collected data
Shepherd D, Mcbride D, Welch D, Dirks KN, Hill E. Wind turbine noise and health-related quality of life of nearby residents: a cross sectional study in New Zealand. Fourth International Meeting on Wind Turbine Noise; 12-14 April 2011; Rome, Italy.	Exclude	Duplicate of data already included in Independent Review
Shepherd D, McBride D, Welch D, Dirks KN, Hill EM. Evaluating the impact of wind turbine noise on health-related quality of life. *Noise Health*. 2011;13(54):333-9.	Exclude	Already considered and either included or excluded from the Independent Review
Shepherd D, Welch D, Dirks KN, McBride D. Do quiet areas afford greater health-related quality of life than noisy areas? *Int J Environ Res Pub Health*. 2013;10(4):1284-303.	Exclude	Wind turbine and outcome findings all taken from Shepherd 2011, which was included in the Independent Review

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Siponen D. Noise annoyance of wind farms. Research report VTT-R-00951-11. Technical Research Centre of Finland, 2011.	Exclude	Narrative paper; not based on new (or new analysis of) systematically collected data
Smith MG, Croy I, Ogren M, Persson Waye K. On the influence of freight trains on humans: a laboratory investigation of the impact of nocturnal low frequency vibration and noise on sleep and heart rate. *PloS One*. 2013;8(2):e55829.	Parallel Evidence	Laboratory study of six subjects: noise and vibration
Standing Senate Committee on Social Affairs SaT. A healthy, productive Canada: A determinant of health approach. Ottawa, Canada: Senate, 2009.	Exclude	Committee report; not based on new (or new analysis of) systematically collected data
Stantec Consulting Ltd. Health effects and wind turbines: A review for renewable energy approval (REA) applications submitted under Ontario Regulation 359/09. 2011.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data
Stantec Consulting Ltd. Ostrander Point wind energy design and operations report. Gilead Power Corporation, 2010.	Exclude	Operations report; not based on new (or new analysis of) systematically collected data of relevance to wind farm emissions or outcomes
Stigwood M, Large S, Stigwood D. Audible amplitude modulation - results of field measurements and investigations compared to psycho-acoustical assessment and theoretical research. 5th International Conference on Wind Turbine Noise 28-30 August 2013; Denver.	Exclude	Conference abstract
Styles P, Simpson I, Toon S, England R, Wright M. Microseismic and infrasound monitoring of low frequency noise and vibrations from wind farms - Recommendations on the siting of wind farms in the vicinity of Eskdalemuir, Scotland. Keele, Staffordshire UK: Applied and Environmental Geophysics Research Group, Earth Sciences and Geography, School of Physical and Geographical Sciences, Keele University, 2005.	Background Evidence	Systematically collected wind farm noise data
Superior Court, Falmouth Massachusetts Preliminary Injunction. 2013.	Exclude	Legal proceedings; not based on new (or new analysis of) systematically collected data
Suter AH. Noise and its effects. Administrative Conference of the United States, 1991.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected data
Swinbanks M. Peer review of Crichton et al 2013. 2013.	Exclude	Not based on new (or new analysis of) systematically collected data
Swinbanks MA. Numerical simulation of infrasound perception, with reference to prior reported laboratory effects. Inter-noise 2012; 19-22 August; New York City, NY.	Exclude	Simulation study; not systematically collected wind farm emission data
Tachibana H, Yano H, Sakamoto S. Nationwide field measurements of wind turbine noise in Japan. 42nd International Congress and Exposition on Noise Control Engineering; 15-18 September 2013; Innsbruck, Austria.	Exclude	Wind turbine noise survey in Japan (cannot obtain full article). [Appears to be linked to Yano study]

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Taylor J, Eastwick C, Lawrence C, Wilson R. Noise levels and noise perception from small and micro wind turbines. *Renewable Energy*. 2013;55:120-27.	Mechanistic Evidence	Small postal survey of residents around wind turbines
Taylor J, Eastwick C, Wilson R, C L. The influence of negative oriented personality traits on the effects of wind turbine noise. *Personality and Individual Differences*. 2013;54(3):338-43.	Direct Evidence	Identified as Direct Evidence in the updated literature search
Tharpaland International Retreat Centre. Three wind farm studies and an assessment of infrasound. Submission to the Inquiry into Scottish Government's Renewables Targets 2012.	Exclude	Not based on new (or new analysis of) systematically collected data
Thorne B, Shepherd D. Quiet as an environmental value: A contrast between two legislative approaches. *Int J Environ Res Pub Health*. 2013;10(7):2741-59.	Exclude	Not based on new (or new analysis of) systematically collected data
Thorne B. The problems with ''noise numbers'' for wind farm noise assessment. *Bull Sci Technol Soc*. 2011;31:262.	Exclude	Already considered and either included or excluded from the Independent Review
Thorne B. Wind farm generated noise and adverse health effects: Hearing before the Senate Hearing on 'Excessive Noise from Wind Farms' Bill (14 November 2012).	Exclude	Not research
Thorne B. Wind farm noise and human perception: a review. Enoggera, QLD: Noise Measurement Services Pty Ltd, 2013.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected wind farm emission data
Tickell C. Low frequency, infrasound and amplitude modulation noise from wind turbines - some recent findings. *Acoustics Aust*. 2012;40(1):64-6.	Background Evidence	Presents findings on amplitude modulation
Trustpower Australia Holdings Pty Ltd. Neighbour deed, Palmer Wind Farm, SA. Undated.	Exclude	Not based on new (or new analysis of) systematically collected data
Turnbull C, Turner J, Walsh D. Measurement and level of infrasound from wind farms and other sources. *Acoustics Aust*. 2012;40(1):45.	Background Evidence	Noise survey near wind turbines and other environmental sources
Unit C-KPH. The health impact of wind turbines: A review of the current white, grey, and published literature. Chatham, Ontario, Canada: Chatham-Kent Municipal Council, 2008.	Exclude	Narrative review; not based on new (or new analysis of) systematically collected wind farm emission data
US EPA. Noise pollution. Undated; Available from: http://www.epa.gov/air/noise.html.	Exclude	Information web site: not based on new (or new analysis of) systematically collected data
van den Berg F, Pedersen E, Bouma J, Bakker R. WINDFARM perception: Visual and acoustic impact of wind turbine farms on residents. Final report. Groningen: University of Groningen; Goeteborg University; University Medical Centre, 2008.	Exclude	Already considered and either included or excluded from the Independent Review
Wagner S. Wind turbine noise. Berlin Heidelberg: Springer; 1996.	Exclude	Not based on new (or new analysis of) systematically collected data

CITATIONS OF SUBMITTED LITERATURE	CATEGORY	REASON
Walker B, Hessler G, Hessler D, Rand R, Schomer P. Cooperative measurement survey and analysis of low-frequency and infrasound at the Shirley Wind Farm. Wisconsin Public Service Commission, 2012.	Background Evidence	Systematically collected wind turbine noise data
WHO. Burden of disease from environmental noise. Quantification of healthy life years lost in Europe. Copenhagen: World Health Organization; 2011.	Exclude	Already considered and either included or excluded from the Independent Review
WHO. Night noise guidelines for Europe. Copenhagen: World Health Organization; 2009.	Exclude	Already considered and either included or excluded from the Independent Review
Willingale B. Infrasound and low frequency noise in the locomotive cab. 10th International Congress on Acoustics; Sydney 1980.	Exclude	Extended conference abstract; not based on new (or new analysis of) systematically collected data
Witthoft M, Rubin GJ. Are media warnings about the adverse health effects of modern life self-fulfilling? An experimental study on idiopathic environmental intolerance attributed to electromagnetic fields (IEI-EMF). *J Psychosom Res*. 2013;74(3):206-12.	Parallel Evidence	Small laboratory study not directly about wind farms
Wolsink M. Planning of renewables schemes: Deliberative and fair decision-making on landscape issues instead of reproachful accusations of non-cooperation. *Energy Policy*. 2007;35:2692-704.	Exclude	Not based on new (or new analysis of) systematically collected data
Xue S. UK Amplitude modulation noise analysis and first look at off-shore wind turbine aeroacoustics simulation study. 5th International Conference on Wind Turbine Noise, Denver.	Exclude	Conference abstract
Yano T, Kuwano S, Kageyama T, Sueoka S, Tachibana H. Dose-response relationships for wind turbine noise in Japan. 42nd International Congress and Exposition on Noise Control Engineering; 15-18 September 2013; Innsbruck, Austria.	Direct Evidence	Full conference paper [Secondary publication to Kuwano 2013]
Yokoyama S, Sakamoto S, Tachibana H. Study on the amplitude modulation of wind turbine noise: Part 2 - Auditory experiments. 42nd International Congress and Exposition on Noise Control Engineering; 15-18 September 2013; Innsbruck, Austria.	Exclude	Conference abstract
Zajamsek B, Doolan CJ, Moreau DJ, Hansen K. Simultaneous indoor low-frequency noise, annoyance and direction of arrival monitoring. 5th International Conference on Wind Turbine Noise 28-30 August 2013; Denver.	Background Evidence	Noise levels measured at two households around a wind farm at different distances [Secondary publication to Doolan 2013]
Zajamsek B, Moreau D, Doolan C, Hansen K. Indoor infrasound and low-frequency noise monitoring in a rural environment. Acoustics; 17-20 November 2013; Victor Harbor, SA.	Background Evidence	Preliminary assessment of an annoyance testing tool based on one case [Secondary publication to Doolan 2013]
Zajamsek B, Moreau DJ , Doolan CJ. Characterising noise and annoyance in homes near a wind farm. Acoustics Australia. 2014;42(1):14-9.	Background Evidence	Identified by ONHMRC shortly after the public consultation period [Secondary publications to Doolan 2013]

Appendix 6 – Data extraction forms for included studies

See page 36 for Explanatory Notes

Janssen 2011

Reference [1]

Janssen SA, Vos H, Eisses AR, Pedersen E. A comparison between exposure-response relationships for wind turbine annoyance and annoyance due to other noise sources. *Journal of the Acoustical Society of America*. 2011;130(6):3746-53.

Affiliation/source of funds [2]

Netherlands Organisation for Applied Scientific Research/Funded by the Ministry of Housing, Spatial Planning and the Environment of the Netherlands.

Study design [3]

Data from 3 previously published cross-sectional surveys; 2 from Sweden and 1 from the Netherlands were combined to investigate exposure-response relationships between noise and annoyance.

Level of evidence [4]

IV

Location/setting [5]

One study in an agricultural setting in South Sweden, another in a mixture of urban/rural settings in Sweden and the third in a mixed setting in the Netherlands.

Proximity/distance:

Not specified for the two Swedish studies, within a 2.5 km radius from wind turbines in the Netherlands study.

Exposure description [6]

Annual day, evening and night A-weighted equivalent noise level (L_{den}) was calculated from the wind turbine noise emission data in the original 3 studies. Assumptions were made about wind velocity of 8 m/sec, a neutral atmosphere and noise at 10 m height, in line with recommendations by European regulatory agencies.

Wind farm details:

Not specified in this paper.

Specific exposure details:

No new exposure data collected for this analysis.

Sample size [7]

1820 participants in total across the 3 studies (341 + 754 + 725).

Control(s) description [8]

No control groups were used in these studies.

All comparisons were across the L_{den} exposure gradient for the exposed groups.

Sample size [9]

N/A

Population characteristics [10]

Exposure group:
Mean age 51.5 years, 53.6% female, 48.9% noise sensitive, economic benefit 7.6%, visible wind turbine 74%, rural 45.8% and flat terrain 79.4%. While no formal tests of statistical significance were reported, there are some potentially important differences between the three groups. For example, the Dutch study had a considerably higher percentage of participants with economic benefit from the wind turbines (14.3%), compared with the two Swedish studies (3.0 and 2.7%). Other characteristics where major differences were found include turbine visibility, rural location and flat terrain.

Length of follow-up [11]

N/A as cross-sectional designs used in these studies.

Outcome(s) measured and/or analyses undertaken [12]

Indoor and outdoor annoyance only. No health measures used. Annoyance was measured using a 1-item self-report scale (4-point scale in the Swedish study and a 5-point scale in the Dutch study).

INTERNAL VALIDITY

Confounding subscale [13]

Comment on sources of confounding:
The population characteristics noted above were adjusted for in the models used in the study. However, data on some other potentially important confounders, such as socioeconomic status, medical status, other potential sources of annoyance and country, were either not collected or not adjusted for in the analyses. Therefore, confounding may have affected the results, as annoyance can be influenced by a very wide range of demographic, lifestyle, health and environmental factors.

Bias subscale [14]

Comment on sources of bias:
The major source of bias is participation bias, due to the moderate to low participation rates across the 3 studies. The two Swedish studies had participation rates of 68% and 58%, while participation in the Dutch study was 37%. In the Swedish studies, respondents were not found to differ from the population in the study areas on age and gender (other characteristics not reported) and early vs late respondents were reported not to differ in their answers, but no data on this were reported. In the Dutch study, 200 non-responders were sent a questionnaire about annoyance and 48% responded and no differences in annoyance were found between this group and the study participants. The other likely source of bias is information bias, as all outcome and demographic data were self-reported, including noise sensitivity and annoyance.

EXTERNAL VALIDITY

Generalisability [15]

While appropriate comparator data for communities around wind turbines in Australia are not readily available, the demographic characteristics of the study sample reported in the study are unlikely to be grossly dissimilar from rural communities in Australia. However, socioeconomic and cultural differences between the European countries and Australia are likely to affect generalisability.

Applicability [16]

These analyses were undertaken using data from two European countries (Sweden and the Netherlands). As no data were reported in the study about wind turbine characteristics in the areas where the studies were undertaken, it is not possible to assess whether these finding are applicable to the Australian setting. Applicability to the Australian situation will depend upon the degree of similarity of Australian wind turbines with the wind turbines included in this research. Other possible reasons why applicability may be low is climatic and terrain differences between Australia and the two European countries and sociocultural differences.

Reporting subscale [17]

Comment on quality of reporting:
While not all of the questions in the reporting subscale were applicable to this study, those that were applicable were generally reported satisfactorily. These include aims and objectives, the annoyance outcome which was measured and characteristics of the study population being clearly described. Noise emission levels had been collected in the original studies and development of the exposure metrics (based on these data) for the analyses in this paper were well described. Reporting of the findings was generally satisfactory, although beta coefficients are used with no confidence intervals and just a note of whether they were statistically significant ($p< 0.05$). Exposure-response relationships were clearly presented in a series of figures.

Chance [18]

As there was only one outcome – annoyance (although this was for annoyance both inside and outside, so two variables) – and only one exposure measure (L_{den}), there was not an excessive number of analyses in the paper, which reduces the potential for chance to explain the associations found.

Overall quality assessment (descriptive) [19]

The design of this pooled study had some strengths over much of the other published epidemiological wind turbine research, such as having a clear and limited set of specific objectives, the large sample size of 1820 participants, acceptable recruitment rates in the two Swedish studies (however, not in the Dutch study), robust exposure metrics based on measured data and high quality reporting in the paper. Conversely, there were some weaknesses, such as the cross-sectional design, using non-validated self-report outcome measures of annoyance and noise sensitivity, pooling data from 3 different studies from 2 different countries (with inevitable differences in methods used, although these are small) and lack of data on potentially important factors which may influence annoyance. Therefore, confidence in the results is considered moderate.

RESULTS

Adverse effect outcomes [20]

TABLE II. Results of the annoyance indoors basic model (far left column) and backward model (far right column). Dummy variables *Swe00* and *Swe05* equal to 1 indicate data from 2000 and 2005 Swedish studies, respectively. Statistically significant effects ($P < 0.05$) are underlined.

	Basic	Age	Female	Sensitive	Eco. benefit	Visible	Rural	Flat terrain	Backward
β_0	−154.40	−213.01	−145.94	−180.07	−201.12	−142.71	−155.26	−152.06	−242.88
L_{den}	3.08	3.25	3.11	3.03	4.47	2.21	3.01	3.09	3.65
Swe00	2.16	3.35	2.10	0.43	−3.12	−4.91	3.59	2.19	−9.03
Swe05	−24.90	−24.44	−25.37	−27.46	−28.08	−26.95	−22.95	−26.23	−31.27
Age		166.38							44.26
Age^2		−119.78							
Female			−6.33						
Sensitive				0.60					0.56
Economic benefit					−64.00				−56.74
Visible						33.38			33.70
Rural							5.09		
Flat terrain								−2.93	

This table shows that in the adjusted models there was a small positive association between noise level and indoor annoyance. There was significant variability between the three studies, with lower annoyance in the Swedish studies. Visibility of the wind turbines had a considerably stronger positive effect than for the noise level, while self-reported noise sensitivity was only weakly associated with noise. Annoyance was found to be strongly reduced for economic benefit. A similar pattern of associations was found for outdoor annoyance. Repeating the analyses, taking out those who did not benefit economically and not taking the individual study effects into account, resulted in a steeper slope of the relationship between noise and annoyance for both indoors (B = 5.50) and outdoors (B = 5.48).

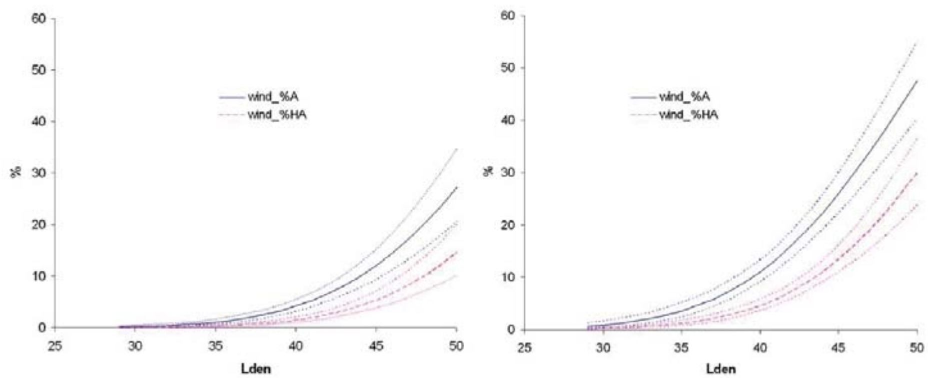

FIG. 1. (Color online) The exposure-response relationships between L_{den} and the percentage of residents annoyed (%*A*) and highly annoyed (%*HA*) indoors (left) and outdoors (right).

This figure demonstrates the shape of the dose-response curve for those defined as annoyed and those highly annoyed. This shows that noise levels up to about 35 dB caused almost no annoyance for both indoors and outdoors. The authors estimated that an L_{den} of 45 dB resulted in 12% annoyed participants indoors and 26% annoyed participants outdoors. It should be noted that the numbers of highly annoyed participants indoors and outdoors were very small (specific numbers not reported) and this, coupled with small numbers exposed above 45 dB, resulted in wide error bars at the higher noise levels.

Exposure group [21]	**Control group [22]**	**Measure of effect / effect size [23]** **95% CI [25]**	**Harms (NNH) [24]** **95% CI [25]**
Indoor annoyance > 50% (the definition of 'annoyed' used in the study) was only 4.2%. Outdoor annoyance > 50% was higher at 8.7%	N/A	Adjusted Beta coefficient for indoor annoyance and L_{den} was 3.65 ($p < 0.05$) Adjusted Beta coefficient for outdoor annoyance and L_{den} was 3.85 ($p < 0.05$)	For both indoors and outdoors, a 1 dB increase in L_{den} was estimated to increase annoyance by about three points on a 100-point scale. No confidence intervals or p-values given.

Public health importance (1–4) [26]	**Relevance (1–5) [27]**
It is difficult to apply the rating scale on page 23 of the NHMRC Guidelines, as it is not suitable for this type of study and it is difficult to consider annoyance in terms of a 'clinically important benefit'. The paper does not address the duration or likely impacts of increased annoyance at higher noise levels from wind turbines. Therefore the public health importance of annoyance from wind turbines, based on the findings from this study, is unclear.	It is difficult to apply the rating scale on page 27 of the NHMRC Guidelines, as it is not suitable for this type of non-intervention study and annoyance has been investigated, rather than 'patient-relevant outcomes'. A more important consideration of relevance is how these findings might apply to the wind turbine situation in Australia, such as proximity of communities, types of wind turbines, measured noise levels and sociocultural differences in what constitutes annoyance compared with Europeans.

Comments [28]

The authors have also attempted to compare annoyance levels related to noise from wind turbines with noise from other environmental sources; aircraft, road and rail. The authors suggested that annoyance is higher from wind turbines compared with the other sources at similar noise levels, but no details are given on the methods used and derivation of the data for the other sources of noise, so such comparisons must be treated with considerable caution. This is the weakest part of this paper.

<table>
<tr><td colspan="3">Kuwano 2013</td></tr>
<tr><td colspan="3">Reference [1]
Kuwano S, Yano T, Kageyama T, Sueka S, Tachibana H. Social survey on community response to wind turbine noise in Japan. 42nd International Congress and Exposition on Noise Control Engineering, Innsbruck, Austria, 15-18 September 2013.</td></tr>
<tr><td colspan="3">Affiliation/source of funds [2]
Osaka University, Japan; Kumamoto University, Japan; Oita University of Nursing and Health Sciences, Japan; Sueoka Professional Engineer Office, Japan; Chiba Institute of Technology, Japan. Funding from the Ministry of the Environment of Japan (Project No. S2-11).</td></tr>
<tr><td>Study design [3]
Cross-sectional survey</td><td>Level of evidence [4]
IV</td><td>Location/setting [5]
Japan
Proximity/distance:
Not reported in present paper (see Yano 2013)</td></tr>
</table>

<table>
<tr><td>Exposure description [6]
Wind farm details:
36 ‘target sites’ were identified with audible wind turbine noise from Hokkaido to Okinawa, Japan. Details of wind farm installations not provided (see Yano 2013).
Specific exposure details:
Not reported in present paper (see Yano 2013: Average sound pressure 26-50 dB).
Sample size [7]
747 respondents in ‘target site’ areas were approached by door knocking, of whom 49% participated (n=~ 366, calculated).</td><td>Control(s) description [8]
Residents at 16 control sites where wind turbine noise is inaudible and no turbines were visible.
Sample size [9]
332 control site respondents were approached by door knocking, of whom 45% responded (n= ~145, calculated).</td></tr>
</table>

Population characteristics [10]

Exposure group

Approximately equal sex ratio, with approximately 80% over 50 years of age (and approximately 30% over 70). Statistical tests for differences between exposed and control group demographics not mentioned.

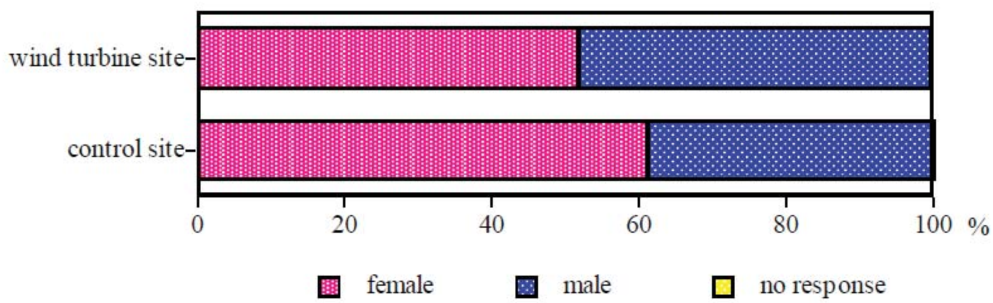

Figure1 Sex of the respondents

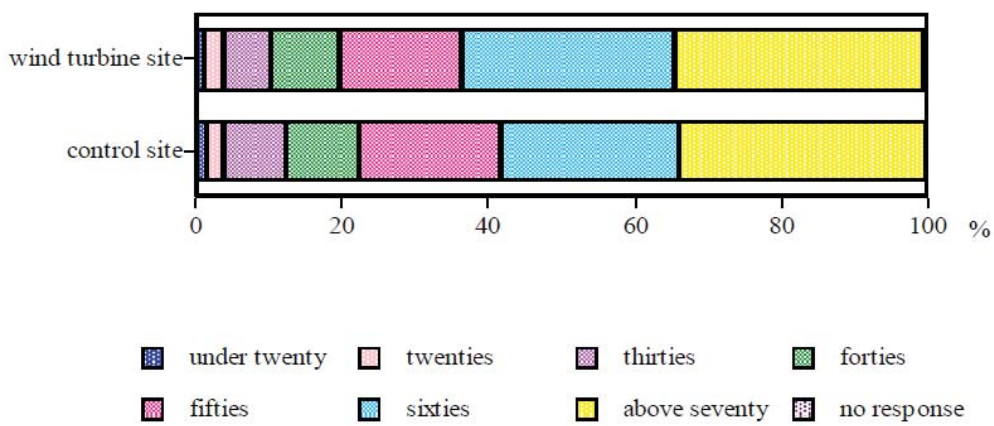

Figure 2 Age of the respondents

Length of follow-up [11]	**Outcome(s) measured and/or analyses undertaken [12]**
N/A as cross-sectional study design used.	Self-reported satisfaction with living environment (shopping convenience, transportation, amount of greenery, clean air, quietness and public facilities). Self-reported degree of annoyance of road traffic noise, aircraft noise, high-speed train (Shinkansen) noise, conventional train noise, noise from factories, construction noise and wind turbine noise (5 step categories). Self-reported trouble with sleep.

INTERNAL VALIDITY	EXTERNAL VALIDITY
Confounding subscale [13] ***Comment on sources of confounding:*** No confounders are identified by the authors, however few demographic variables are reported and differences not tested statistically. **Bias subscale [14]** ***Comment on sources of bias:*** Poor response rate indicates potential for selection bias. Blinding is not mentioned but very general nature of survey questions appears to indicate that respondents may have been blinded to purpose, possibly reducing potential for selection bias.	**Generalisability [15]** Cross-sectional survey limits ability to determine causality. Elderly residents over-represented in sample, limits generalisability to younger age groups and broader population. Likely that Japanese expectations of local amenity are dissimilar to Australian expectations. **Applicability [16]** Population density in wind turbine areas surveyed not clear but likely more dense than wind turbine areas in Australia which are typically rural and relatively sparsely populated. Likely differences in background noise and sound paths due to different environments.

Reporting subscale [17]

Comment on quality of reporting:
Key details unreported, for example full description of the wind turbine and control areas (urban/rural, population density), numerical results not provided (predominantly histograms only), tests of statistical significance and detailed recruitment methodology.

Chance [18]

N/a, no statistical tests for differences.

Overall quality assessment (descriptive) [19]

There is potential for misclassification of exposure (duration of exposure not quantified), sample selection bias (low response rate) and confounding. Survey design does not permit authors to definitively link outcomes to wind turbine noise exposure.

RESULTS

Adverse effect outcomes [20]

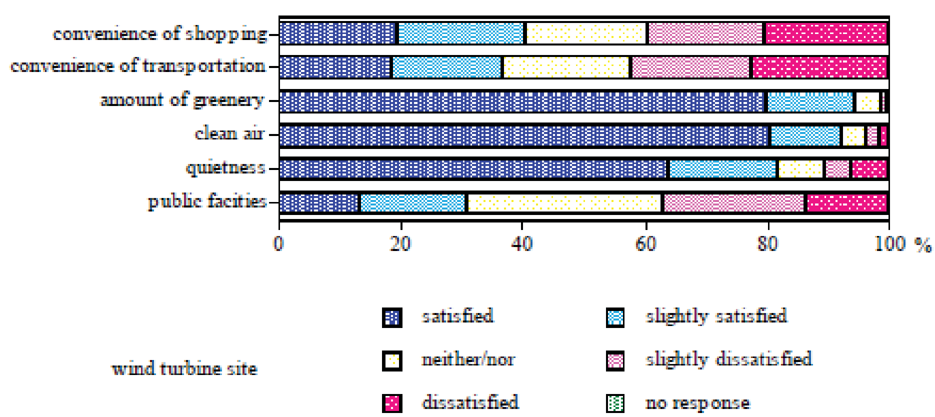

Figure 3 Satisfaction with their living environment in wind turbine site

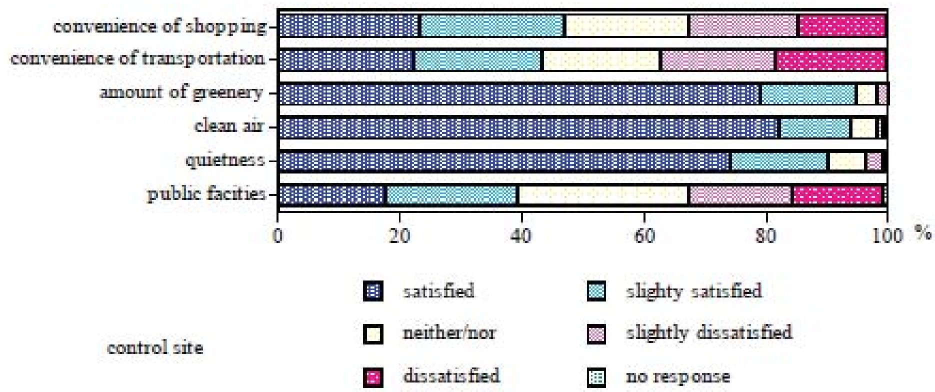

Figure 4 Satisfaction with their living environment in control site

Statistical tests not reported by satisfaction with living environment metrics, however the authors highlight a difference between satisfaction with quietness between wind turbine sites and control sites.

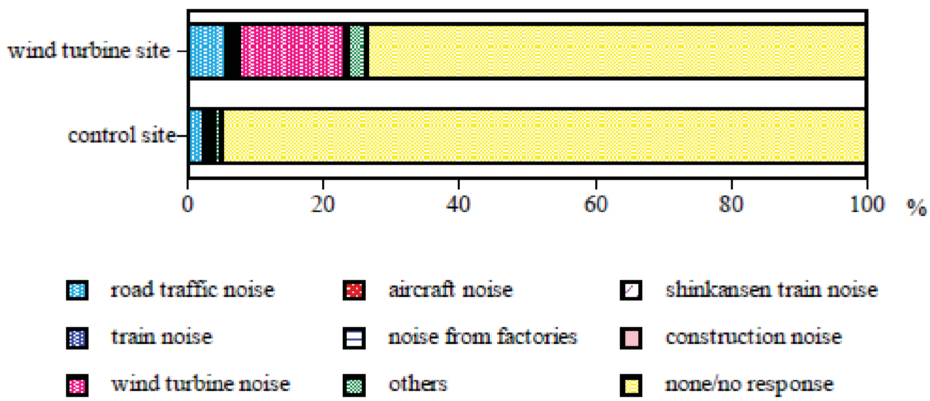

Figure 5 Most annoying sound

Statistical tests not reported, but more control site respondents reported no concerns with noise compared with wind turbine site respondents and more wind turbine site respondents reported that wind turbines were the most annoying sound in their environment. However, more wind turbine respondents also nominated road traffic noise or "other" noise as their most annoying noise suggesting that wind turbine areas surveyed may have a different overall noise profile compared with control areas.

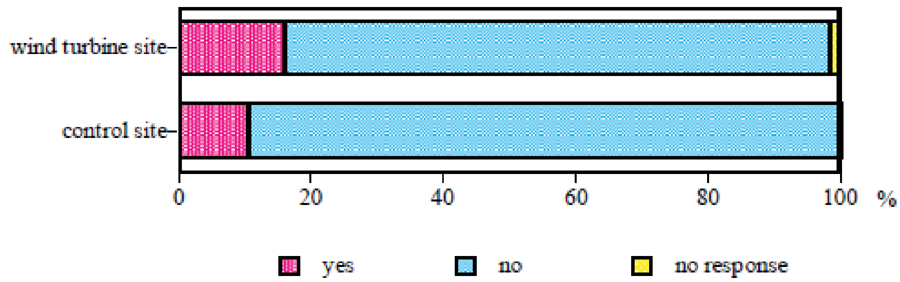

Figure 6 The percentage of the responses to the question whether they had a trouble with sleep.

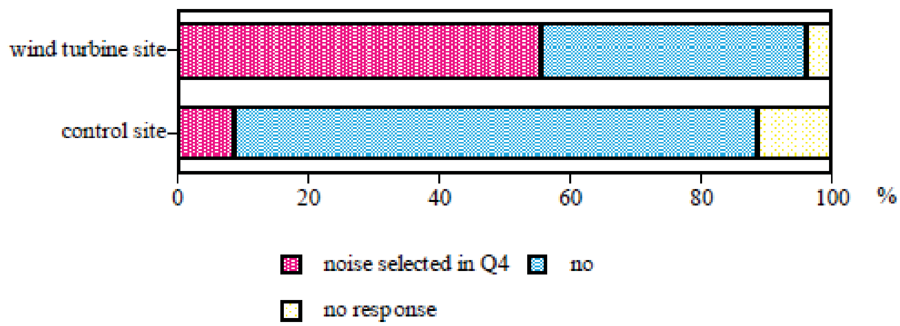

Figure 7 The reason of the trouble with sleep.

Statistical tests not reported but somewhat more wind turbine site respondents reported trouble with sleep. More wind turbine site respondents also did not answer this question. Wind turbine site respondents who had trouble sleeping were reportedly more likely to identify noise as the reason. However, what type of noise was apparently not investigated and earlier questions indicated that this group were troubled more than control groups by other types of noise as well as wind turbine noise.

Exposure group [21]	**Control group [22]**	**Measure of effect / effect size [23]**	**Harms (NNH) [24]**
See ‘Adverse effect outcomes’ [20].	See ‘Adverse effect outcomes’ [20].	**95% CI [25]** No effect measures presented and no 95% CIs	**95% CI [25]** N/A

Public health importance (1–4) [26]	**Relevance (1–5) [27]**
It is difficult to apply the rating scale on page 23 of the NHMRC Guidelines, as it is not suitable for this type of study, where many outcomes have been measured, but given the limitations of this research, the lowest ranking (4) seems most appropriate.	It is difficult to apply the rating scale on page 27 of the NHMRC Guidelines, as it is not suitable for this type of non-intervention study, but given the limitations of this research, the lowest ranking (5) seems most appropriate.

Comments [28]
This cross-sectional survey does not permit any conclusions about causation and it is unclear whether the reported differences between control and exposed groups are associated with wind turbine noise. Survey design does not associate reported outcomes to wind turbine noise and the overall noise profile of control areas and wind turbine areas may be systematically different in other ways. Lack of statistical testing makes it difficult to determine if differences between control and exposed groups are likely to be due to chance. Low recruitment rate indicates possibility for recruitment bias and over-recruitment of elderly residents limits generalisability to broader population. Context poorly described but likely to be very different to the Australian context of wind turbine exposure, limiting generalisability to the Australian context. This study has very limited capacity to inform the assessment of wind turbine noise of adverse health effects.

Abbreviations: NR = not reported; NC = not calculable; N/A = not applicable

McBride 2013		
Reference [1] McBride D, Shepherd D, Welch D, Dirks K. A longitudinal study of the impact of wind turbine proximity on health related quality of life. *42nd International Congress and Exposition on Noise Control Engineering*, Innsbruck, Austria, 15-18 September 2013		
Affiliation/source of funds [2] Department of preventive and Social Medicine, University of Otago, NZ Department of Psychology, School of public Health, Auckland University of Technology, NZ School of Population Health, The University of Auckland, NZ Funding source not given.		
Study design [3] Repeated cross-sectional study (using the same design as an earlier study conducted in this community in 2010, but a different sample of the population).	**Level of evidence [4]** IV	**Location/setting [5]** Makara Valley, New Zealand; hilly terrain with long ridges 250-450 m above sea level. **Proximity/distance:** Exposed participants in dwellings <2 km from nearest wind turbine; non-exposed controls resided (n = 250 homes) >10 km from turbine installation.

Exposure description [6] **Wind farm details:** 66 turbines (Siemens SWT-2.3-82 VS) Turbine height =125 m Rotor diameter =82 m **Specific exposure details:** Measured $L_{95(10mins)}$ Typical noise exposure range 20 dB(A) to 54 dB(A) **Sample size [7]** Not stated. Present sample not same as 2010 survey.	**Control(s) description [8]** Selected from 250 homes located in a socioeconomically and geographically matched area differing from the exposure group only by distance from wind turbines (≥ 10 km). **Sample size [9]** Not stated. Present sample not same as 2010 survey (Shepherd, 2011). **Shepherd 2011** Shepherd D, et al. Evaluating the impact of wind turbine noise on health-related quality of life. *Noise & Health* 2011;**13**(54):333-9, doi: 10.4103/1463-1741.85502.
Population characteristics [10] **Exposure group:** The exposure group recruited from population of residents of 56 dwellings in the Makara Valley which were within a 2 km radius of a single wind turbine. Recruitment rate and actual number of respondents included in analysis were not stated. Noise measurements indicated sound levels between 20 dB(A) and 54 dB(A). Amplitude modulation effects were identified by independent investigation.	
Length of follow-up [11] n/a, cross-sectional study. A 2-year follow-up of a previous cross-sectional survey of the same community (different sample).	**Outcome(s) measured and/or analyses undertaken [12]** The WHOQOL-BREF (26 item version) measured physical (7 items), psychological (6 items), and social (3 items) HRQOL, an additional eight item domain measuring environmental QOL and 2 'generic' items asking about general health and overall quality of life. Two amenity items were included.
INTERNAL VALIDITY **Confounding subscale [13]** ***Comment on sources of confounding:*** Detail about recruitment, selection and matching not provided in present report, however the methodology was presumably common to the 2010 survey and a number of limitations were evident in Shepherd 2011 which indicated possible confounding. For example, unequal distribution of some baseline characteristics between groups, not statistically significant. Socioeconomic and geographic matching was undertaken and adjustment by length of residence. Unclear whether there was any clustering effect of responses as two questionnaires delivered to each household or if clustering was accounted for in analysis. Plausible confounders not addressed, i.e. age, education, chronic disease and risk factors for chronic disease, occupation, employment, background noise, and turbine visibility (see Shepherd 2011).	**EXTERNAL VALIDITY** **Generalisability [15]** Survey sample members were either within 2 km of a turbine (exposed) at least 10km from a turbine installation (non-exposed); potential for demographic differences between the exposed and control populations. Difficult to assess on basis of limited information provided about recruitment process and recruitment rates. **Applicability [16]** Unknown whether the population characteristics and the wind turbine exposures of those living near wind farms in New Zealand are comparable to those living near wind farms in Australia. Authors note that "NZ wind farms are often situated in complex terrain" typical NZ terrain is generally dissimilar to terrain in most parts of Australia.

Participants were blinded to study purpose in original survey but authors acknowledge participants possibly unblinded in present survey due to publicity associated with original survey. **Bias subscale [14]** ***Comment on sources of bias:*** Response bias may be present. Insufficient detail about recruitment process and recruitment rate to evaluate. Response rates in 2010 survey were poor (see Shepherd, 2011). Response bias self-selection may have been more likely in 2012 survey than in 2010 survey because blinding to purpose of the study likely less effective. Authors report that five comparison group respondents were excluded because they were multivariate outliers (as defined by extreme Mahalanobis distances), with response set acquiescence clearly evident in all five cases. Without knowing the actual number of control participants it is unclear how large a proportion of the control group these five represent.	
Reporting subscale [17] ***Comment on quality of reporting:*** Certain key details not reported, for example the recruitment rate and total number of exposed and comparison group participants.	
Chance [18] No mention of statistical adjustments for chance.	
Overall quality assessment (descriptive) [19] High probability of exposure misclassification (exposure time not well-defined), sample selection bias (if response rate similar to 2010 survey, approximately 34%), and confounding. There is also the potential for outcome misclassification (amenity questions apparently not validated instruments) and recall bias (unclear if blinding to study purpose was effective, likely to have been less effective than in 2010). Potential lack of blinding to study purpose would plausibly increase selection bias, favouring recruitment of concerned individuals. In the context of this review, this study is considered poor quality.	

RESULTS

Adverse effect outcomes [20]

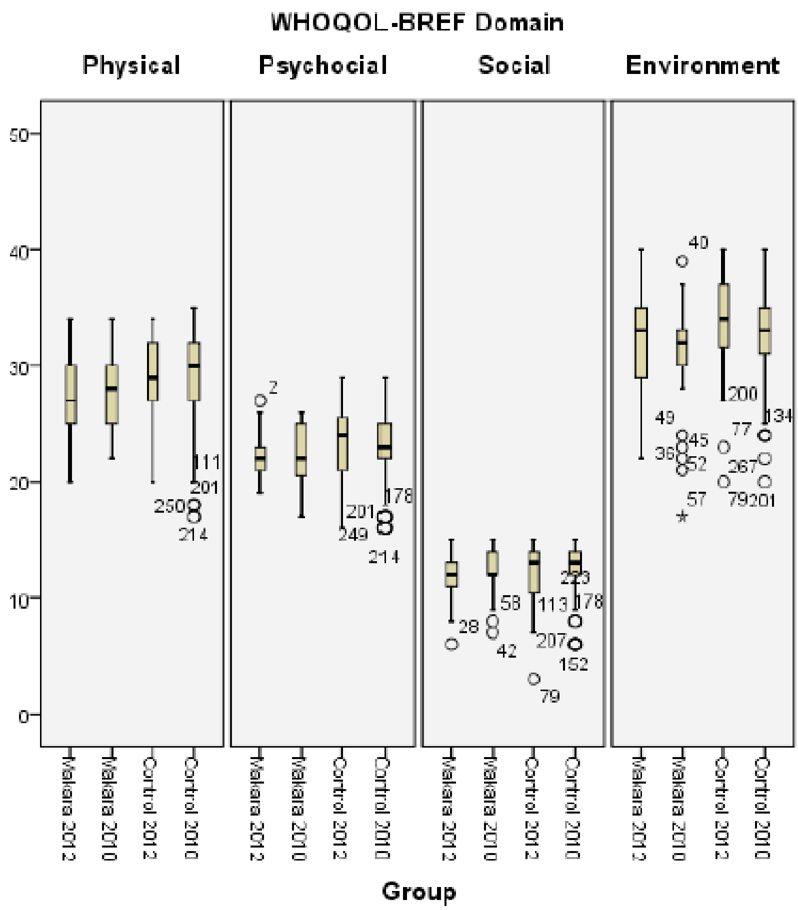

Figure 1, box-plot of WHOQOL-BREF domain scores for turbine and control groups.

There was little difference evident in WHOQOL scores among exposed (Makara) residents in 2010 and 2012. In the current survey, exposed residents scored significantly lower (i.e. poorer) than (2012) control residents in the physical domain (Mann-Whitney U test p=0.043). Examination of individual WHOQOL questions revealed that exposed residents scored significantly lower (i.e. poorer) on the question, "how satisfied are you with your health." (p = 0.020).

The Amenity scores are shown in figure 2.

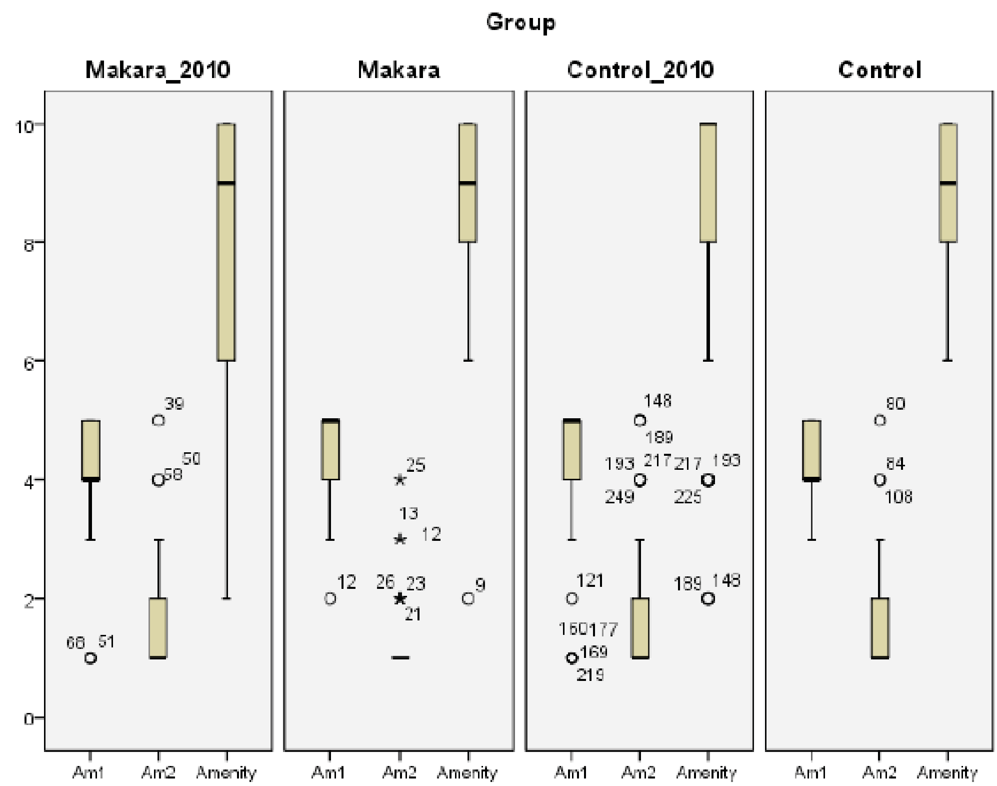

Figure 2, box-plot of amenity scores for turbine and control groups.

Answers to the amenity questions indicated no significant difference in scores over time, however there was a significant decrease in amenity in the control group over time (p = 0.034)

Exposure group [21]	**Control group [22]**	**Measure of effect / effect size [23]**	**Harms (NNH) [24]**
See 'Adverse effect outcomes' [20].	See 'Adverse effect outcomes' [20].	**95% CI [25]** See 'Adverse effect outcomes' [20].	**95% CI [25]** Health effects not reported.

Public health importance (1–4) [26]	**Relevance (1–5) [27]**
It is difficult to apply the rating scale on page 23 of the NHMRC Guidelines, as it is not suitable for this type of study, where many outcomes have been measured, but given the limitations of this research, the lowest ranking (4) seems most appropriate.	It is difficult to apply the rating scale on page 27 of the NHMRC Guidelines, as it is not suitable for this type of non-intervention study, but given the limitations of this research, the lowest ranking (5) seems most appropriate.

Comments [28]

This cross-sectional study, although it replicates a previous cross-sectional study in the same community, does not permit conclusions regarding causality. Therefore, it is unknown if the exposure preceded the self-reported health and amenity outcomes. Also, given that the outcomes are based on self-report, it is plausible that pre-existing opinions about the turbine installation in question and/or about wind turbines in general may have influenced participant recruitment and/or self-reported outcomes. Differences between groups were small and potentially influenced by factors other than exposure to the turbine, given that other confounders were not taken into account in the analysis.

Follow up of individuals in comparison to communities would have been more beneficial.

This study has limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.

Abbreviations: NR = not reported; NC = not calculable; N/A = not applicable

Mroczek 2012

Reference [1]

Mroczek B, Kurpas D, Karakiewicz B. Influence of distances between places of residence and wind farms on the quality of life in nearby areas. *Annals of Agricultural and Environmental Medicine*. 2012;19(4):692-6.

Affiliation/source of funds [2]

Public Health Department, Pommeranian Medical University, Szczecin, Poland

Family Medicine Department, medical University, Wroclaw, Poland

Public Higher medical Professional School, Opole, Poland

Study design [3]	**Level of evidence [4]**	**Location/setting [5]**
Cross-sectional survey	IV	Northern Poland, the Mazurian, Greater Poland and Lower Silesian Province, Podlaskie Province and Sub-Carpathian Province **Proximity/distance:** People living less than 700 m, 700-1000 m and greater than 1500 m from wind farms

Exposure description [6]	**Control(s) description [8]**
Wind farm details: No details of wind farms provided except that there were 34 wind farms in Northern Poland; the Mazurian, Greater Poland and Lower Silesian Province had 12 wind farms; Podlaskie Province had 11 and Sub-Carpathian Province had 9 wind farms. **Specific exposure details:** **Sample size [7]** 1277 respondents (703 women and 574 men)	No non-exposed groups were included in the study. **Sample size [9]** N/A

Population characteristics [10]

Exposure group: The mean age was 45.54±16.1 years (18-94).

Five exposure groups were described by the distance from the responders house to a wind farm:

Distance 1: below 700 m; Distance 2: 700 m - 1000 m; Distance 3: 1000 m - 1500 m; Distance 4: more than 1500 m; Distance 5: knows nothing about the plans of wind farm construction.

Length of follow-up [11] N/A

Outcome(s) measured and/or analyses undertaken [12] The respondents assessed their health through answering questions in SF-36 and VAS. SF-36 divided up into 8 sub-scales:

- Physical functioning (PF)
- Role-functioning physical (RP)
- Bodily pain (BP)
- General health (GH)
- Vitality (V)
- Social functioning (SF)
- Role functioning emotional (RE)
- Mental health (HE)

INTERNAL VALIDITY

Confounding subscale [13]

Comment on sources of confounding:
Plausible confounders that were not addressed included SES factors, chronic diseases and risk factors for chronic diseases and occupation.

Bias subscale [14]

Comment on sources of bias:
Unknown whether respondents influenced by renting their land for wind farm construction and use. Response rate not given and distance was used as a crude surrogate for noise and visual exposure of wind turbines.

EXTERNAL VALIDITY

Generalisability [15]

Subjects were randomly chosen using a two stage sampling technique. Results may be generalisable to responders only.

Applicability [16]

Unknown whether the population characteristics and wind turbine exposure of those living around wind turbines in Poland are comparable to those living near wind farms in Australia.

Reporting subscale [17]

Comment on quality of reporting:

Overall good reporting of results but lack of data on non-responders, participant characteristics such as chronic disease status and SES.

Chance [18] Chance findings due to multiple statistical testing cannot be excluded.

Overall quality assessment (descriptive) [19] Overall the use of the SF-36 and VAS as tools for Quality of Life (QoL) was well described. However, exposure assessment was crudely described by distance groups, no information was given regarding non-responders, subjects were not blinded and whether responders were renting land to the wind farm operators.

RESULTS

Adverse effect outcomes [20]

It was found that the distance between a place of residence and a wind farm had an effect on the QoL, where the closer the house to a wind farm the higher the QoL. The detailed results are as follows:

Table 1. The quality of the respondents' lives in the SF-36 eight subscales

	N	Mean	CI-95%	CI+95%	Range min.-max.	SD
PF	1277	**76.05**	74.51	77.58	0-100	**27.97**
RP	1276	59.83	57.67	61.98	0-100	39.29
BP	1277	63.66	61.89	65.43	0-100	32.22
GH	1277	55.28	53.96	56.61	0-100	24.06
V	1277	58.23	56.90	59.55	0-100	24.14
SF	1277	58.74	56.75	60.74	0-100	36.30
RE	1276	62.73	60.51	64.94	0-100	40.36
MH	1276	60.13	58.87	61.40	0-100	23.05

PF – physical functioning; RP – role-physical; BP – bodily pain; GH – general health; V – vitality; SF – social functioning; RE – role-functioning emotional; MH – mental health.

Of the eight aspects of QoL evaluated in the survey (Table 1), results indicated that respondents rated their physical functioning (PF subscale) higher than other aspects of QoL and they rated their general health (GH subscale) lower than other aspects of QoL.

Table 3. The ranks of the quality of life self-assessment scores within particular subscales with reference to the distance between a place of living and a wind farm

Sub-scale	Number of people No %				
	Distance 1	Distance 2	Distance 3	Distance 4	Distance 5
PF	57 (25.91)	60 (21.51)	44 (19.91)	61 (14.39)	11 (12.94)
RP	75 (34.09)	122 (43.73)	88 (39.82)	182 (42.92)	44 (51.76)
BP	90 (40.91)	108 (38.71)	80 (36.20)	183 (43.16)	33 (38.82)
GH	**162 (73.64)**	**207 (74.19)**	**157 (71.04)**	**274 (64.62)**	**60 (70.59)**
V	138 (62.73)	168 (60.22)	138 (62.44)	256 (60.38)	49 (57.65)
SF	59 (26.82)	77 (27.60)	85 (38.46)	234 (55.19)	29 (34.12)
RE	70 (31.82)	107 (38.35)	82 (37.10)	149 (35.14)	47 (55.29)
MH	129 (58.64)	152 (54.48)	130 (58.82)	253 (59.67)	48 (56.47)

The distance between a house and a wind farm or the intended place of construction: *Distance 1: below 700 m, *Distance 2: 700-1000 m, *Distance 3: 1000-1500 m, *Distance 4: more than 1500 m, *Distance 5: knows nothing about the plans of wind farm construction

Table 3 reports the proportion of respondents within each distance category who scored less than or equal to 4 on each QoL subscale. Low QoL scores (</=4) were most common on the general health (GH) subscale

and did not appear to be influenced by distance and was similar for men and women.

Table 4. The analysis of variance (ANOVA) for the quality of life scores within PF (physical functioning), MH (mental health) and V (vitality) subscales depending on distances between houses and wind farms

	SS	Df	MS	F	p
RP (role-physical)					
Absolute term	3366989	1	3366989	2216.793	0.0001
Distance	20889	4	5222	3.438	0.0083
Error	1857560	1223	1519		
MH (mental health)					
Absolute term	3488069	1	3488069	6801.397	0.0001
Distance	30079	4	7520	14.663	0.0001
Error	627211	1223	513		
V (vitality)					
Absolute term	3253875	1	3253875	5684.188	0.0001
Distance	12094	4	3023	5.282	0.0003
Error	700670	1224	572		

SS – sums of squares for the analysed effects and errors; df – degrees of intragroup freedom (concerning error) and intergroup freedom (concerning effect); MS – mean square effect and error; F – F-test for comparing variances; p – F-statistics probability value

Each quality of life area was evaluated separately using analysis of variance (ANOVA) (results for role-physical, mental health and vitality were reported, see Table 4) and the authors reported that distance to wind farm was a statistically significant predictor of self-reported QoL scores within the role-physical (RP), mental health (MH) and vitality (V) subscales ($p < 0.05$).

Post-hoc analysis using a Tukey test for unequal group sizes found no significant differences between groups in the QoL scores within the role-physical (RP), mental health (MH) and vitality (V) subscales between distance groups. The Tukey test found that people living more than 1,500 m from a wind farm assessed their vitality (V) significantly lower than those living in the closest distance from a wind farm ($p < 0.05$) and respondents living in the closest distance from a wind farm assessed mental health QoL (MH) significantly higher than to those living from 1,000 m - 1,500 m or more from a wind farm ($p < 0.05$ in both cases).

Distance to wind farm was associated with reported social functioning (SF) QoL and the role functioning-emotional (RE) QoL ($p<0.05$). Multiple comparison test showed that people living within the distance of 1,000 m - 1,500m or more from a wind farm assessed their social functioning (SF) QoL significantly lower than those living closer, and those who did not know about the plans for construction of a wind farm (all $p < 0.05$).

Statistically significant differences in the QoL scores within other subscales were not found between other groups of respondents with reference to the distance between a place of residence and a wind farm.

Regression analysis was also performed to estimate the parameters of a model describing the QoL perception with reference to socio-demographic and health variables (including whether respondents worked, learned or had a farm) within the particular subscales, however those variables that were

statistically significant had only limited influence on how respondents perceived their QoL. Overall, those living in the immediate neighbourhood of wind farms assessed their QoL higher than those living further away and the authors acknowledge that confounders (such as personal gain from nearby wind farm development) which were not assessed in this research project may have influenced the results.			
Exposure group [21] See 'Adverse effect outcomes' [20]	**Control group [22]** See 'Adverse effect outcomes' [20]	**Measure of effect / effect size [23]** **95% CI [25]** See 'Adverse effect outcomes' [20]	**Harms (NNH) [24]** **95% CI [25]** See 'Adverse effect outcomes' [20]
Public health importance (1–4) [26] It is difficult to apply the rating scale on page 23 of the NHMRC Guidelines, as it is not suitable for this type of study, but given the limitations of this research, the lowest ranking (4) seems most appropriate.		**Relevance (1–5) [27]** 4: evidence of an effect on proven surrogate outcomes but for a different intervention and population.	
Comments [28] This study was cross-sectional in design and does not permit any conclusions regarding causation between QoL and wind farms. The finding that QoL was inversely related to distance of home from a wind farm was unconvincing given the lack of data regarding responders living near wind farms receiving rent from wind farm operators. Other bias and confounders were not addressed and this study has limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.			

Abbreviations: NR = not reported; NC = not calculable; N/A = not applicable

Paller 2014
Reference [1] Paller, C. Exploring the association between proximity to industrial wind turbines and self-reported health outcomes in Ontario, Canada. Master of Science Thesis; 2014.
Affiliation/source of funds [2] University of Waterloo, Ontario, Canada Funded by Ontario Research Chair in Renewable Energy Technologies and Health

<table>
<tr><td colspan="2">Study design [3]
Cross-sectional study undertaken between February and May 2013.</td><td colspan="2">Level of evidence [4]
IV</td><td colspan="2">Location/setting [5]
Wind farms in Ontario, Canada
Proximity/distance:
The mean self-reported distances of survey respondents to wind farms was 2.78 km ±3.95 km (range 0.4 m - 55,000 metres). The mean calculated distance from residence to the closest industrial wind turbine was 4.52 km ±4.42 km (range 316 m - 22,661 m), therefore participants underestimated by about 1.6 km their distance from the wind farms.</td></tr>
<tr><td colspan="3">Exposure description [6]
Wind farm details:
The largest wind farm in each of eight counties in Ontario. Number of turbines ranging from 18-110 turbines per farm and turbine installed capacity ranging from 1.5 MW to 2.3 MW.
Specific exposure details:
Exposure was assessed by calculated distance to nearest turbine from each respondent’s home, using geocoding (ArcGIS). Distances were ranked by percentile (1st percentile – 100th percentile) and then divided into 4: quartile 1<25th percentile, quartile 2 <50th, quartile 3 <75th and quartile 4 <100th percentile. From these quartiles, four setback groups were created. In addition, self-reported distances to nearest wind turbine were compared to calculated distances using ArcGIS.
Sample size [7]
The survey questionnaire was sent to 4,876 residences (i.e. sum of houses, apartments and farms), including one reminder, with 412 returned (8.45% response rate) of which only 396 (8.12%) were included in the analysis because 16 did not include an address. Only those residences which did not opt out of receiving unaddressed mail could be approached; 86.8% of the total eligible population. Response rates varied by county between 6.9% and 12.4%.</td><td colspan="3">Control(s) description [8]
No non-exposed groups were included in this study. The reference group for the analyses was the group in the quartile furthest away from the wind farms, based on calculated distance.
Sample size [9]
N/A</td></tr>
<tr><td colspan="6">Population characteristics [10]
Exposure group:
The questionnaire collected the following possible confounding factors; age, gender, county, marital status, income and education level, but only some were used for adjustment in some analyses.</td></tr>
</table>

Length of follow-up [11]	**Outcome(s) measured and/or analyses undertaken [12]**
N/A	Pittsburgh Sleep Quality Index (PSIQ) SF-12 The Satisfaction with Life Scale (SWLS) Wind Turbine Syndrome (WTS) Index using 8 questions drawn from the Quality of Life and Renewable Energy Technologies Study survey. Frequency of the following symptoms in the past month: headache, irritability, concentration problems, nausea, vertigo, undue tiredness, tinnitus.

INTERNAL VALIDITY	EXTERNAL VALIDITY
Confounding subscale [13] ***Comment on sources of confounding:*** Age, gender and county were used for adjustment in some analyses, but not the other collected demographic information (education, income, marital status) and no other potential lifestyle, health or environmental confounders. Confounding is likely to have affected the results, as many of the outcomes used, such as quality of life, symptomatology, sleep and life satisfaction are influenced by a very wide range of demographic, lifestyle, health and environmental factors. **Bias subscale [14]** ***Comment on sources of bias:*** The major source of bias is participation bias, due to the very low participation rate, which averaged 8.45% across the eight counties. While there was an attempt to assess degree of likely response bias in two ways, neither method was very convincing, as neither comparison involved the non-responders. The first method involved comparing the responders with the whole population in the county and large differences were found on many demographic characteristics, but the approached population would not be representative of the whole County population, so this isn't very meaningful. The other method of trying to assess participation bias was to compare the participants from the two counties with the highest (12.4%) and lowest (6.9%) participation rates. Many of the factors were similar, but some large differences were found (e.g. tinnitus prevalence, SF-12 and WTS prevalence, often in different directions), it is difficult to interpret this in relation to the impact of any response bias, as both counties had very low participation rates. If one county had a very high participation rate, these results would have been more meaningful. The other likely source of bias is information bias, as the self-reported distance from the nearest wind farm was grossly underestimated. No blinding was possible.	**Generalisability [15]** The study sample had a median age of 56 years, 52% male, 79% married, median income of $60,000 and 59% having undertaken post-secondary education. No other demographic or other characteristics for the study sample were reported. While appropriate comparator data for communities around wind farms in Australia are not readily available, the demographic characteristics of the study sample are unlikely to be grossly dissimilar from rural communities in Australia. A more important point which is likely to affect generalisability is the low participation rate of the study sample and the high likelihood that it is unrepresentative of the community around wind farms. **Applicability [16]** The study was undertaken in Canada and the researcher chose the largest wind farms in each county around which to undertake this study. These farms contained a wide variety of wind turbines (Table 2), with varying size, manufacturer and number of turbines in the wind farm ranging from 18 to 110. Applicability to the Australian situation will depend upon the degree of similarity of Australian wind farms with the wind farms included in this research. Other possible reasons why applicability may be low is differences in local terrain around the wind farms between Australia and Canada and proximity of surrounding residences.

Reporting subscale [17] ***Comment on quality of reporting:*** While not all of the questions in the reporting scale were applicable to this study, those that were applicable were generally reported satisfactorily. These include aims/objectives, main outcomes which were measured and characteristics of the study population being clearly described. Other aspects of the study, such as exposure (calculated distance only) and principal confounders were less well described or ignored. Reporting of the findings and random variability were very poorly described, with an absence of measures of risk or 95% confidence intervals, the overuse of p-values and the reporting of regression analyses, without the presentation of the descriptive data on which the regressions were based. Distance-response relationships, while shown in figures for some outcomes, were also not adequately investigated or reported.
Chance [18] There were many analyses conducted, including analyses comparing across the individual wind farms (e.g. Table 13), although not all of the analyses which were undertaken were reported in this thesis. The findings for outcomes where associations were found, such as for PSQI, vertigo and tinnitus, were reported in the Tables, but the findings related to outcomes for which no associations were found were generally not reported in Tables. In addition, when a summary measure was analysed and no association with distance was found, variables which made up the summary measure were then analysed, for example the WTS index was found not to be related to distance, so the 8 variables which make up that index were analysed individually, so increasing the number of analyses. Therefore, taking into account all of these factors, it was difficult to determine the total number of analyses, but this is likely to have been very high given the number of wind farms, the number of outcome measures and their component variables. No correction for multiple comparisons was undertaken. Therefore, chance cannot be excluded as an explanation for at least some of the associations found.
Overall quality assessment (descriptive) [19] While the design of this study had some strengths over much previous epidemiological research related to the study of wind farms and health outcomes (e.g. including several wind farms, trying to recruit a large population, using some validated instruments (e.g. the SF-12), some other parts of the study design and some aspects of the execution were poor on several levels. These included the very low participation rates across the different counties, the lack of any exposure data apart from calculated distance, the use of some non-validated instruments (e.g. symptom reporting and the WTS index), lack of data on potentially important confounders, multiple comparisons and selective reporting of results. Therefore, confidence in the results is considered low.

RESULTS

Adverse effect outcomes [20]

The main reported outcomes are:

Association between the logarithm of distance and PSQI, with sleep improving with greater distance from the wind farm (adjusted R-Squared value of 0.08 and p-value of 0.01 for the adjusted model were the only ways that these findings were presented).

Association between logarithm of distance and vertigo, with vertigo worse among participants living closer to the wind farm (adjusted R-Squared value of 0.11 and p-value of < 0.001 for the adjusted model were the only ways that these findings were presented).

Distance-response relationships were presented for those outcomes shown to be associated with the logarithm distance (PSQI and vertigo) or close to being statistically significant (tinnitus p = 0.08). One example is given below, which shows that the PSQI drops more rapidly at closer distances to the wind farm:

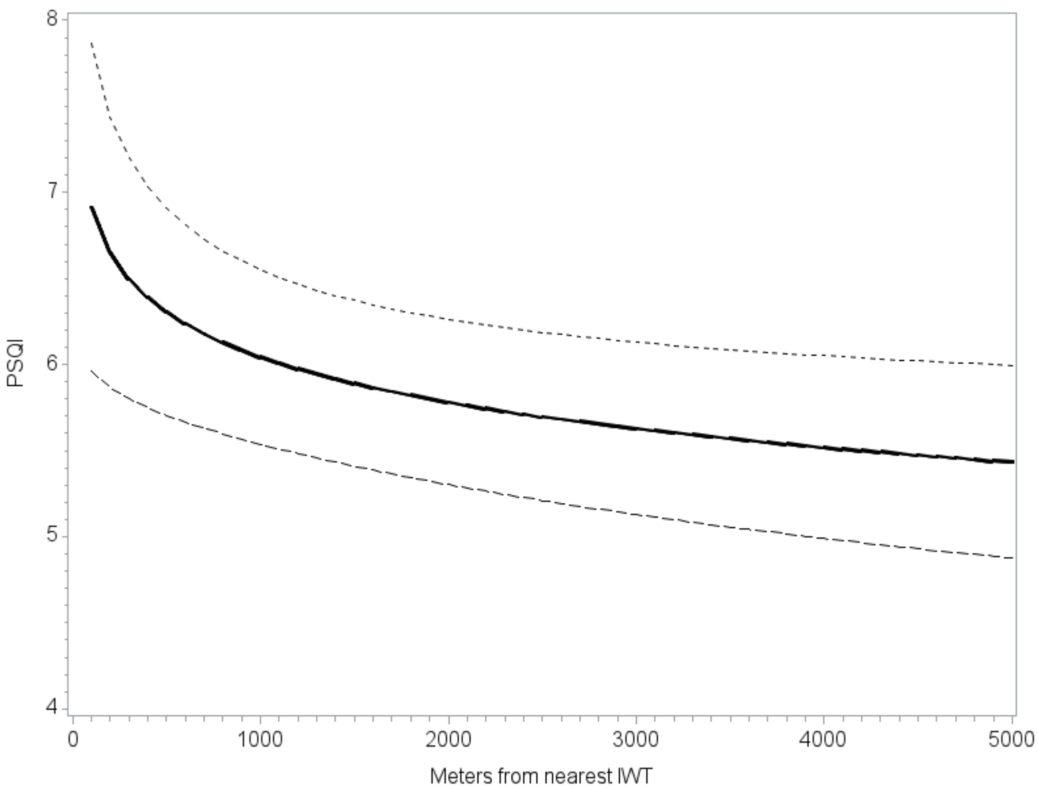

Figure 10: ***PSQI ln_dist Relationship (P=0.01). Graph shows modeled mean and upper and lower 95% confidence intervals***

While no data were presented for a similar analysis of WTS index, it is stated in the text that there was no association with the logarithm of distance, but vertigo was one of the variables used in this index.

No measures of risk are given for any of the other outcome variables used in the study, but there is a very large table (Table 13) which presents descriptive data for these outcomes across each of the 8 wind farms and for each of the quartiles of distance from a wind farm. The only statistical result given is a p-value for comparisons across the groups. The health outcomes for which the p-values are < 0.05 are for PSQI and vertigo. There was no significant difference across these groups for the following outcomes: the Physical Component Score (PCS) and Mental Component Score (MCS) of the SF-12, depression, SWLS, WTS index, headache, irritability score, concentration problems, nausea, undue tiredness, tinnitus or sleep quality.

Exposure group [21]	Control group [22]	Measure of effect / effect size [23]	Harms (NNH) [24]
See section 20 above.	N/A	**95% CI [25]** No effect measures presented and no 95% CIs, apart from in the figures describing log distance and PSQI and vertigo.	**95% CI [25]** N/A

Public health importance (1–4) [26]	Relevance (1–5) [27]
It is difficult to apply the rating scale on page 23 of the NHMRC Guidelines, as it is not suitable for this type of study, where many outcomes have been measured, but given the limitations of this research, the lowest ranking (4) seems most appropriate.	It is difficult to apply the rating scale on page 27 of the NHMRC Guidelines, as it is not suitable for this type of non-intervention study, but given the limitations of this research, the lowest ranking (5) seems most appropriate.

Comments [28]

While the serious limitations in design, execution, analysis and presentation make interpretation of these findings difficult, most health outcomes did not appear to have a relationship with distance from a wind farm and the two findings for which there appeared to be an association, this could be explained by chance, bias or confounding. Therefore, it is unlikely that the findings of this study have any clear implications in relation to the question of proximity of wind farms and human health.

Abbreviations: NR = not reported; NC = not calculable; N/A = not applicable

Pohl 2012

Reference [1]

Pohl J, Hubner G, Mohs A. Acceptance and stress effects of aircraft obstruction markings of wind turbines. *Energy Policy*. 2012;50:592-600.

Affiliation/source of funds [2]

Martin Luther Universität, Halle Wittenberg, Germany.

The study was funded by the Federal Ministry for Environment, Nature Conservation and Nuclear Safety, under a resolution by the Lower House of the German Parliament (Deutscher Bundestag), and by the State Agency for Agriculture, Environment and Rural Areas of Schleswig-Holstein.

Study design [3]	Level of evidence [4]	Location/setting [5]
Cross-sectional survey	IV	See [6] **Proximity/distance:** Less than 8 km from 13 wind farms with line of sight view of turbines.

Exposure description [6]	Control(s) description [8]
Wind farm details: 13 wind farms	No non-exposed groups were included.

Table A1
Features of each of the 13 wind farms.

German state	Day obstruction marking	Night obstruction marking	Synchronisation	Intensity adjustment	WT number	WT total height (m)	Wind farm total power (MW)	Wind farm's time in operation until survey (months)	Landscape
Lower Saxony	Xenon	Fire W, red	Yes	Yes	5	140.00	11.50	40	Simple
Brandenburg	Xenon	Fire W, red	Yes	Yes	9	150.00	14.00	30	Simple
Saxony	Xenon	Fire W, red	Yes	Yes	9	149.00	18.00	33	Complex
Schleswig-Holstein	LED	Fire W, red	Yes	Yes	8	133.50	21.60	40	Simple
Bremen	LED	Fire W, red	Yes	Yes	5	118.00	10.00	78	Complex
Bremen	Colour Markings	Fire W, red	Yes	Yes	9	149.50	6.90	31	Simple
Schleswig-Holstein	Colour Markings	Fire W, red	Yes	Yes	18	133.50	50.30	28	Simple
Rhineland-Palatinate	Colour Markings	Fire W, red	Yes	Yes	10	133.50	19.20	52	Complex
Brandenburg	Xenon	Red hazard beacon	No	No	6	123.50	9.00	76	Simple
Brandenburg	Xenon	Red hazard beacon	No	No	7	120.00	10.50	68	Simple
Thuringia	Xenon	Fire W, red	No	No	11	140.00	22.00	61	Complex
Lower Saxony	Xenon	Red hazard beacon	Yes	No	8	138.50	12.00	33	Simple
Saxony	Xenon	Fire W, red	Yes	No	8	150.00	16.00	68	Complex

Specific exposure details:

Table 1
Comparing day markings in simple vs. complex landscape scenery by research region (number of participants).

Landscape scenery	White Xenon	White LED	Colour Markings
Simple landscape	Lower Saxony, Brandenburg (50)	Schleswig-Holstein (57)	Bremen, Schleswig-Holstein (61)
Complex landscape	Saxony (38)	Bremen (38)	Rhineland-Palatinate (37)

Table 2
Testing of synchronisation of wind farms in simple vs. complex landscape scenery by research region (number of participants).

Landscape scenery	Without synchronisation	With synchronisation
Simple landscape	2 x Brandenburg (35)	Lower Saxony (36)
Complex landscape	Thuringia (36)	Saxony (32)

Table 3
Features of 13 wind farms.

Features	M (SD)	Median	Range
WT number	8.69 (3.33)	8	5-18
WT total height (m)	136.85 (11.28)	138.50	118-150
Wind farm total power (MW)	17.00 (11.12)	14.00	6.90-50.30
Wind farm's time in operation until survey (month)	49.08 (18.81)	40.00	28-78

Sample size [7]

N=281 respondents of first research design in 6 states

N=139 respondents of second research design in 4 states

Sample size [9] N/A

Population characteristics [10]

Exposure group: Up to 200 questionnaires were distributed to households around each wind farm. Response average rate was 24.8%. Average age was 51 years and average house duration was 21 years. Home owners were over-represented (85%), men participated (57%) more often than women. Majority were married (69%), 39% had completed junior high school qualifications and 38% held University entrance qualifications. The most frequently presented occupations were employees (33%), civil servants (11%), and self-employed persons (8%); 27% were retired. Of the respondents who worked, 31% also conducted their work at home. Only 4% worked in the wind business. About one-fourth of the participants had a household net income from 1001 to 2000 EUR, 26% from 2001 to 3000 EUR, and 16% from 3001 to 4000 EUR.

Length of follow-up [11] N/A

Outcome(s) measured and/or analyses undertaken [12]

The following stress indicators were used:

- General impact
- Annoyance
- Annoyance changes over the years
- Psychological and somatic symptoms
- Behaviour
- Coping response

INTERNAL VALIDITY

Confounding subscale [13]

Comment on sources of confounding: bias:

No potential confounders, such as SES, were considered in the analysis.

Bias subscale [14]

Comment on sources of bias:

High potential for sample selection bias due to low response rate. The study purpose was not masked and an incentive to take part was offered, so responder bias may have been enhanced.

EXTERNAL VALIDITY

Generalisability [15] Average response rate was 24.8%, potential for differences between the total exposed population and those that responded to the questionnaire.

Applicability [16] Unknown whether findings in Germany are comparable to those living near wind farms in Australia.

Reporting subscale [17]

Comment on quality of reporting: Overall quality of reporting was high but main deficit is that information was not presented on characteristics of non-responders.

Chance [18]

The possibility of spurious significant associations arising by chance cannot be excluded as multiple statistical tests were conducted.

Overall quality assessment (descriptive) [19]

This was a high quality cross-sectional study that made adjustments for confounders and bias, only low misclassification of outcomes is expected due to the methods and scales. However, the study intent was not masked and the relatively low response rate was not investigated.

RESULTS

Adverse effect outcomes [20]

We only report the annoyance outcomes as there were many other outcomes reported not directly related to health (e.g. strength of preference concerning obstruction marking):

While p-values were not reported, according to the study authors overall annoyance was rated significantly stronger for night (M = 1.32, SD = 1.38) than day markings (M = 0.97, SD = 1.21), independent of intensity adjustment.

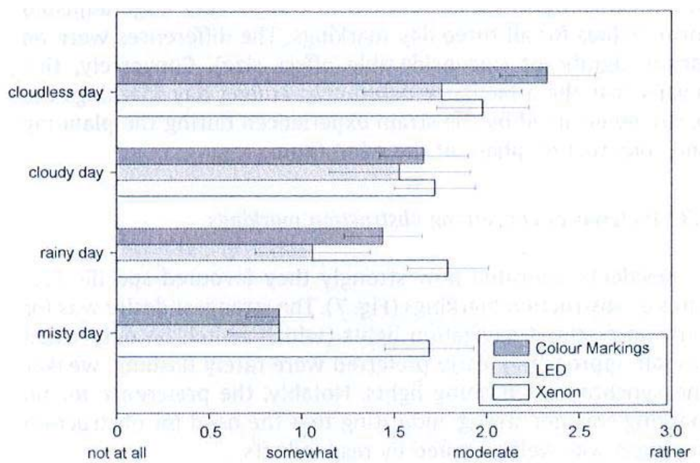

Fig. 2. Weather conditions characterised by particularly strong annoyance due to day marking (M ± SEM, scale range: 0–4).

In general, respondents reported annoyance to daytime obstruction markings was greatest on cloudless days and least on misty days. 29.7% of respondents reported strong annoyance in response to daytime obstruction markings and these respondents reported most annoyance by day markings on cloudless days, independent of marking type (Figure 2). Although annoyance was independent of marking type on cloudless days, on misty days, reported annoyance was higher for Xenon markings than other types of marking.

Almost all participants who reported being particularly annoyed by day markings also reported being annoyed by night markings as well (28.6%). In general annoyance was rated highest on cloudless nights, independent of intensity adjustment.

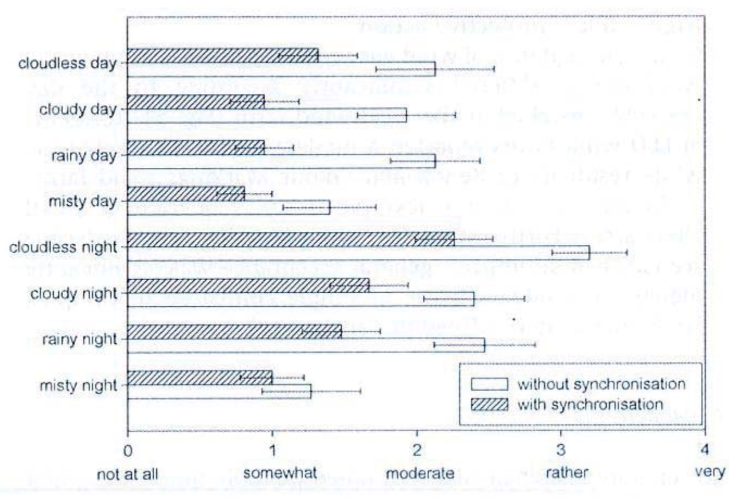

Fig. 3. Weather conditions with particularly strong annoyance caused by day and night marking for synchronised as well as non-synchronised wind farms without intensity adjustment (M ± SEM, scale range: 0–4).

For wind farms with markings not intensity adjusted for different visibility conditions, wind farms with synchronised markings attracted lower annoyance ratings (Figure 3). Of participants living near wind farms without intensity adjustment, annoyance was associated with particular weather conditions, especially cloudless nights. Misty conditions were associated with lower reported annoyance.

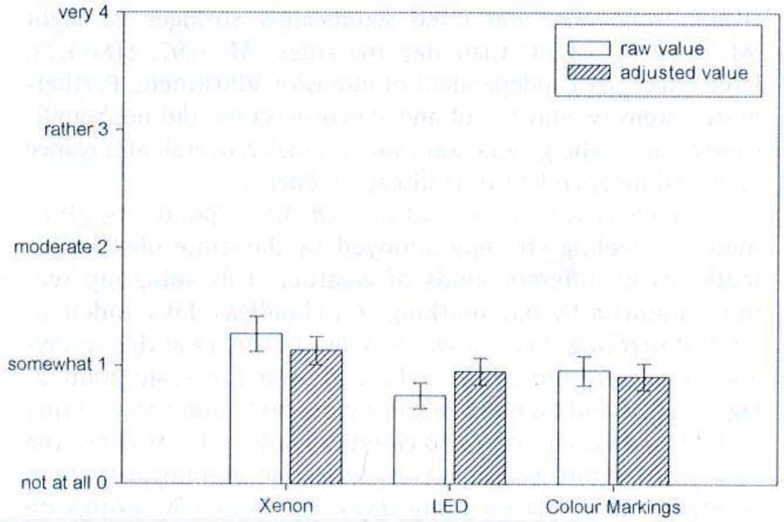

Fig. 6. Annoyance caused by day marking with (raw value) and without (adjusted value) consideration of the factor "strain during the planning and construction phase" (*M* ∓ SEM, scale range: 0–4).

Possible influence of stressors on the relationship between wind farm marking characteristics and annoyance was evaluated by considering participants' responses to questions which evaluated indications of stress. Of the more than 100 stress indicators evaluated, only one was associated: "strain during the planning and construction phase" ($r > 0.30$). Respondents reporting high strain during the planning and construction phase were more annoyed than respondents who did not report high strain during planning and construction. (Figure 6 shows the moderating effect of this strain variable on annoyance in relation to day markings.)

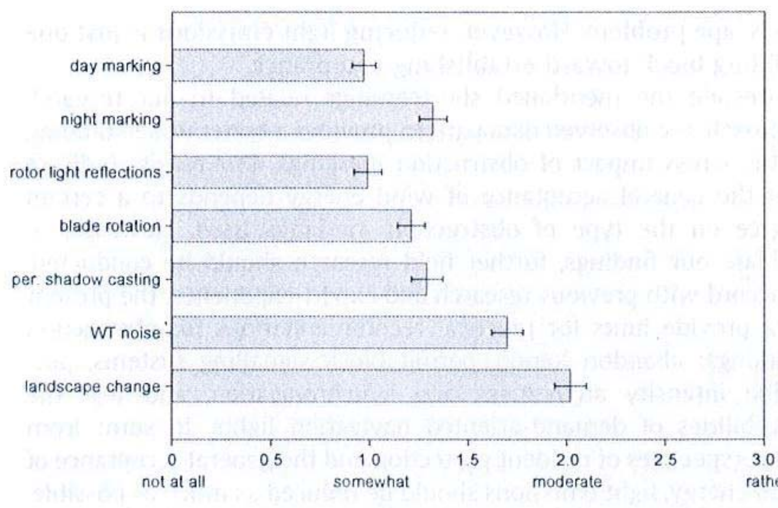

Fig. 8. Annoyance caused by obstruction markings compared to other WT emissions (total sample, *M* ∓ SEM, scale range: 0–4).

Of all wind farm "emissions", respondents reporting most annoyance associated with the change to the visual landscape, followed by noise with obstruction markings (day and night), reflections, blade rotation and shadow casting associated with lower degrees of annoyance (Figure 8).

Exposure group [21]	Control group [22]	Measure of effect / effect size [23]	Harms (NNH) [24]
See 'Adverse effect outcomes' [20]	N/A	**95% CI [25]** See 'Adverse effect outcomes' [20]	**95% CI [25]** See 'Adverse effect outcomes' [20]

Public health importance (1–4) [26]	Relevance (1–5) [27]
It is difficult to apply the rating scale on page 23 of the NHMRC Guidelines, as it is not suitable for this type of study, but given the limitations of this research, the lowest ranking (4) seems most appropriate.	It is difficult to apply the rating scale on page 27 of the NHMRC Guidelines, as it is not suitable for this type of study, but given the limitations of this research, the lowest ranking (5) seems most appropriate.

Comments [28]
This study was cross-sectional in design. This does not permit any conclusions regarding causation and health outcomes, in this case annoyance, from wind turbines. However, the results are consistent and the findings of the research robust. The study has limited capacity to inform the assessment of wind turbine obstruction markings as a cause of adverse health effects.

Abbreviations: NR = not reported; NC = not calculable; N/A = not applicable

Taylor 2013

Reference [1]
Taylor J, Eastwick C, Wilson R, Lawrence C. The influence of negative oriented personality traits on the effects of wind turbines. *Personality and Individual Differences.* 2013;54:338-43.

Affiliation/source of funds [2]
Mechanical, Materials and Manufacturing Engineering, University of Nottingham, Nottingham, UK Department of Architecture and the Built Environment, University of Nottingham, Nottingham, UK School of Psychology, University of Nottingham, Nottingham, UK Funded by a National Environment Research Council Grant issued by UK Energy Research Centre

Study design [3]	Level of evidence [4]	Location/setting [5]
Cross-sectional survey	IV	Two cities in the Midlands of the UK. **Proximity/distance:** Households living within 500m of eight 0.6 kW micro turbine installations and within 1 km of four 5 kW small wind turbine installations.

<table>
<tr><td>Exposure description [6]
Wind farm details: Eight 0.6 kW micro turbine installations and four 5 kW small wind turbines.
Specific exposure details:
Modelled sound pressure in A-weighted decibels with a sound map with 1m grid over map area. Grid plane located 1.5 m above ground. Across all turbine sites, approximately 9.5% of those living within region 2, 13.5% living in region 1 and 10% living within region 0 responded.
Sample size [7]
Questionnaires sent to N = 1270 households with 138 completed survey returned (response rate 10.7%).</td><td>Control(s) description [8] No non-exposed groups were included in the survey.
Sample size [9] See population characteristics.</td></tr>
<tr><td colspan="2">Population characteristics [10]
Exposure group: Any member of each household over the age of 18 could anonymously complete the survey. In total, 138 completed surveys were returned (age range of respondents = 20 - 95; mean age = 53.8, SD = 15.6; 1.4% were aged between 18 and 25, 12.3% between 26 and 35, 15.9% between 36 - 45, 23.2% between 46 - 55, 22.5% between 56 - 65, 12.3% between 66 - 75, 7.3% between 76 - 85 and 5.1% between 86 - 95. Response rate was 10.86% with 54.4% male.</td></tr>
<tr><td>Length of follow-up [11]
N/A</td><td>Outcome(s) measured and/or analyses undertaken [12] All outcomes measured by a self-reporting survey.</td></tr>
<tr><td>INTERNAL VALIDITY
Confounding subscale [13]
Comment on sources of confounding:
No adjustments were provided on likely confounders such as employment, economic benefit from turbines and background noise.
Bias subscale [14]
Comment on sources of bias:
The low response rate suggests that there may be sample selection bias. Masking of responders to the intent of the survey was not described.</td><td>EXTERNAL VALIDITY
Generalisability [15]
Survey mailed to a sample of subjects in the Midlands of the UK may not reflect the total population living within the 1 km distance from the wind farms.
Applicability [16]
Unknown whether the population characteristics and wind turbine exposures of the responders are comparable to those living near wind farms in Australia.</td></tr>
<tr><td colspan="2">Reporting subscale [17]
Comment on quality of reporting:
Overall reporting good, but negative orientated personality not well defined and there was a very low participation rate.</td></tr>
<tr><td colspan="2">Chance [18]
The possibility of spurious significant associations arising by chance cannot be excluded as multiple statistical tests were conducted.</td></tr>
</table>

Overall quality assessment (descriptive) [19]

Although the description of negative oriented personality traits was defined with some rigour, the results were not convincing given the relatively small response rate. The use of perceived turbine noise scale and its comparison to the calculated actual sound level (modelled) appeared plausible. However, discussion of confounders or bias was limited and the authors conceded that it was possible the responders were significantly different to the non-responders in terms of the variables measured.

RESULTS

Adverse effect outcomes [20]

Positive Affectivity (PA)

Negative Affectivity (NA)

Neuroticism (N)

Discomfort intolerance (F-disc)

Emotional intolerance (F-emot)

Non-specific somatic symptoms (SYMP)

Exposure group [21]

Table 2
Moderation results for loudness/occurrence of noise – symptom link with NOP measures as moderator.

	DR²	b		DR²	b
Step1	.229*		Step1	.001	
LOUD		.231*	ACTUAL		.028
PA		□.022	PA		□.027
Step 2	.003		Step 2	.004	
LOUD □ PA		□.055	ACTUAL □ PA		.063
Step1	.359***		Step1	.122**	
LOUD		.107	ACTUAL		□.49
NA		□.303**	NA		□.349**
Step 2	.038		Step 2	.001	
LOUD □ NA		□.390*	ACTUAL □ NA		□.004
Step1	.469***		Step1	.204**	
LOUD		.160	ACTUAL		□.098
N		□.415**	N		□.455**
Step 2	.016		Step 2	.002	
LOUD □ N		□.135	ACTUAL □ N		.056
Step1	.427***		Step1	.139**	
LOUD		.208*	ACTUAL		.008
F-disc		□.362**	F-disc		□.374**
Step 2	.039*		Step 2	.027	
LOUD □ F-disc		□.230*	ACTUAL □ F-disc		□.231
Step1	.412***		Step1	.153**	
LOUD		.135	ACTUAL		□.018
F-emot		□.355**	F-emot		□.390**
Step 2	.041*		Step 2	.018	
LOUD □ F-emot		□.338*	ACTUAL □ F-emot		□.192

Note: ACTUAL, estimated sound level score for each household; LOUD, perceived loudness of turbine; SYMP, mean symptom score; PA, Positive Affectivity; NA, Negative Affectivity; N, Neuroticism; F-disc, discomfort intolerance; F-emot, emotional intolerance.
* $p < .05$.
** $p < .01$.
*** $p < .001$

Respondents living in areas with low probability of hearing turbine noise had higher PA (mean = 2.86; SD = 1.05) than those living in areas with moderate (mean = 2.38; SD = 1.21) or high (1.97; SD = 1.04) probability of hearing turbine noise ($p \leq 0.05$) ($F_{2,118}$ = 6.40; partial g^2 = 0.10; $p < 0.01$). There were no sex differences across the three regions (υ^2 = 2.11; p = 0.35).

Control group [22]

N/A

Measure of effect / effect size [23]

95% CI [25]

NC

Harms (NNH) [24]

95% CI [25]

NC

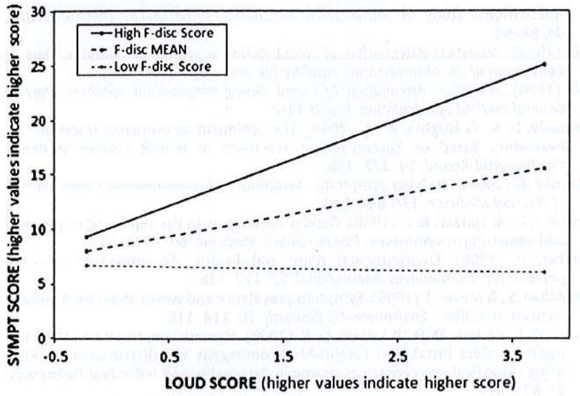

Fig. 2. Simple slopes for the loudness of noise–symptoms link with F-disc as moderator. *Note:* LOUD = perceived loudness of wind turbine noise, F-disc = discomfort intolerance; SYMP = mean symptom score.

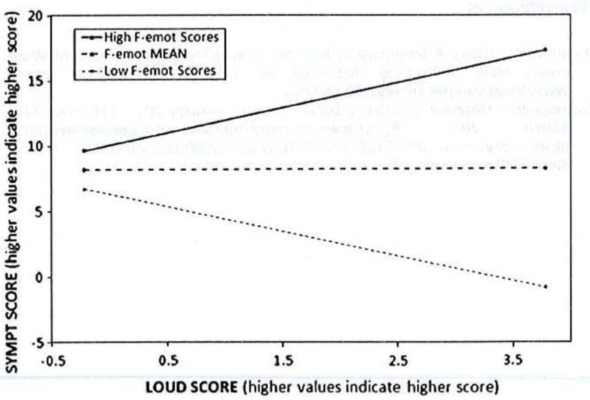

Fig. 3. Simple slopes for the loudness of noise–symptoms link with F-emot as moderator. *Note:* LOUD = perceived loudness of wind turbine noise, F-emot = emotional intolerance; SYMP = mean symptom score.

The simple slope analyses showed that the link between perceived loudness and symptoms reporting only occurred at high levels of discomfort intolerance ($b = 3.954$, $t = 3.4815$, $p < 0.001$, Fig 2) and emotional intolerance ($b = 1.921$, $t = 1.677$, $p < 0.096$, Fig 3). However, the simple slope analyses examining the link between perceived loudness and symptoms reporting did not reach significance at any level of NA. Calculated actual turbine noise did not affect symptom reporting directly or interactively.

Public health importance (1–4) [26]	Relevance (1–5) [27]
It is difficult to apply the rating scale on page 23 of the NHMRC Guidelines, as it is not suitable for this type of study, but given the limitations of this research, the lowest ranking (4) seems most appropriate.	It is difficult to apply the rating scale on page 27 of the NHMRC Guidelines, as it is not suitable for this type of study, but given the limitations of this research, the lowest ranking (5) seems most appropriate.

Comments [28] The overall finding was that perception of noise rather than actual noise exposure is important in predicting symptoms of ill-health, and that this relationship is stronger in those who have personality characterised by Negative Affect, and intolerance of negative emotion and events. However this finding is not convincing given the low response rate, lack of description of non-responders and use of modelled noise exposure instead of actual measurements for relatively small wind turbines. The study has limited capacity to inform the assessment of wind turbine noise as a cause of adverse health effects.

Abbreviations: NR = not reported; NC = not calculable; N/A = not applicable

Yano 2013

Reference [1]

Yano T, Kuwano S, Kageyama T, Sueka S, Tachibana H. Dose-response relationship for wind turbine noise in Japan. *42nd International Congress and Exposition on Noise Control Engineering*, Innsbruck, Austria, 15-18 September 2013.

Affiliation/source of funds [2]

Osaka University, Japan; Kumamoto University, Japan; Oita University of Nursing and Health Sciences, Japan; Sueoka Professional Engineer Office, Japan; Chiba Institute of Technology, Japan. Funding from the Ministry of the Environment of Japan (Project No. S2-11).

Study design [3]	Level of evidence [4]	Location/setting [5]
Cross-sectional study.	IV	Various sites from Hokkaido to Okinawa in Japan. **Proximity/distance:** Respondents' houses were from 90 to 1466 m apart from the closest wind turbine.

Exposure description [6]	Control(s) description [8]
Wind farm details: 36 "target sites" were identified with audible wind turbine noise from Hokkaido to Okinawa, Japan. Regular electricity generation of wind turbines was from 400 kW to 3,000 kW, mainly more than 1,500 kW. **Specific exposure details:** The average sound pressure levels $L_{Aeq,n}$ in decibels was measured with sound levels ranging from 26 dB to 50 dB. Nine sites were observed to have strong sea wave sound during winter. **Sample size [7]** 747 respondents in 'target site' areas were approached by door knocking, of whom 49% participated (n=~ 366, calculated).	Residents at 16 control sites where wind turbine noise is inaudible but no turbines were visible. **Sample size [9]** 332 control site respondents were approached by door knocking, of whom 45% responded (n= ~145, calculated).

Population characteristics [10]

Exposure group

Table 1 Noise exposure, the number of respondents and the prevalence of annoyance

$L_{Aeq,n}$ (dB)	No. of respondents	%extremely	%extremely+very	%extremely+very+moderately
-30	30	10.0	10.0	26.7
31-35	114	2.6	9.7	31.6
36-40	247	6.5	12.6	36.0
41-45	207	14.0	19.8	38.7
45+	53	18.9	22.6	50.9

Length of follow-up [11]

N/a cross-sectional study.

Outcome(s) measured and/or analyses undertaken [12]

Annoyance related to wind turbine noise was evaluated by ICBEN 5-point verbal scale: extremely, very, moderately, slightly or not at all. Analysis metric was created by combining moderately, very and extremely annoyed by wind turbine noise (see Kuwano 2013, appendix).

INTERNAL VALIDITY

Confounding subscale [13]

Comment on sources of confounding:
No mention of addressing of confounders.

Bias subscale [14]

Comment on sources of bias:
Poor response rate

EXTERNAL VALIDITY

Generalisability [15]

Cross-sectional survey limits ability to determine causality.

Demographics not reported in detail in present paper but see Kuwano et al (2013) for detailed about this survey sample and its generalisability. Age distribution and cultural expectations of elderly Japanese likely to limit generalisability to Australia.

Applicability [16]

Population density in wind turbine areas surveyed not clear but likely more dense than wind turbine areas in Australia which are typically rural and relatively sparsely populated. Likely differences in background noise and sound paths due to different environments.

Reporting subscale [17]

Comment on quality of reporting:
Key details unreported, for example full description of the wind turbine and control areas (urban/rural, population density) and detailed recruitment methodology.

Chance [18]

Large number of statistical tests indicates possibility for chance findings however directionality of dose-response curves are as expected. No mention of statistical adjustments for chance.

Overall quality assessment (descriptive) [19]

Possibility of exposure misclassification (exposure time not evaluated), outcome misclassification (some questions not validated instruments) sample selection bias (low response rate), confounding and reporting bias (unclear if participants were blinded to purpose of study, unlikely to be blinded to purpose of the particular question used to assess the outcome in this analysis). Conclusions based on sea wave noise speculative and not clearly supported by systematically collected data. Sensitivity to noise poorly defined.

RESULTS

Adverse effect outcomes [20]

Table 2 Relation between $L_{Aeq,n}$ and % extremely annoyed per subgroup

Factors	Category	% extremely annoyed	Relation between $L_{Aeq,n}$ and % extremely annoyed (Chi^2_{MH})
Are you interested in environmental problems?	No/neither “no” nor “yes”	2.5	2.53 (ns)
	Yes	18.4	9.67 ***
	Fisher’s exact test	***	
Is wind turbine generator a good method?	Yes	5.9	9.23 **
	No	14.6	3.61 (ns)
	Fisher’s exact test	*	
Do you receive any benefit from wind turbine?	Yes	4.9	0.36 (ns)
	No/do not know	10.0	12.15 ***
	Fisher’s exact test	ns	
Does wind turbine disturb the landscape?	No	5.1	13.60 ***
	Yes	37.2	2.21 (ns)
	Fisher’s exact test	***	
Are you sensitive to noise?	No/neither “no” nor “yes”	2.5	5.41 *
	Yes	15.9	26.04 ***
	Fisher’s exact test	***	

Respondents were significantly more likely to report being extremely annoyed by wind turbines if they reported being interested in environmental problems, believed that wind turbines were not a good method and if they viewed wind turbines as a landscape disturbance. Self-reported sensitivity to noise was also associated with greater propensity to report being extremely annoyed by wind turbines.

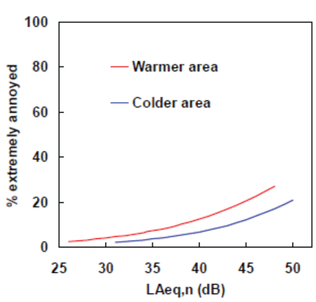

Figure 3 Comparison of dose-response relationships between colder and warmer areas

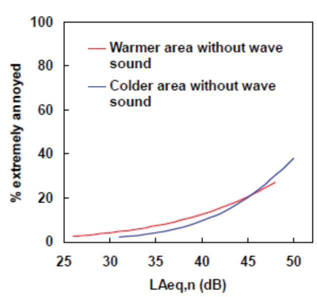

Figure 4 Comparison of dose-response relationships between colder and warmer areas without wave sound

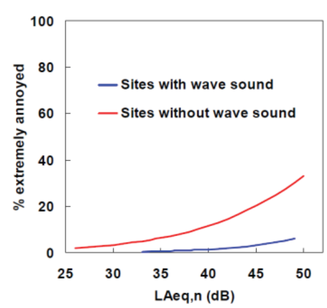

Figure 5 Effects of sea wave sound on dose-response relationships for wind turbine noise annoyance

Using multiple logistic regression analyses using probability of extremely annoyed or not as the dependent variable, no significant differences were found for colder and warmer areas (p > 0.05), however similar analyses showed that sea wave sound was inversely associated with probability of extremely annoyed

<table>
<tr><td colspan="4">(p < 0.005) and the authors suggested this was because of masking of turbine noise by sea wave sound.</td></tr>
<tr><td>Exposure group [21]
See ‘Adverse effect outcomes’ [20].</td><td>Control group [22]
See ‘Adverse effect outcomes’ [20].</td><td>Measure of effect / effect size [23]
95% CI [25]
See ‘Adverse effect outcomes’ [20].</td><td>Harms (NNH) [24]
95% CI [25]
See ‘Adverse effect outcomes’ [20].</td></tr>
<tr><td colspan="2">Public health importance (1–4) [26]
It is difficult to apply the rating scale on page 23 of the NHMRC Guidelines, as it is not suitable for this type of study, where many outcomes have been measured, but given the limitations of this research, the lowest ranking (4) seems most appropriate.</td><td colspan="2">Relevance (1–5) [27]
It is difficult to apply the rating scale on page 27 of the NHMRC Guidelines, as it is not suitable for this type of non-intervention study, but given the limitations of this research, the lowest ranking (5) seems most appropriate.</td></tr>
<tr><td colspan="4">Comments [28]
This cross-sectional survey does not permit any conclusions about causation because it cannot be determined that exposures precede outcomes. Self-reported exposures and outcomes are likely to be subject to reporting bias and recruitment bias is also likely. Overall noise profile of control areas is likely to be systematically different to wind turbine areas in ways other than presence of turbines. Over-recruitment of elderly residents limits generalisability to broader population. Although context is poorly described, differences between Japanese and Australian contexts likely limit generalisability to Australia.
This study has very limited capacity to inform the assessment of wind turbine noise of adverse health effects.</td></tr>
</table>

Explanatory notes

[1] Full reference citation details

[2] Details of how the study was funded or other relevant affiliations of the authors (designed to expose potential conflicts of interest)

[3] The study type (e.g. RCT, case-control study, cohort study), with additional detail where relevant

[4] As per the NHMRC levels of evidence in Merlin, Weston and Tooher (2009) or NHMRC (2009)

[5] Country/setting (e.g. detail on location in rural area, wind farm distance/proximity to study participants and turbine visibility)

[6] Detail on the exposure, including the type of wind farm, number of turbines, design/model of turbines, age of turbines, when construction of the wind farm was completed, community participation in decision making etc. Detail is required on the specific exposures—audible noise, infrasound/inaudible noise, shadow flicker, electromagnetic radiation, e.g. dose/level of exposure

[7] Number of participants enrolled in the exposure group

[8] The type of control used. There may be more than one comparator (e.g. no wind farm (no exposure), different type of wind farm)

[9] Number of participants enrolled in the comparison/control group(s)

[10] Any factors that may confound/influence the results and/or the external validity (see below) of the results (e.g. age, sex, comorbidities, existing medications, socioeconomic status, baseline attitudes to wind farm siting, education level, occupation (e.g. shift work), psychosocial stressors, financial implications of wind farm siting)

[11] Length of follow-up of the participants

[12] The outcomes studied (all adverse health effects mentioned in the study)

INTERNAL VALIDITY (QUALITY ASSESSMENT)

[13] Report outcomes of use of modified Downs & Black checklist for the Confounding subscale. Comment on likelihood of confounding having affected the results and justify

[14] Report outcomes of use of modified Downs & Black checklist for the Bias subscale. Comment on likelihood of bias having affected the results and justify

EXTERNAL VALIDITY

[15] Report outcomes of use of modified Downs & Black checklist for the External Validity subscale. Comment on generalisability of the study results and justify; that is, are the participants in the study so different from the target population for the NHMRC recommendation that the results may not be generalisable to them?

[16] Is the exposure in the study so different from the exposures likely to occur in Australia that the results may not be applicable?

[17] Report outcomes of use of modified Downs & Black checklist for the Reporting subscale. Comment on appropriateness of reporting in the study

[18] When assessing the role of chance, note the use of multiple statistical testing and data dredging, which may result in spurious statistically significant results

[19] Describe your assessment (in words) of the overall quality of the study. Is the study quality good enough that you have confidence in the results?

RESULTS

Allowing one row for each relevant outcome, enter the following data from the results of the study:

[20] The outcome relevant for this entry in the database (Note: more than one table may be required if there are several outcomes relevant to different questions)

[21] For binary outcomes, show numbers of participants with the outcome. For continuous outcomes, show means ± standard deviations; or medians and interquartile ranges

[22] For binary outcomes, show numbers of participants with the outcome. For continuous outcomes, show means ± standard deviations; or medians and interquartile ranges. Add number of columns as needed (e.g. 3-arm trials)

[23] Absolute and relative measures of effect and measure of variability, for example risk differences (absolute risk reduction or absolute risk increase), mean differences, relative risk, odds ratio

[24] A measure of harm, when the exposure increases the risk of specified adverse outcomes. The number needed to expose to harm (NNH) = the number of participants who, if they receive the exposure, would lead to one additional person being harmed compared with participants who are not exposed; calculated as 1/absolute risk increase, rounded up to the next highest whole number

[25] 95% confidence interval (CI) for all measures, if available; otherwise, use p value (be explicit on what comparison the p value relates to)

[26] Insert the appropriate rating from the scale provided at p. 23 of the NHMRC toolkit publication: *How to use the evidence: assessment and application of scientific evidence*

[27] Insert the appropriate rating from the scale provided at p. 28 of the NHMRC toolkit publication: *How to use the evidence: assessment and application of scientific evidence*

[28] Add your overall comments regarding the interpretation or implications of this study.