

# Literature Review 2013: Association between Wind Turbine Noise and Human Distress



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# Introduction

- General Wind Turbine Statistics
- Hill's Criteria for Causation
- Level of Evidence in Research
- General View of the Research Process

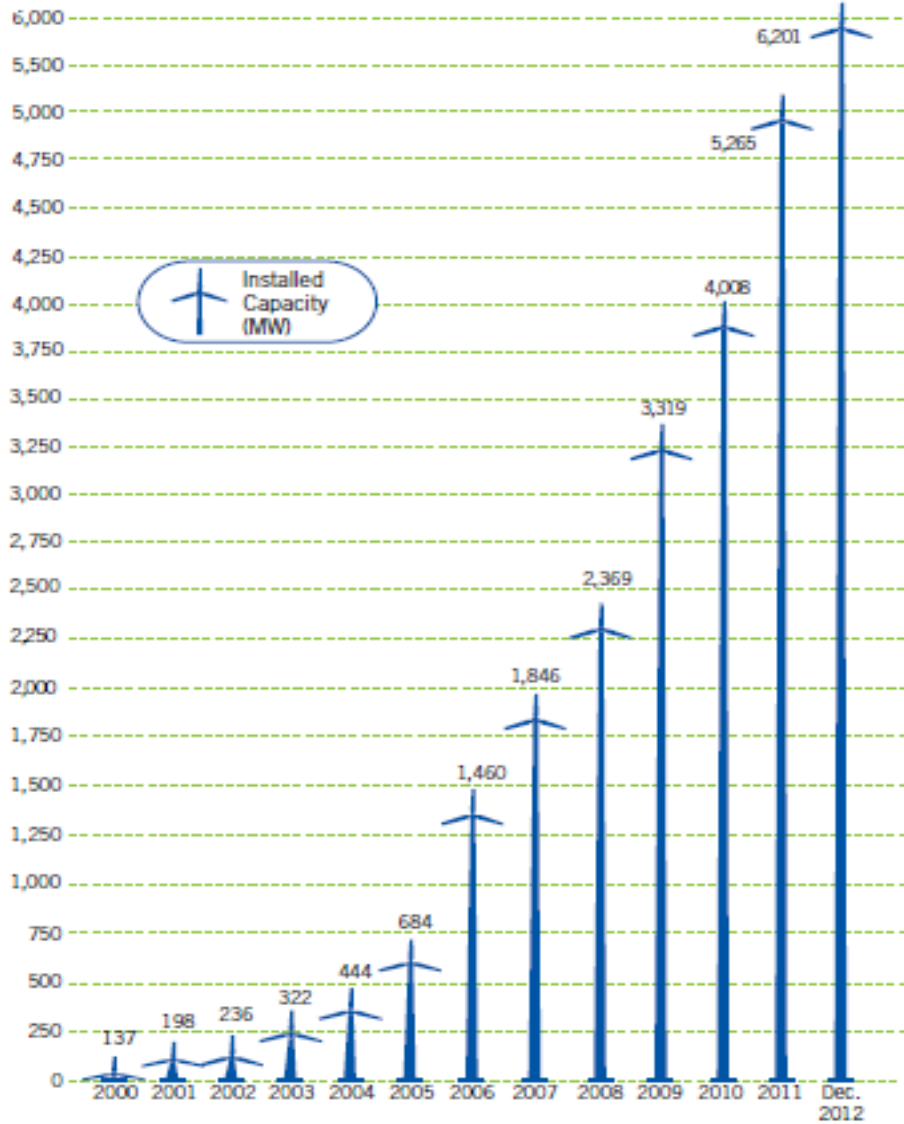
# General Wind Turbine Statistics

## Number of Turbines in Canada Dec 2012: **(3510)**

- Alberta: 644 turbines
- British Columbia: 83 turbines
- Manitoba: 123 turbines
- New Scotland: 276 turbines
- Ontario: 1,064 turbines
- Prince Edward: 95 turbines
- Québec : 1,052 turbines
- Saskatchewan: 132 turbines
- Terre-Neuve-et-Labrador: 39 turbines
- Yukon: 2 turbines

[www.thewindpower.net/country\\_zones\\_en\\_14\\_canada.php](http://www.thewindpower.net/country_zones_en_14_canada.php) (Update : Dec 2012  
Accessed : Jan 26 2013 )

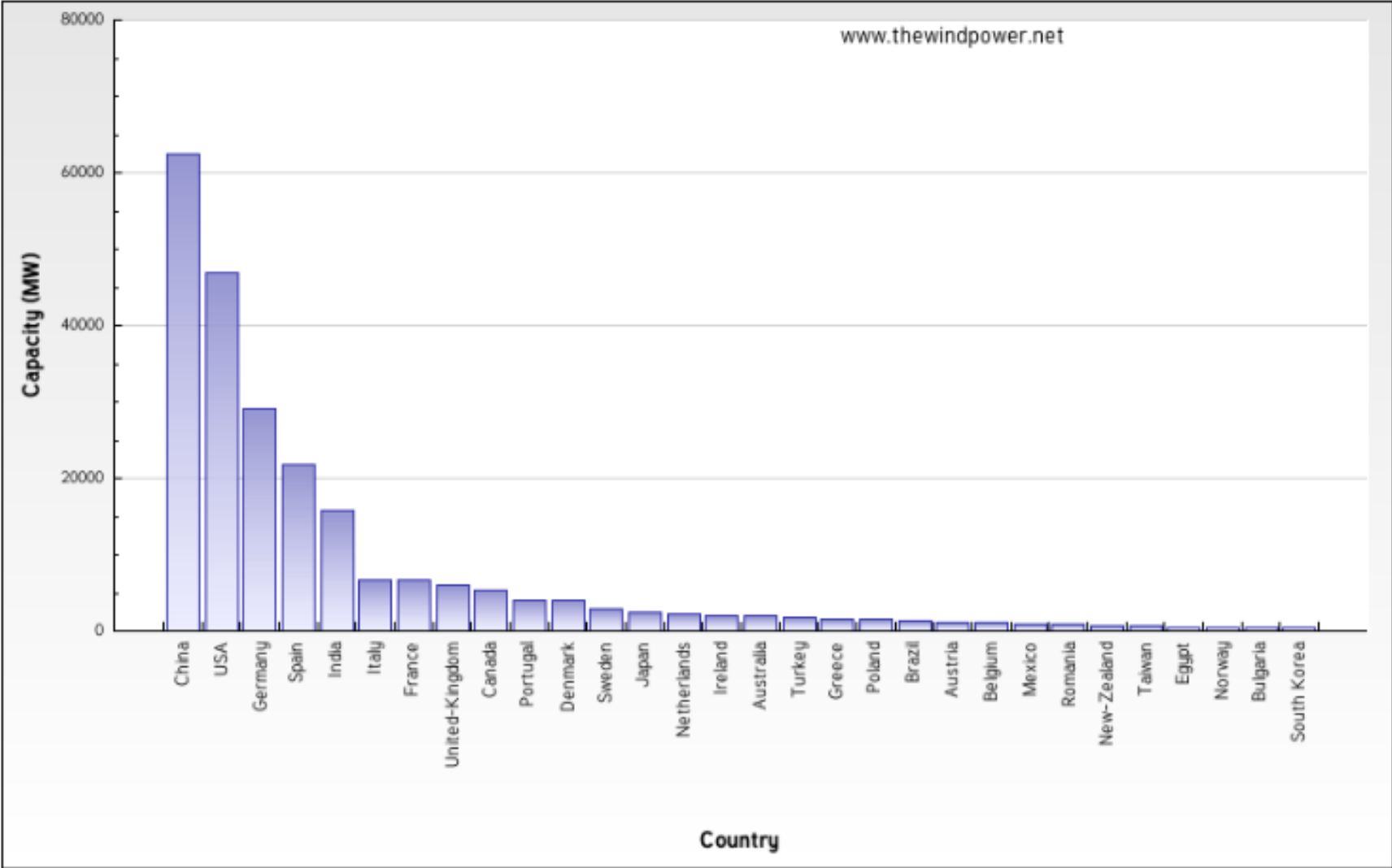
# General Wind Turbine Statistics



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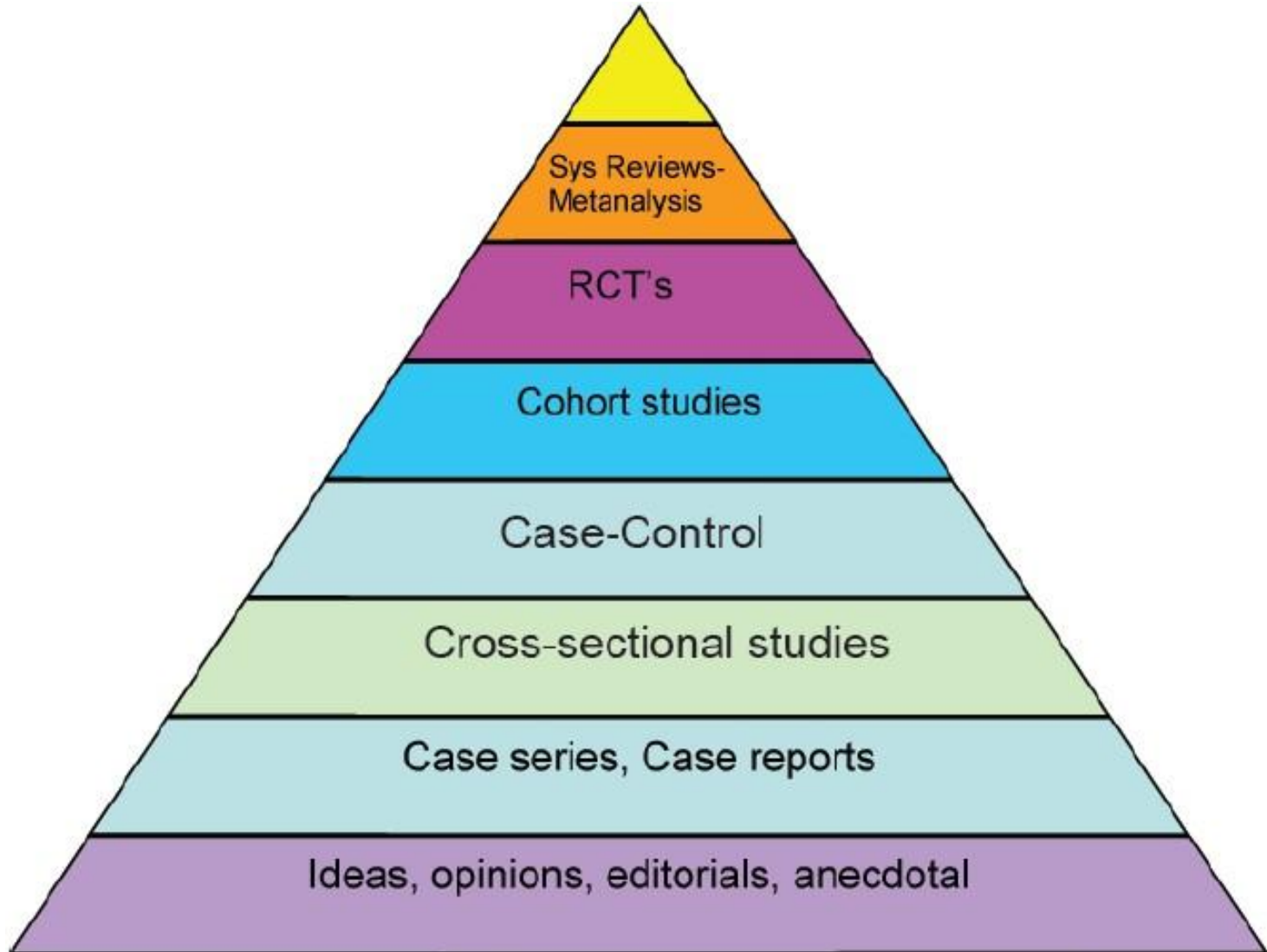
# General Wind Turbine Statistics



# Hill's Criteria for Causality

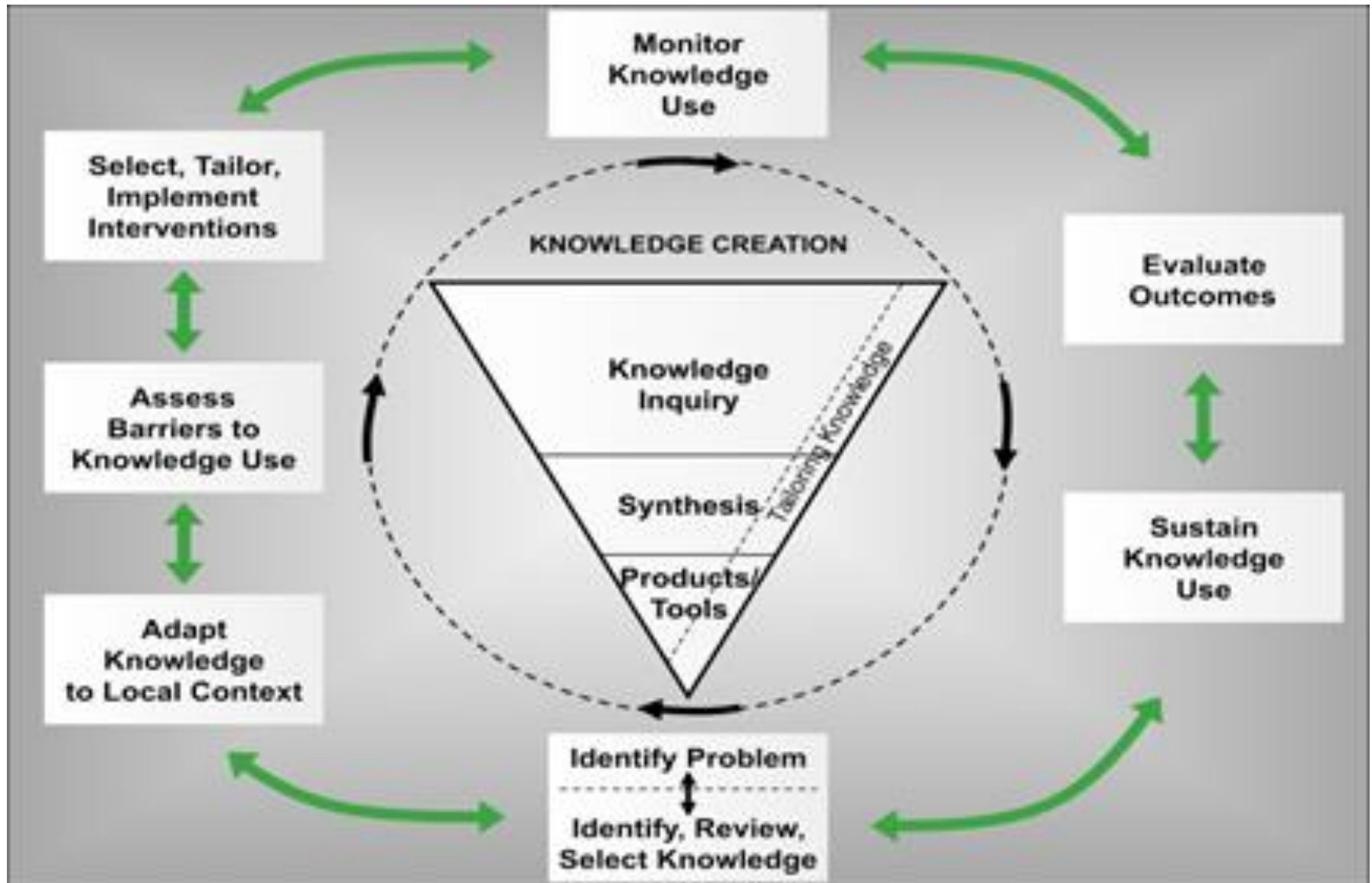
- Strength of the association.** How large is the effect?
- The consistency of the association.** Has the same association been observed by others, in different populations, using a different method?
- Specificity.** Does altering only the cause alter the effect?
- Temporal relationship.** Does the cause precede the effect?
- Biological gradient.** Is there a dose response?
- Biological plausibility.** Does it make sense?
- Coherence.** Does the evidence fit with what is known regarding the natural history and biology of the outcome?
- Experimental evidence.** Are there any clinical studies supporting the association?
- Reasoning by analogy.** Is the observed association supported by similar associations?

# Level of Evidence in Research

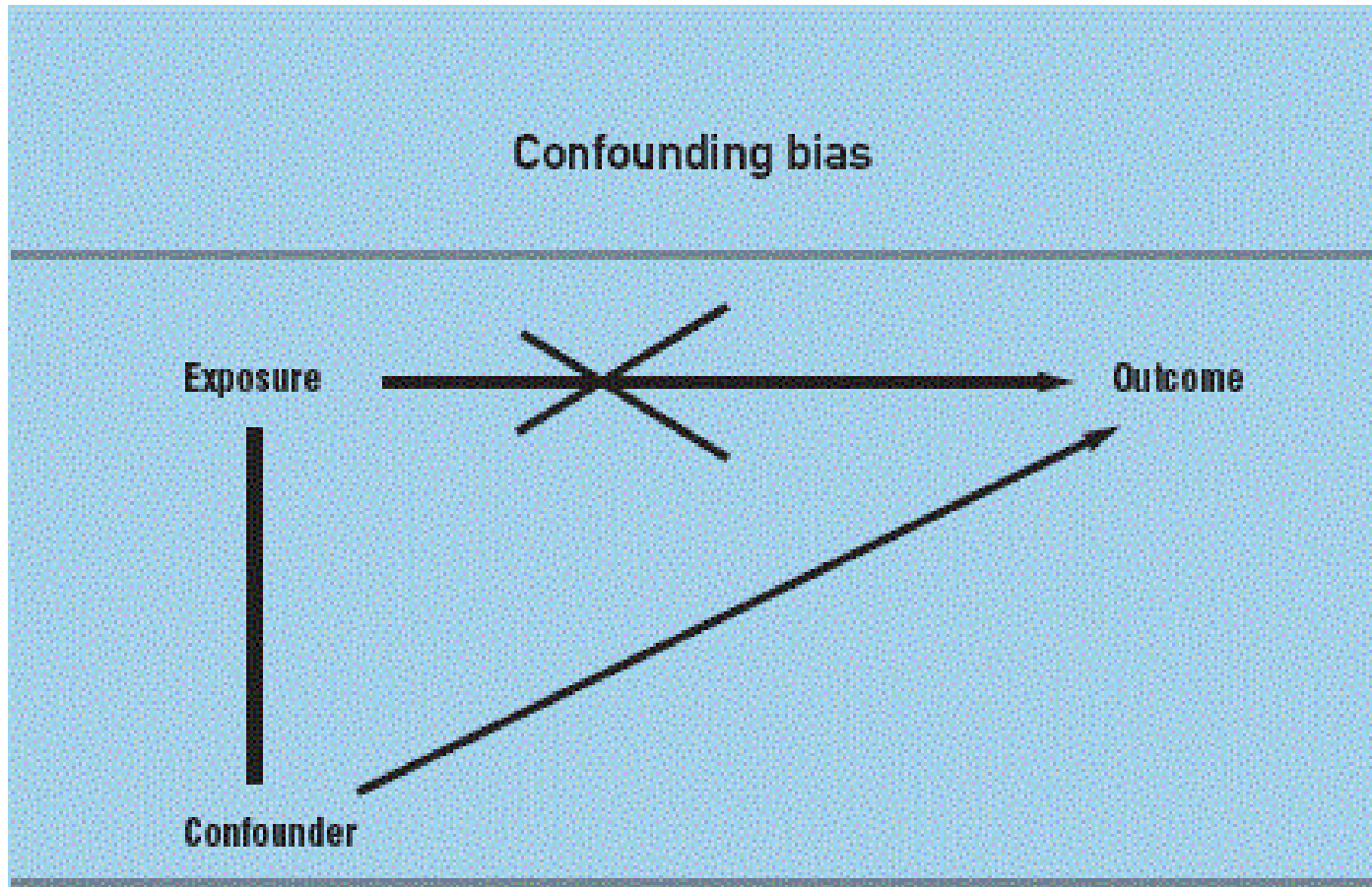




# The Process of Research



# The Process of Research



In confounding bias, there is an association between the exposure (such as a treatment), and some other factor (the confounder) that actually leads to the outcome. Despite the apparent direct relationship between the exposure and the outcome, the latter is actually due to the confounding factor.



# Study Objectives

To search the literature investigating the presence or absence of association between wind turbines induced-noise and human distress.

# Hypothesis

**Null Hypothesis** (Our investigation will disprove or fail to disprove , never prove):

There is no association between wind turbines induced-noise and human distress

**Alternative Hypothesis** ( Will be accepted if the Null is disproven):

An association exists between wind turbines induced-noise and human distress

# Search Stages

## 1 Database Search (Stage 1)

A search strategy was developed and conducted to capture articles in compliance with the review's Inclusion Criteria.

## 2 Titles and Abstract Review (Stage 2)

The titles and abstracts of the articles captured by Stage 1 was screened to exclude any obvious ineligible articles.

## 3 Full Article Review (Stage 3)

A copy of the full article was obtained for each of the studies included in Stage 2. A full article review of the these articles was conducted to achieve the following two goals.

- First, to exclude any reports of ineligible articles, and
- second, to collect data on the review variables

# Databases Included in the Search

EMBASE: "more than 7,600 currently indexed peer-reviewed journals"

PubMed: A commonly used database for clinical research

PsycINFO: "is an expansive abstracting and indexing database with more than 3 million records devoted to peer-reviewed literature in the behavioral sciences and mental health, making it an ideal discovery and linking tool for scholarly research in a host of disciplines."

The Cochrane Library: "Database of Systematic Reviews"

Scopus "The largest abstract and citation database of research literature and quality web sources covering nearly 18,000 titles from more than 5,000 publishers".

Scirus: "Scirus is the most comprehensive science-specific search engine on the Internet. Driven by the latest search engine technology, Scirus searches over 440 million science-specific Web pages"

Open SIGLE (System for Information on Grey Literature in Europe)

# Study Design

## Inclusion Criteria:

- Studies examining association between wind turbine noise and distress
- Studies that are published in peer-reviewed journals
- English language
- Studies involving humans

## Exclusion Criteria:

- Investigations reporting interim analysis that did not result in stopping the study
- Secondary and long-term update
- Duplicate reports
- Cost effectiveness and economic studies



# Variables Considered in this Review

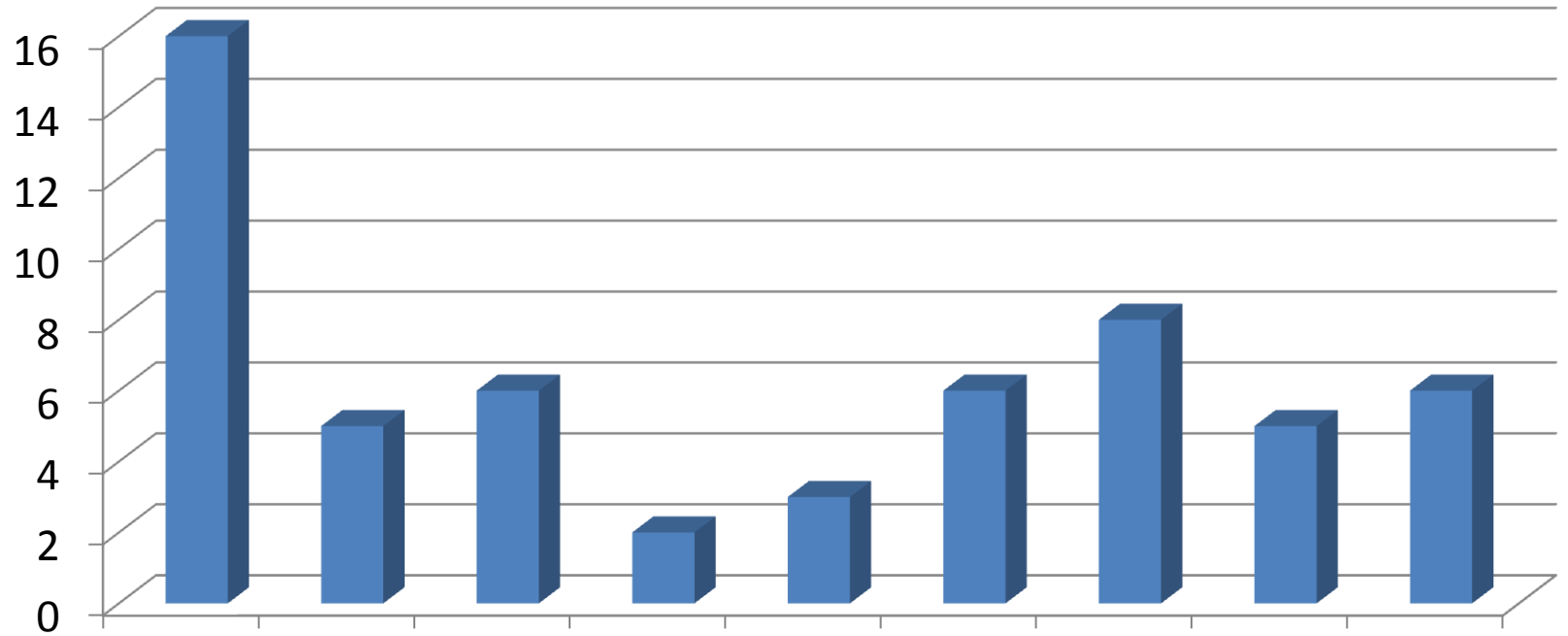
- First Author
- Year of publication
- Journal of Publication
- Country of Study
- Study Design
- Sample Size
- Response Rate
- Objective of Study
- Level of Evidence
- Quality of Study
- Conclusion of Study Effect

# Variables Examined in the Studies

- Annoyance (sensitivity to noise)
- Attitude to wind turbines
- Dose-response
- Economical benefit
- Infrasound effect Road Traffic Noise / quiet rural environment
- Sleep Disturbance
- Visual impact
- Well being (Quality of Life / mental effect)

# Results

# Frequency of Variable Investigated



Annoyance / sensitivity to noise

Attitude to wind turbines

Does-response

Economical benefit

Infrasound effect

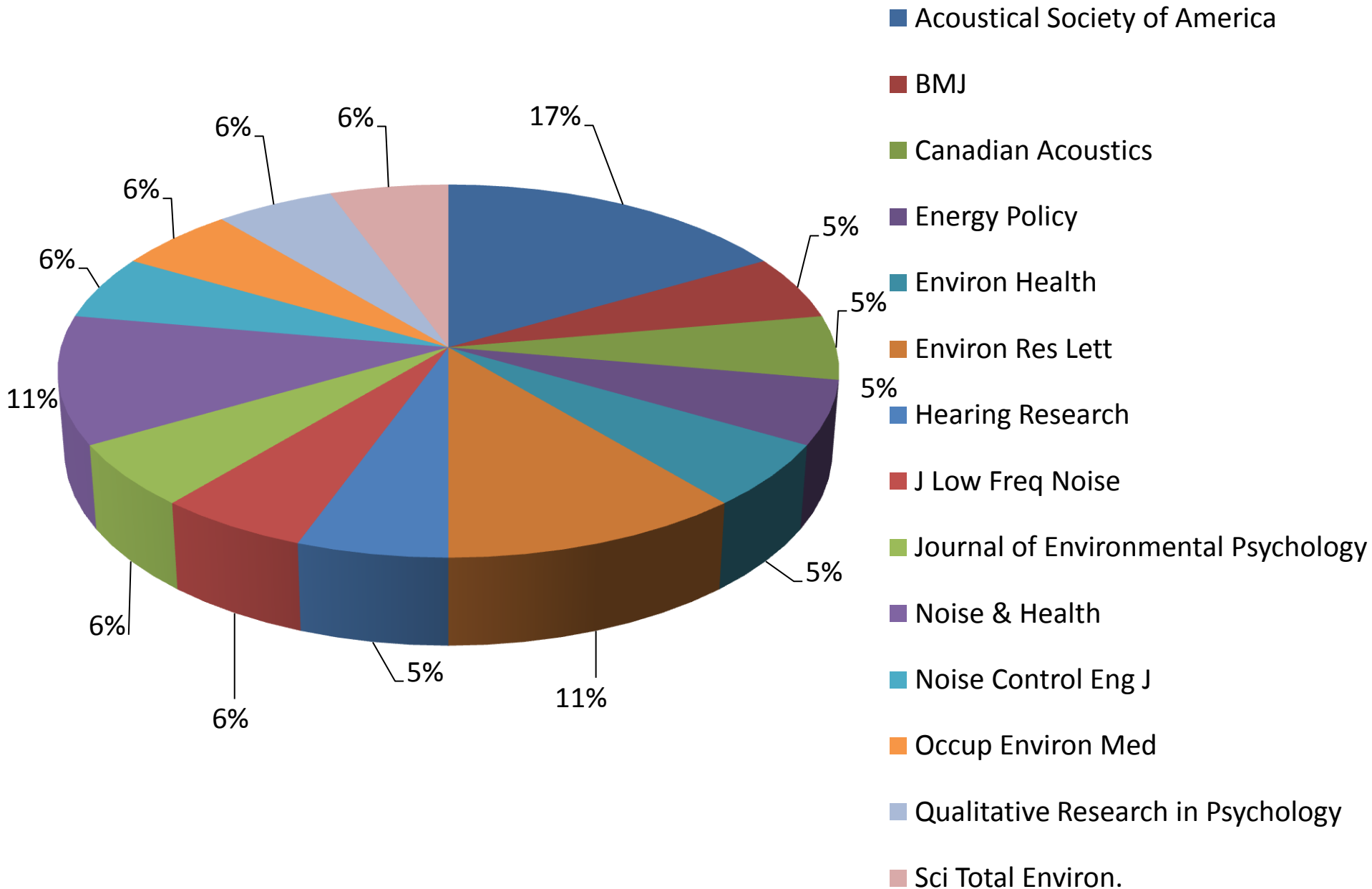
Road Traffic Noise / quiet rural environment

Sleep Disturbance

Visual impact

Well being (Quality of Life / mental effect)

# Percentage by Journal of Publication



# Frequency by Country

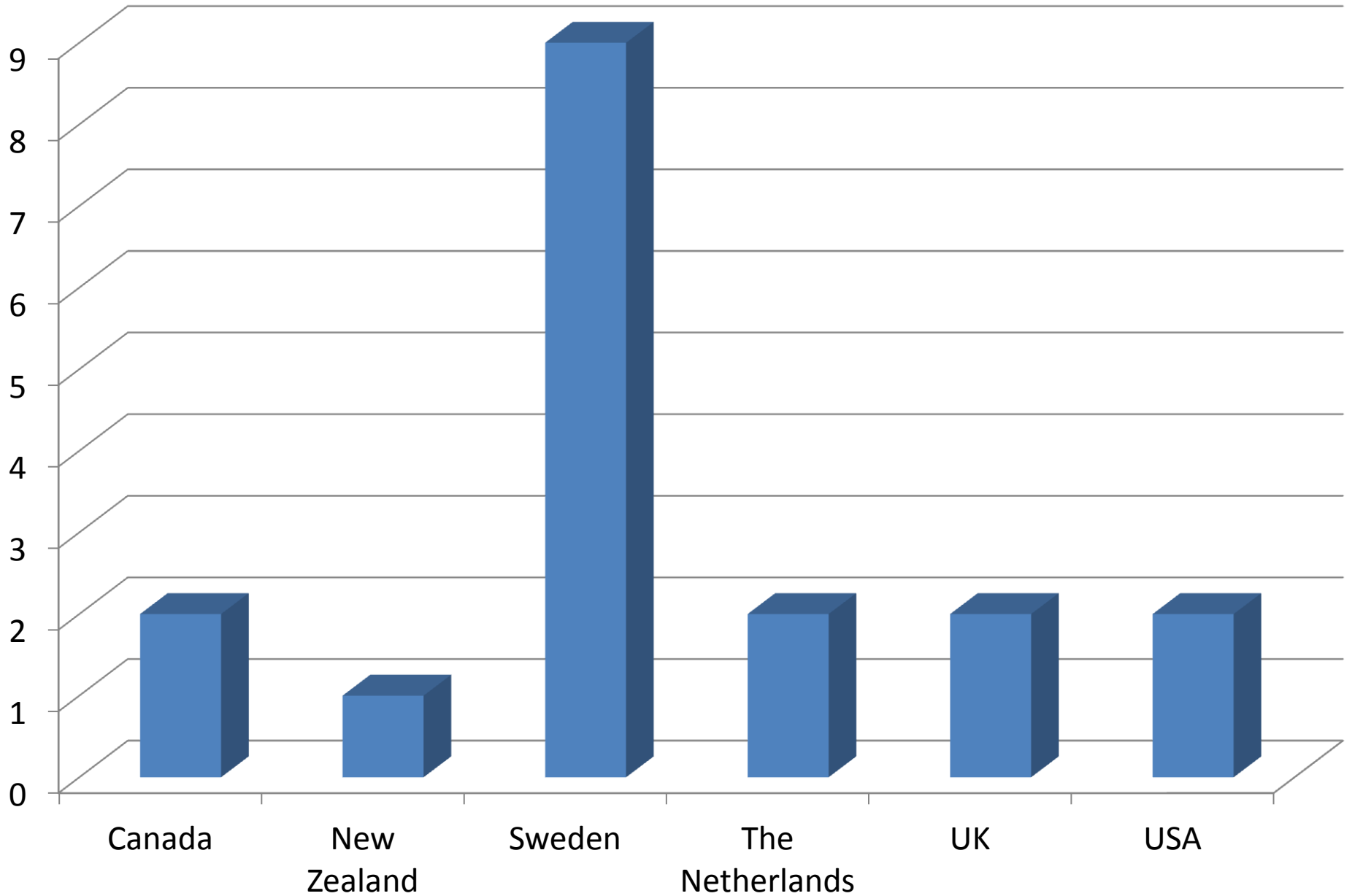


Table 1, Part 1: Review of Peer-reviewed Studies Published between January 1992- November 2012 Investigating the Association between Wind Turbine Noise and Human Distress									
1st Author, Year	Journal Name	Country	Level of Evidence	Quality of Study	Study Design	Sample Size	Response Rate	Effect	Comments
Bakker, 2012	Sci Total Environ	The Netherlands	4	Low	Cross-sectional (Survey)	725	37%	+	multiple sources of potential bias
Hanning, 2012	BMJ	UK	5	Moderate	Expert Opinion/Review	N/A	N/A	+	Review
Nissenbaum, 2012	Noise & Health	USA	4	High	Stratified Cross-sectional (375- 1400 m/3.3 - 6.6km)	N= 79	<sup>1</sup>	+	Excellent Research
Knopper, 2011	Environ Health	Canada	4	High	Review	15 articles	N/A	+	Review
Shepherd, 2011	Noise & Health	New Zealand	3 / 4	High	Cross-sectional	39 vs 158 from the turbine and comparison groups	34% vs 32%	+	Extremely robust research
Janssen, 2011	Acoustical Society of America	The Netherlands	?	?	Analysis of data from 3 cross-sectional studies	(N=341, N=754, N=725)	<sup>1</sup>	+	Full article is not available

N/A = Not applicable; <sup>1</sup> = Data not available; High<sup>2</sup> = Available data indicates high quality

**Table 1, Part : Review of Peer-reviewed Studies Published between January 1992- November 2012 Investigating the Association between Wind Turbine Noise and Human Distress**

1st Author, Year	Journal Name	Country	Level of Evidence	Quality of Study	Study Design	Sample Size	Response Rate	Effect	Comments
Pedersen, 2011	Noise Control Eng J	Sweden	4	High	Analysis of data from 3 cross-sectional studies	1755	Not reported	+	
Bolin, 2011	Environ Res Lett	Sweden	4	Low	Review			+	Review
Pedersen, 2010	Energy Policy	Sweden	4	High	Cross-sectional (Survey)	725	37%	+	500kW Versus road data
Salt, 2010	Hearing Research	USA	5	High	Expert Opinion	N/A	N/A	+	
Pedersen, 2009	Acoustical Society of America	Sweden	4	High <sup>2</sup>	Cross-sectional (Survey)	1	1	+	Full article is not available
Pedersen, 2008	J of Environ Psychology	Sweden	4	High	Analysis of data from 2 cross-sectional studies	1095	N/A	+	

N/A = Not applicable; <sup>1</sup> = Data not available; High<sup>2</sup> = Available data indicates high quality



Table 1, Part3: Review of Peer-reviewed Studies Published between January 1992- November 2012 Investigating the Association between Wind Turbine Noise and Human Distress									
1st Author, Year	Journal	Country	Level of Evidence	Quality of Study	Study Design	Sample Size	Response Rate	Effect	Comments
Keith, 2008	J Low Freq Noise	Canada	5	High <sup>2</sup>	Expert Opinion	N/A	N/A	+	using predicted noise levels
Pedersen, 2008	Environ Res Lett	Sweden	4	High <sup>2</sup>				+	Full article is not available
Pedersen, 2007	Qualitative Res in Psychology	Sweden	4	High	Qualitative Study (In-depth interviews)	15	N/A	+	Robust research
Pedersen, 2007	Occup Environ Med	Sweden	4	High	Cross-sectional (Survey)	754	57.60%	+	
Pedersen, 2004	Acoustical Society of America	Sweden	4	High <sup>2</sup>	Cross-sectional (Survey)	351	68.40%	+	Full article is not available
Leventhall, 2006	Canadian Acoustics	UK	5	High	Expert Opinion	N/A	N/A	+	
N/A = Not applicable; <sup>1</sup> = Data not available; High <sup>2</sup> = Available data indicates high quality									

Table 2, Review of Peer-reviewed Studies Published between January 1992- November 2012 Investigating the Association between Wind Turbine Noise and Human Distress									
1st Author, Year	Dose-response	Road Traffic Noise / quiet rural environment	Sleep Disturbance	Annoyance/ sensitivity to noise	visual impact	attitude to wind turbines	Infrasound effect	Well being (Quality of Life / mental effect)	economic benefit
Bakker, 2012	✓		✓	✓				✓	
Hanning, 2012			✓	✓				✓	
Nissenbaum, 2012	✓		✓	✓				✓	
Knopper, 2011	✓	✓	✓	✓	✓	✓	✓		
Shepherd, 2011			✓	✓				✓	
Janssen, 2011		✓		✓	✓				✓
Pedersen, 2011				✓				✓	
Bolin, 2011			✓						
Pedersen, 2010		✓		✓					
Salt, 2010				✓			✓		
Pedersen, 2009	✓			✓	✓	✓			✓
Pedersen, 2008			✓	✓	✓	✓			
Keith, 2008				✓					
Pedersen, 2008						✓			
Pedersen, 2007		✓		✓					
Pedersen, 2007	✓	✓	✓	✓					
Pedersen, 2004	✓	✓		✓	✓	✓			
Leventhall, 2006				✓			✓	✓	

# Discussion

- All studies rejected the Null Hypothesis (no association between wind turbine noise and human distress). In other words, evidence of association was found (Weak evidence: Level 4 and 5)
- No published peer-reviewed study showed no association
- Three studies showed **dose-response relationship**
- The studies are level 4 or 5 (A weak type of evidence). Nevertheless, **strongly warrant further research** (Multiple studies, multiple designs, investigating multiple hypothesis).

# Potential Solutions

“There is one company in particular, though, that has developed a new “style” of wind turbine “Quiet Revolution” turbine.... The company that manufactures these turbines claims that the eccentric “S” shaped blades enable it to mostly eradicate all noise related to the turning of the blades.”



# Potential Solutions

- “The most obvious example (and, as evidenced above, not necessarily always the most doable one) would be to locate turbines and their generators in as remote a location as possible. However, sometimes the close proximity of residences and towns make this task next to impossible.”
- Perhaps off shore

# Potential Solutions

“Another suggestion seems rather simple as well: research the existing “background” noise levels for the area intended for wind turbine construction. Following this step, measurements of noise levels for the turbine itself should be recorded. Then the question must be asked: how do these two noise levels compare? If the “normal” existing background noise is projected to be greater than that of the turbine, then noise should not necessarily become a mitigating factor in construction of said turbine”