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 (Update : Dec 2012
Accessed : Jan 26 2013 )
General Wind Turbine Statistics
General Wind Turbine Statistics

Canada’s current installed capacity: 6,201 MW
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

- Sys Reviews/Metanalysis
- RCT's
- Cohort studies
- Case-Control
- Cross-sectional studies
- Case series, Case reports
- Ideas, opinions, editorials, anecdotal
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
<table>
<thead>
<tr>
<th>1st Author, Year</th>
<th>Journal Name</th>
<th>Country</th>
<th>Level of Evidence</th>
<th>Quality of Study</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Response Rate</th>
<th>Effect</th>
<th>Comments</th>
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<tbody>
<tr>
<td>Bakker, 2012</td>
<td>Sci Total Environ</td>
<td>The Netherlands</td>
<td>4</td>
<td>Low</td>
<td>Cross-sectional (Survey)</td>
<td>725</td>
<td>37%</td>
<td>+</td>
<td>multiple sources of potential bias</td>
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<tr>
<td>Hanning, 2012</td>
<td>BMJ</td>
<td>UK</td>
<td>5</td>
<td>Moderate</td>
<td>Expert Opinion/Review</td>
<td>N/A</td>
<td>N/A</td>
<td>+</td>
<td>Review</td>
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<td>Nissenbaum, 2012</td>
<td>Noise &amp; Health</td>
<td>USA</td>
<td>4</td>
<td>High</td>
<td>Cross-sectional</td>
<td>N= 79</td>
<td>1</td>
<td>+</td>
<td>Excellent Research</td>
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<tr>
<td>Knopper, 2011</td>
<td>Environ Health</td>
<td>Canada</td>
<td>4</td>
<td>High</td>
<td>Review</td>
<td>15 articles</td>
<td>N/A</td>
<td>+</td>
<td>Review</td>
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<tr>
<td>Shepherd, 2011</td>
<td>Noise &amp; Health</td>
<td>New Zealand</td>
<td>3 / 4</td>
<td>High</td>
<td>Cross-sectional</td>
<td>39 vs 158 from the turbine and comparison groups</td>
<td>34% vs 32%</td>
<td>+</td>
<td>Extremely robust research</td>
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<tr>
<td>Janssen, 2011</td>
<td>Acoustical Society of America</td>
<td>The Netherlands</td>
<td>?</td>
<td>?</td>
<td>Analysis of data from 3 cross-sectional studies</td>
<td>(N=341, N=754, N=725)</td>
<td>1</td>
<td>+</td>
<td>Full article is not available</td>
</tr>
</tbody>
</table>

N/A = Not applicable; ¹ = Data not available; High² = 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

<table>
<thead>
<tr>
<th>1st Author, Year</th>
<th>Journal Name</th>
<th>Country</th>
<th>Level of Evidence</th>
<th>Quality of Study</th>
<th>Study Design</th>
<th>Sample Size</th>
<th>Response Rate</th>
<th>Effect</th>
<th>Comments</th>
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<td>Pedersen, 2011</td>
<td>Noise Control Eng J</td>
<td>Sweden</td>
<td>4</td>
<td>High</td>
<td>Analysis of data from 3 cross-sectional studies</td>
<td>1755</td>
<td>Not reported</td>
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<td>Bolin, 2011</td>
<td>Environ Res Lett</td>
<td>Sweden</td>
<td>4</td>
<td>Low</td>
<td>Review</td>
<td>N/A</td>
<td>+</td>
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<td>Energy Policy</td>
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<td>4</td>
<td>High</td>
<td>Cross-sectional (Survey)</td>
<td>725</td>
<td>37%</td>
<td>+</td>
<td>500kW Versus road data</td>
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<td>USA</td>
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<td>High</td>
<td>Expert Opinion</td>
<td>N/A</td>
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<td>Pedersen, 2009</td>
<td>Acoustical Society of America</td>
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<td>4</td>
<td>High²</td>
<td>Cross-sectional (Survey)</td>
<td>1</td>
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<td>+</td>
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<td></td>
<td>J of Environ Psychology</td>
<td>Sweden</td>
<td>4</td>
<td>High</td>
<td>Analysis of data from 2 cross-sectional studies</td>
<td>1095</td>
<td>N/A</td>
<td>+</td>
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<tr>
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<td>J Low Freq Noise</td>
<td>Canada</td>
<td>5</td>
<td>High(^2)</td>
<td>Expert Opinion</td>
<td>N/A</td>
<td>N/A</td>
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<td>Sweden</td>
<td>4</td>
<td>High(^2)</td>
<td>Qualitative Study (In-depth interviews)</td>
<td>15</td>
<td>N/A</td>
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<td>Cross-sectional (Survey)</td>
<td>754</td>
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<td>351</td>
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<td>UK</td>
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<td>N/A</td>
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<th>1st Author, Year</th>
<th>Dose-response</th>
<th>Road Traffic Noise / quiet rural environment</th>
<th>Sleep Disturbance</th>
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<th>visual impact</th>
<th>attitude to wind turbines</th>
<th>Infrasound effect</th>
<th>Well being (Quality of Life / mental effect)</th>
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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”