

Summary of main conclusions reached in 17 reviews of the research literature on wind farms and health.

Compiled by Prof Simon Chapman, School of Public Health and Teresa Simonetti, Sydney University Medical School

Simon.chapman@sydney.edu.au

30 Jan 2012

This list will be updated regularly.

- 2012: Massachusetts Department of Environmental Protection. **Independent Expert Science Panel Releases Report on Potential Health Effects of Wind Turbines**
<http://www.mass.gov/dep/public/press/0112wind.htm>
- 2012: Oregon Wind Energy Health Impact Assessment.
[http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon Wind Energy HIA Public comment.pdf](http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf)
- Fiumicelli D. Windfarm noise dose-response: a literature review. *Acoustics Bulletin* 2011; Nov/Dec:26-34 [copies available from S Chapman]
- 2011: Bolin K et al. Infrasound and low frequency noise from wind turbines: exposure and health effects. *Environmental Res Let* 2011; <http://iopscience.iop.org/1748-9326/6/3/035103/>
- 2010: Knopper LD, Ollsen CA. Health effects and wind turbines: a review of the literature. *Environmental Health* 2010; 10:78
<http://www.ehjournal.net/content/10/1/78>
- 2010: UK Health Protection Agency Report on the health effects of infrasound
http://www.hpa.org.uk/web/HPAwebFile/HPAweb_C/1265028759369
- 2010: NHMRC Rapid Review of the evidence
http://www.nhmrc.gov.au/files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf
- 2010: Chief Medical Officer of Health in Ontario
http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf
- 2010: UK Health Protection Agency. Environmental noise and health in the UK. A report by the Ad Hoc Expert Group on Noise and Health. (this report is about all environmental noise)
http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747
- 2009: Minnesota Department of Health. Environmental Health Division. Public Health Impacts of Wind Turbines.
<http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf>
- 2009: Canadian Wind Energy Association. *Addressing Concerns with Wind Turbines and Human Health*. CanWEA, Ottawa. [http://www.canwea.ca/pdf/CanWEA - Addressing concerns with wind turbines and human health.pdf](http://www.canwea.ca/pdf/CanWEA_-_Addressing_concerns_with_wind_turbines_and_human_health.pdf)

- 2009: Colby et al. Wind Turbine Sound and Health Effects: An Expert Panel Review. http://199.88.77.35/EFiles/docs/CD/PlanCom/10_0426_IT_100416160206.pdf
- 2008: Chatham-Kent Public Health Unit [.http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf](http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf)
- 2007: National Research Council (USA): Impact of wind energy development on humans (Chapter 4: pp97-120) of: Environmental Impacts of Wind-Energy Projects. http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf
- 2005: Jakobsen J. Infrasound emission from wind turbines. *Jf Low Frequency Noise, Vibration and Active Control* 2005; 24(3):145-155
- 2004: Leventhall G. Low frequency noise and annoyance. *Noise & Health* 2004;.6(23):59-72 <http://tinyurl.com/4yc3oht>
- 2003: Eja Pedersen's Review for the Swedish EPA <http://www.naturvardsverket.se/Documents/publikationer/620-5308-6.pdf>

Reviews of the evidence - extracted highlights

Direct health effects from noise and WTS

- “There are no direct pathological effects from wind farms and that any potential impact on humans can be minimised by following existing planning guidelines.” *Source: NHMRC 2010*
http://www.nhmrc.gov.au/files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf
- “There is no evidence that the audible or sub-audible sounds emitted by wind turbines have any direct adverse physiological effects.” *Source: Colby 2009 review*
http://199.88.77.35/EFiles/docs/CD/PlanCom/10_0426_IT_100416160206.pdf
- “... surveys of peer-reviewed scientific literature have consistently found no evidence linking wind turbines to human health concerns.” *Source: CanWEA*
<http://www.canwea.ca/pdf/CanWEA%20-%20Addressing%20concerns%20with%20wind%20turbines%20and%20human%20health.pdf>
- “There is insufficient evidence that the noise from wind turbines is directly... causing health problems or disease.” *Source: Massachusetts review*
http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf
- “There is no reason to believe, based on the levels and frequencies of the sounds and... sound exposures in occupational settings, that the sounds from wind turbines could plausibly have direct adverse health consequences.” *Source: Colby 2009 review*
http://199.88.77.35/EFiles/docs/CD/PlanCom/10_0426_IT_100416160206.pdf

- "... while some people living near wind turbines report symptoms such as dizziness, headaches, and sleep disturbance, the scientific evidence available to date does not demonstrate a direct causal link between wind turbine noise and adverse health effects. The sound level from wind turbines at common residential setbacks is not sufficient to cause hearing impairment or other direct health effects..." *Source: Ontario CMOH Report*
http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf
- "... the audible noise created by a wind turbine, constructed at the approved setback distance does not pose a health impact concern." *Source: Chatham-Kent Public Health Unit* <http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf>
- There is no evidence for a set of health effects, from exposure to wind turbines that could be characterized as a "Wind Turbine Syndrome." *Source: Massachusetts review* http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf
- "... there is not an association between noise from wind turbines and measures of psychological distress or mental health problems." *Source: Massachusetts review* http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf
- "Evidence that environmental noise damages mental health is... inconclusive." *Source: Ad Hoc Expert Group on Noise and Health* http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747
- "...no association was found between road traffic noise and overall psychological distress..." *Source: Ad Hoc Expert Group on Noise and Health* http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747
- "To date, no peer reviewed scientific journal articles demonstrate a causal link between people living in proximity to modern wind turbines, the noise (audible, low frequency noise, or infrasound) they emit and resulting physiological health effects." *Source: Knopper&Ollson review* <http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf>
- "... there is no scientific evidence that noise at levels created by wind turbines could cause health problems other than annoyance..." *Source: Eja Pedersen 2003 Review* <http://www.naturvardsverket.se/Documents/publikationer/620-5308-6.pdf>
- "None of the... evidence reviewed suggests an association between noise from wind turbines and pain and stiffness, diabetes, high blood pressure, tinnitus, hearing impairment, cardiovascular disease, and headache/migraine." *Source: Massachusetts review* http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf

- “...there are no evidences that noise from wind turbines could cause cardiovascular and psycho-physiological effects.” *Source: Eja Pedersen 2003 Review*
<http://www.naturvardsverket.se/Documents/publikationer/620-5308-6.pdf>
- “...there was no evidence that environmental noise was related to raised blood pressure...” *Source: Ad Hoc Expert Group on Noise and Health*
http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747
- “The health impact of the noise created by wind turbines has been studied and debated for decades with no definitive evidence supporting harm to the human ear.” *Source: Chatham-Kent Public Health Unit* <http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf>
- “The electromagnetic fields produced by the generation and export of electricity from a wind farm do not pose a threat to public health...” *Source: NHMRC 2010*
http://www.nhmrc.gov.au/files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf
- “... no consistent associations were found between wind turbine noise exposure and symptom reporting, e.g. chronic disease, headaches, tinnitus and undue tiredness.” *Source: Bolin et al 2011 Review* http://iopscience.iop.org/1748-9326/6/3/035103/pdf/1748-9326_6_3_035103.pdf
- “... low level frequency noise or infrasound emitted by wind turbines is minimal and of no consequence... Further, numerous reports have concluded that there is no evidence of health effects arising from infrasound or low frequency noise generated by wind turbines.” *Source: NHMRC 2010*
http://www.nhmrc.gov.au/files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf
- “... renewable energy generation is associated with few adverse health effects compared with the well documented health burdens of polluting forms of electricity generation...” *Source: NHMRC 2010*
http://www.nhmrc.gov.au/files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf
- “Although opposition to wind farms on aesthetic grounds is a legitimate point of view, opposition to wind farms on the basis of potential adverse health consequences is not justified by the evidence.” *Source: Chatham-Kent Public Health Unit*
<http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf>
- “What is apparent is that numerous websites have been constructed by individuals or groups to support or oppose the development of wind turbine projects, or media sites reporting on the debate. Often these websites state the perceived impacts on, or benefits to, human health to support the position of the individual or group hosting the

website. The majority of information posted on these websites cannot be traced back to a scientific, peer-reviewed source and is typically anecdotal in nature. In some cases, the information contained on and propagated by internet websites and the media is not supported, or is even refuted, by scientific research. This serves to spread misconceptions about the potential impacts of wind energy on human health..." Source: Knopper&Ollson review <http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf>

Annoyance

- "... wind turbine noise is comparatively lower than road traffic, trains, construction activities, and industrial noise." Source: Chatham-Kent Public Health Unit <http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf>
- "The perception of noise depends in part on the individual - on a person's hearing acuity and upon his or her subjective tolerance for or dislike of a particular type of noise. For example, a persistent "whoosh" might be a soothing sound to some people even as it annoys others." Source: NRC 2007 http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf
- "... some people might find [wind turbine noise annoying. It has been suggested that annoyance may be a reaction to the characteristic "swishing" or fluctuating nature of wind turbine sound rather than to the intensity of sound." Source: Ontario CMOH Report http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf
- "... being annoyed can lead to increasing feelings of powerlessness and frustration, which is widely believed to be at least potentially associated with adverse health effects over the longer term." Source: Ad Hoc Expert Group on Noise and Health http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747
- "Wind turbine annoyance has been statistically associated with wind turbine noise, but found to be more strongly related to visual impact, attitude to wind turbines and sensitivity to noise." Source: Knopper&Ollson review <http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf>
- "... self reported health effects like feeling tense, stressed, and irritable, were associated with noise annoyance and not to noise itself..." Source: Knopper&Ollson review <http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf>
- "... many of the self reported health effects are associated with numerous issues, many of which can be attributed to anxiety and annoyance." Source: Knopper&Ollson review <http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf>

- “To date, no peer reviewed articles demonstrate a direct causal link between people living in proximity to modern wind turbines, the noise they emit and resulting physiological health effects. If anything, reported health effects are likely attributed to a number of environmental stressors that result in an annoyed/stressed state in a segment of the population.” *Source: Knopper&Ollson review*
<http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf>
- “... some community studies are biased towards over-reporting of symptoms because of an explicit link between...noise and symptoms in the questions inviting people to remember and report more symptoms because of concern about noise.” *Source: Ad Hoc Expert Group on Noise and Health*
http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747
- “... it is probable that some persons will inevitably exhibit negative responses to turbine noise wherever and whenever it is audible, no matter what the noise level.” *Source: Fiumicelli review Fiumicelli article abstract*
- “The major source of uncertainty in our assessment is related to the subjective nature of response to sound, and variability in how people perceive, respond to, and cope with sound.” *Source: Oregon review*
<http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf>
- “... sleep difficulties, as well as feelings of uneasiness, associated with noise annoyance could be an effect of the exposure to noise, although it could just as well be that respondents with sleeping difficulties more easily appraised the noise as annoying.” *Source: NHMRC 2010*
http://www.nhmrc.gov.au/files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf
- “Even noise that falls within known safety limits is subjective to the recipient and will be received and subsequently perceived positively or negatively.” *Source: Chatham-Kent Public Health Unit* <http://www.harvestingwindsupport.com/blog/wp-content/uploads/2011/03/Chatham-KentHealth-and-Wind-.pdf>
- “... annoyance was strongly correlated with a negative attitude toward the visual impact of wind turbines on the landscape...” *Source: NHMRC 2010*
http://www.nhmrc.gov.au/files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf
- “Respondents tended to report more annoyance when they also noted a negative effect on landscape, and ability to see the turbines was strongly related to the probability of annoyance.” *Source: Minnesota Health Dept 2009*
<http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf>

- “[It is proposed that annoyance is not a direct health effect but an indication that a person’s capacity to cope is under threat. The person has to resolve the threat or their coping capacity is undermined, leading to stress related health effects... Some people are very annoyed at quite low levels of noise, whilst other are not annoyed by high levels.” *Source: NHMRC 2010*
http://www.nhmrc.gov.au/files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf
- “Further, sounds, such as repetitive but low intensity noise, can evoke different responses from individuals... Some people can dismiss and ignore the signal, while for others, the signal will grow and become more apparent and unpleasant over time... These reactions may have little relationship to will or intent, and more to do with previous exposure history and personality.” *Source: Minnesota Health Dept 2009*
<http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf>
- “Stress and annoyance from noise often do not correlate with loudness. This may suggest [that other factors impact an individual’s reaction to noise... individuals with an interest in a project and individuals who have some control over an environmental noise are less likely to find a noise annoying or stressful.” *Source: Minnesota Health Dept 2009*
<http://www.health.state.mn.us/divs/eh/hazardous/topics/windturbines.pdf>
- “There is a possibility of learned aversion to low frequency noise, leading to annoyance and stress...” *Source: Leventhall 2005 review*
<http://www.noiseandhealth.org/article.asp?issn=1463-1741;year=2004;volume=6;issue=23;spage=59;epage=72;aualast=Leventhall>
- “Noise produced by wind turbines generally is not a major concern for humans beyond a half mile or so because various measures to reduce noise have been implemented in the design of modern turbines.” *Source: NRC 2007*
http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf
- “Noise... levels from an onshore wind project are typically in the 35-45 dB(A) range at a distance of about 300 meters... These are relatively low noise or sound-pressure levels compared with other common sources such as a busy office (~60 dB(A)), and with nighttime ambient noise levels in the countryside (~20-40 dB(A)).” *Source: NRC 2007*
http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf
- “Complaints about low frequency noise come from a small number of people but the degree of distress can be quite high. There is no firm evidence that exposure to this type of sound causes damage to health, in the physical sense, but some people are certainly very sensitive to it.” *Source: Ad Hoc Expert Group on Noise and Health*
http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747
- “... there is the theoretical possibility that annoyance may lead to stress responses and then to illness. If there is no annoyance then there can be no mechanism for any increase in stress hormones by this pathway... if stress-related adverse health effects are mediated solely through annoyance then any mitigation plan which reduces

annoyance would be equally effective in reducing any consequent adverse health effects. It would make no difference whether annoyance reduction was achieved through actual reductions in sound levels, or by changes in attitude brought about by some other means." *Source: Ad Hoc Expert Group on Noise and Health*
http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1279888026747

Infrasound

- "Claims that infrasound from wind turbines directly impacts the vestibular system have not been demonstrated scientifically... evidence shows that the infrasound levels near wind turbines cannot impact the vestibular system."
<http://www.mass.gov/dep/public/press/0112wind.htm>
- "There is no evidence that infrasound ... [from wind turbines ... contributes to perceived annoyance or other health effects." *Source: Bolin et al 2011 Review*
http://iopscience.iop.org/1748-9326/6/3/035103/pdf/1748-9326_6_3_035103.pdf
- "There is no consistent evidence of any physiological or behavioural effect of acute exposure to infrasound in humans." *Source: UK HPA Report*
http://www.hpa.org.uk/webc/HPAwebFile/HPAweb_C/1265028759369
- "... self reported health effects of people living near wind turbines are more likely attributed to physical manifestation from an annoyed state than from infrasound." *Source: Knopper&Ollson review* <http://www.ehjournal.net/content/pdf/1476-069X-10-78.pdf>
- "... infrasound from current generation upwind model turbines [is well below the pressure sound levels at which known health effects occur. Further, there is no scientific evidence to date that vibration from low frequency wind turbine noise causes adverse health effects." *Source: Ontario CMOH Report*
http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf
- "It would appear... that infrasound alone is hardly responsible for the complaints... from people living up to two km from the large downwind turbines." *Source: Jakobsen 2005 review* <http://multi-science.metapress.com/content/w6r4226247q6p416/>
- "From a critical survey of all known published measurement results of infrasound from wind turbines it is found that wind turbines of contemporary design with the rotor placed upwind produce very low levels of infrasound. Even quite close to these turbines the infrasound level is far below relevant assessment criteria, including the limit of perception." *Source: Jakobsen 2005 review* <http://multi-science.metapress.com/content/w6r4226247q6p416/>
- "With older downwind turbines, some infrasound also is emitted each time a rotor blade interacts with the disturbed wind behind the tower, but it is believed that the energy at these low frequencies is insufficient to pose a health hazard." *Source: NRC 2007* http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf

Shadow flicker

- “Scientific evidence suggests that shadow flicker [from the rotating blades of wind turbines does not pose a risk for eliciting seizures as a result of photic stimulation.”
Source: Massachusetts review
http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf
- Shadow flicker from wind turbines... is unlikely to cause adverse health impacts in the general population. The low flicker rate from wind turbines is unlikely to trigger seizures in people with photosensitive epilepsy. Further, the available scientific evidence suggests that very few individuals will be annoyed by the low flicker frequencies expected from most modern wind turbines.” *Source: Oregon review*
<http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf>
- “Flicker frequency due to a turbine is on the order of the rotor frequency (i.e., 0.6-1.0 Hz), which is harmless to humans. According to the Epilepsy Foundation, only frequencies above 10 Hz are likely to cause epileptic seizures.” *Source: NRC 2007*
http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf

Community & social response to wind turbines

- The perception of sound as noise is a subjective response that is influenced by factors related to the sound, the person, and the social/environmental setting. These factors result in considerable variability in how people perceive and respond to sound... Factors that are consistently associated with negative community response are fear of a noise source... [and noise sensitivity...” *Source: Oregon review*
<http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf>
- “Wind energy developments could indirectly result in positive health impacts... if they increase local employment, personal income, and community-wide income and revenue. However, these positive effects may be diminished if there are real or perceived increases in income inequality within a community.” *Source: Oregon review*
<http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf>
- “Effective public participation in and direct benefits from wind energy projects (such as receiving electricity from the neighboring wind turbines) have been shown to result in less annoyance in general and better public acceptance overall.” *Source: Massachusetts review*
http://www.mass.gov/dep/energy/wind/turbine_impact_study.pdf

- “... people who benefit economically from wind turbines [are less likely to report noise annoyance, despite exposure to similar sound levels as those people who [are not economically benefiting.” *Source: NHMRC 2010*
http://www.nhmrc.gov.au/files_nhmrc/publications/attachments/new0048_evidence_review_wind_turbines_and_health.pdf
- “Landowners... may perceive and respond differently (potentially more favorably) to increased sound levels from a wind turbine facility, particularly if they benefit from the facility or have good relations with the developer...” *Source: Oregon review*
<http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf>
- “The level of annoyance or disturbance experienced by those hearing wind turbine sound is influenced by individuals' perceptions of other aspects of wind energy facilities, such as turbine visibility, visual impacts, trust, fairness and equity, and the level of community engagement during the planning process.” *Source: Oregon review*
<http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf>
- “Wind energy facilities... can indirectly result in positive health impacts by reducing emissions of [green house gases and harmful air pollutants, and... Communities near fossil-fuel based power plants that are displaced by wind energy could experience reduced risks for respiratory illness, cardiovascular diseases, cancer, and premature death.” *Source: Oregon review*
<http://public.health.oregon.gov/HealthyEnvironments/TrackingAssessment/HealthImpactAssessment/Documents/Oregon%20Wind%20Energy%20HIA%20Public%20comment.pdf>
- “The environmental and human-health risk reduction benefits of wind-powered electricity generation accrue through its displacement of electricity generation using other energy sources (e.g., fossil fuels), thus displacing the adverse effects of those other generators.” *Source: NRC 2007*
http://www.vawind.org/assets/nrc/nrc_wind_report_050307.pdf
- “Community engagement at the outset of planning for wind turbines is important and may alleviate health concerns about wind farms. Concerns about fairness and equity may also influence attitudes towards wind farms and allegations about effects on health. These factors deserve greater attention in future developments.” *Source: Ontario CMOH Report*
http://www.health.gov.on.ca/en/public/publications/ministry_reports/wind_turbine/wind_turbine.pdf