

**Brief Overview of References**  
**Noise including Industrial Wind Turbines**  
**and Adverse Health Effects**  
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Noise and Adverse Health Effects  
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## **NOTICE TO READER**

Authoritative references are cited as much as possible to support the assertions contained within this overview.

Every reasonable attempt was made to ensure the accuracy of this overview. Any errors or omissions contained within this overview are unintentional.

No financial compensation has been requested nor received for the compilation of this overview.

## **FORWARD**

This overview may be used by other individuals as required.

Due to time and resource constraints this overview does not detail all the references available.

There is, however, ample evidence indicating a risk to health resulting from noise.

## **NOISE ANNOYANCE CAN AFFECT HEALTH**

World Health Organization recognizes annoyance and sleep disturbance as adverse health effects. <sup>1</sup>

Regarding noise induced annoyance the US Environmental Protection Agency states "...“annoyance” can have major consequences, primarily to one’s overall health.” <sup>2</sup>

The health impacts of noise induced annoyance must not be underestimated.

The word annoyance may mean different things to different people; however in clinical terms annoyance is acknowledged to be a risk to human health.

A World Health Organization study "...confirmed, on an epidemiological level, an increased health risk from chronic noise annoyance.” <sup>3</sup>

Noise induced annoyance contributes to stress, <sup>4</sup> sleep disturbance <sup>5</sup> and an increased risk of regulation diseases. <sup>6</sup>

Annoyance may adversely affect physiological health. Research indicates that for “chronically strong annoyance a causal chain exists between the three steps health – strong annoyance – increased morbidity.” <sup>7</sup>

The subjective experience of noise stress can, through central nervous processes, lead to an inadequate neuro-endocrine reaction and finally to regulation diseases. <sup>8</sup>

“Adults who indicated chronically severe annoyance by neighbourhood noise were found to have an increased health risk for the cardiovascular system and

the movement apparatus, as well as an increased risk of depression and migraine...With children the effects of noise-induced annoyance from traffic, as well as neighbourhood noise, are evident in the respiratory system.”<sup>9</sup>

To protect against adverse health effects noise level limits “...should be based on annoyance responses to noise.”<sup>10</sup>

“Dose-response relations for different types of traffic noise (air, road and railway) clearly demonstrate that these noises can cause different annoyance effects at equal LAeq,24h values.”<sup>11</sup>

## **NOISE AND STRESS**

Noise is an environmental stressor<sup>12</sup> which can cause stress related adverse health effects.<sup>13</sup>

“The subjective experience of noise stress can, through central nervous processes, lead to an inadequate neuro-endocrine reaction and finally lead to regulatory diseases.”<sup>14</sup>

Peer reviewed scientific research reveals “With children the effects of noise-induced annoyance from traffic, as well as neighbourhood noise, are evident in the respiratory system. The increased risk of illness in the respiratory system in children does not seem to be caused primarily by air pollutants, but rather, as the results for neighbourhood noise demonstrate, by emotional stress.”<sup>15</sup>

“Also, recent epidemiological studies have shown a connection between disturbed sleep and later occurrence of stress-related disorders such as cardiovascular diseases...and diabetes type II...”<sup>16</sup>

Regarding stress Health Canada states <sup>17</sup>

“...stress is considered to be a risk factor in a great many diseases, including: heart disease, some types of bowel disease, herpes, mental illness.

...Stress also makes it hard for people with diabetes to control their blood sugar.

...Stress is also a risk factor in alcohol and substance abuse, as well as weight loss and gain. Stress has even been identified as a possible risk factor in Alzheimer’s Disease.

...Severe stress can cause biochemical changes in the body, affecting the immune system, leaving your body vulnerable to disease.”

Other health effects associated with stress include becoming increasingly distressed, and irritable, unable to relax or concentrate, have difficulty thinking logically, and making decisions, depression, anxiety, sleep disorders, disorders of the digestive system, increases in blood pressure, headaches and musculo-skeletal disorders. <sup>18, 19</sup>

## **NOISE AND SLEEP DISTURBANCE**

Difficulty falling asleep constitutes sleep disturbance which can have serious consequences.<sup>20</sup>

Sleep disturbance is acknowledged to be an adverse health effect.<sup>21, 22</sup>

The consequences of sleep disturbance can be serious.

In 2009 World Health Organization released a 184 page peer reviewed summary of research regarding the risks to human health from noise induced sleep disturbance. Some of the adverse health effect documented in the report include poor performance at work, fatigue, memory difficulties, concentration problems, motor vehicle accidents, mood disorders (depression, anxiety), alcohol and other substance abuse, cardiovascular, respiratory, renal, gastrointestinal, musculoskeletal disorders, obesity, impaired immune system function and a reported increased risk of mortality.<sup>23</sup>

## **LOW FREQUENCY NOISE AND INFRASOUND**

It is widely affirmed that exposure to audible low frequency noise can cause adverse health effects in humans.<sup>24, 25, 26, 27</sup>

Low frequency noise can cause "...immense suffering to those who are unfortunate to be sensitive to low frequency noise and who plead for recognition of their circumstances."<sup>28</sup>

Annoyance is an acknowledged adverse health effect.<sup>29, 30</sup>



“Regulatory authorities must accept that annoyance by low frequency noise presents a real problem which is not addressed by the commonly used assessment methods.”<sup>31</sup>

Literature reviews and scientific articles confirm the symptoms associated with low frequency noise exposure include annoyance, stress, sleep disturbance, headaches, difficulty concentrating, irritability, fatigue, dizziness or vertigo, tinnitus, heart ailments anxiety, stitch and beating palpitation.<sup>32, 33, 34</sup>

While there is a consensus on the symptoms caused by low frequency noise exposure the mechanism of action is not fully understood.

“Today we know that most illnesses, mental and physical, are influenced by a combination of biological, psychological and social factors.”<sup>35</sup>

“In an integrated and evidence-based model of health, mental health (including emotions and thought patterns) emerges as a key determinant of overall health. Anxious and depressed moods, for example, initiate a cascade of adverse changes in endocrine and immune functioning, and create increased susceptibility to a range of physical illnesses.”<sup>36</sup>

“Mental health is as important as physical health. In fact, the two are intertwined. Our mental health directly affects our physical health and vice versa...mental health factors can increase the risk of developing physical problems such as, diabetes, heart disease, weight gain or loss, gastrointestinal problems, reductions in immune system, efficiency, and blood biochemical imbalances.”<sup>37</sup>

World Health Organization advises that “Health effects due to low-frequency components in noise are estimated to be more severe than for community noises in general...The evidence on low-frequency noise is sufficiently strong to warrant

immediate concern.” and consequently “Noise with low-frequency components require lower guideline values.”<sup>38</sup>

The effects of low frequency noise induced annoyance and stress are acknowledged to be serious as evidenced by “The claim that their "lives have been ruined" by the noise is not an exaggeration...”<sup>39</sup>

“...LFN (*low frequency noise*) does not need to be considered “loud” for it to cause such forms of annoyance and irritation.”<sup>40</sup>

“The effects of infrasound or low frequency noise are of particular concern because of its pervasiveness due to numerous sources, efficient propagation, and reduced efficiency of many structures (dwellings, walls, and hearing protection) in attenuating low frequency noise compared with other noise.”<sup>41</sup>

“Unlike higher frequency noise issues, LFN is very difficult to suppress. Closing doors and windows in an attempt to diminish the effects sometimes makes it worse because of the propagation characteristics and the low-pass filtering effect of structures. Individuals often become irrational and anxious as attempts to control LFN fail, serving only to increase the individual’s awareness of the noise, accelerating the above symptoms”<sup>42</sup>

“Those exposed may adopt protective strategies, such as sleeping in their garage if the noise is less disturbing there. Or they may sleep elsewhere, returning to their own homes only during the day.”<sup>43</sup>

“There is no doubt that some humans exposed to infrasound experience abnormal ear, CNS, and resonance induced symptoms that are real and stressful.”<sup>44</sup>

There is no scientific consensus that infrasonic noise below the threshold of hearing will have no effect on health. There is scientific uncertainty regarding the understanding of human response to infrasound.

“There is no consensus whether sensitivity below 20 Hz is by a similar or different mechanism than sensitivity and hearing above 20 Hz...”<sup>45</sup>

The National Research Council states “Low-frequency vibration and its effects on humans are not well understood. Sensitivity to such vibration resulting from wind-turbine noise is highly variable among humans.... studies on human sensitivity to very low frequencies are recommended.”<sup>46</sup>

The conclusions of a 2010 peer reviewed scientific article states

“1) Hearing perception, mediated by the inner hair cells of the cochlea, is remarkably insensitive to infrasound.

2) Other sensory cells or structures in the inner ear, such as the outer hair cells, are more sensitive to infrasound than the inner hair cells and can be stimulated by low frequency sounds at levels below those that are heard. The concept that an infrasonic sound that cannot be heard can have no influence on inner ear physiology is incorrect.

3) Under some clinical conditions, such as Meniere’s disease, superior canal dehiscence, or even asymptomatic cases of endolymphatic hydrops, individuals may be hypersensitive to infrasound.

4) A-weighting wind turbine sounds underestimates the likely influence of the sound on the ear. A greater effort should be made to document the infrasound component of wind turbine sounds under different conditions.

5) Based on our understanding of how low frequency sound is processed in the ear, and on reports indicating that wind turbine noise causes greater annoyance than other sounds of similar level and affects the quality of life in sensitive individuals, there is an urgent need for more research directly addressing the physiologic consequences of long-term, low level infrasound exposures on humans.”<sup>47</sup>

Recent research on the issue of infrasound below the hearing threshold states:

“For years, people have been told that infrasound you cannot hear cannot affect you. This is completely WRONG.

As the inner ear DOES respond to infrasound at levels that are not heard, people living near wind turbines are being put at risk by infrasound effects on the body that no-one presently understands.

Until a scientific understanding of this issue is established we should not be dismissing these effects, but need to be erring on the side of caution.”<sup>48</sup>

It is incorrect to assume that inaudible low frequency noise cannot cause adverse health effects as “...non-aural physiological and psychological effects may be caused by levels of low frequency noise below the individual hearing threshold.”

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“Low-frequency noise may also produce vibrations and rattles as secondary effects.”<sup>50</sup>

“Jung and colleagues (2008), in a Korean study, concluded that low-frequency noise in the frequency range above 30 Hz can lead to psychological complaints and that infrasound in the frequency range of 5–8 Hz can cause complaints due to rattling doors and windows in homes.”<sup>51</sup>

Living conditions are acknowledged to be a key determinate of health.<sup>52</sup>

A World Health Organization epidemiology study confirms disturbed living conditions caused by noise increases the risk of ill health.<sup>53</sup>

Peer reviewed scientific research confirms “Pollution and degradation of the indoor environment cause illness, increased mortality, loss of productivity, and have major economic and social implications...The health effects of indoor noise include an increase in the rates of diseases and disturbances... these illnesses, and the related reduction in human productivity, can result in substantial economic losses.”<sup>54</sup>

“A limitation of much work on assessment of low frequency noise has been that long term averaged measurements were used and, consequently, information on fluctuations was lost. Many complaints of low frequency noise refer to its throbbing or pulsing nature.”<sup>55</sup>

Research related to low frequency noise “...confirms the importance of fluctuations as a contributor to annoyance and the limitation of those assessment methods, which do not include fluctuations in the assessment.”<sup>56</sup>

Low Frequency Noise is an issue that must be resolved quickly and accurately to improve the sound environment and quality of life for the residents. For this reason, it remains the duty of industry and authorities to implement regulations that will account for low frequency noise.<sup>57</sup>

It is widely affirmed that A-weighting underestimates the sound pressure level of noise with low-frequency components.<sup>58, 59, 60, 61</sup> “A-weighted level is very inadequate...”<sup>62</sup> when assessing low frequency noise and infrasound.

## **NOISE CHARACTERISTICS**

“Noise is multidimensional. A one dimensional view of noise is the A - weighting, which considers only levels and neglects frequencies. Another one-dimensional view is to consider only frequencies and neglect levels. Developing the dimensions further, two dimensions include both frequency and level (the spectrum), three dimensions adds in the time variations of the noise, whilst higher dimensions include subjective response.”<sup>63</sup>

Peer reviewed scientific research confirms “The capacity of a noise to induce annoyance depends upon many of its physical characteristics, including its sound pressure level and spectral characteristics, as well as the variations of these properties over time.”<sup>64</sup>

“Noise measures based solely on LAeq values do not adequately characterize most noise environments and do not adequately assess the health impacts of noise on human well-being. It is also important to measure the maximum noise level and the number of noise events when deriving guideline values. If the noise includes a large proportion of low-frequency components, values even lower than the guideline values will be needed, because low-frequency components in noise may increase the adverse effects considerably. When prominent low-frequency components are present, measures based on A-weighting are inappropriate. However, the difference between dBC (or dBlin) and dBA will give crude information about the presence of low-frequency components in noise. If the

difference is more than 10 dB, it is recommended that a frequency analysis of the noise be performed.”<sup>65</sup>

It is affirmed that modulated broad band noise, low frequency noise, infrasound, tonal noise, and impulse noise have a particularly pronounced effect on people exposed to them.<sup>66, 67, 68, 69</sup>

Peer reviewed scientific research confirms noise limits should be based on annoyance scientific dose responses to individual noise sources.<sup>70</sup>

To protect people from the adverse health effect of noise annoyance World Health Organization states “Noise with low-frequency components require lower guideline values.”<sup>71</sup>

Research confirms is inadequate as A-weighting underestimates the sound pressure level of noise with low-frequency components.<sup>72, 73, 74</sup>

“A-weighted levels for assessment of environmental noise are normally taken outside a residential property. The complexities of low frequency noise, including uncertainties in the transmission loss of the structure and resonances within rooms, require low frequency noise to be assessed by internal measurements.”<sup>75</sup>

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