What Clinical and Acoustic Clues Can Tell Us About The Causes Of Deteriorating Physical and Mental Health

Acoustical Society of America
Conference Presentation 21 May 2015

Pittsburgh, USA

A Diagnostic Conundrum

- Some residents living near sources of industrial infrasound and low frequency noise (ILFN) in quiet rural areas report ***worsening*** existing physical and mental health, and a wide variety of ***new*** symptoms with ***variable*** time of onset after ILFN exposure starts
- Many experience ***new*** repeated sleep disturbance – including "***waking up suddenly at night in an anxious, frightened, panicked state***"
- Some report ***new*** sudden "***pressure bolt***" symptoms

Clinical question - *What is causing these symptoms?*

WAUBRA FOUNDATION

What Causes Annoyance Symptoms?

Question - Are the symptoms caused by "suggestion", (the "nocebo effect") or are the symptoms caused by the sound energy itself?

A nocebo effect is an ill effect caused by the suggestion or belief something is harmful..

Answer – Psychoacoustic research, community reaction and attitudinal studies over the last forty years have shown that excessive noise can harm health.

Animal research evidence, careful clinical histories, and human physiological studies from the last thirty years, all provide evidence of ***direct physiological effects and tissue pathology***, from sound and vibration energy, ***including infrasound.***

WAUBRA FOUNDATION

What We Already Know

- Low frequency noise from ***any*** source can cause a range of symptoms described by engineers as "noise annoyance"
- UK Acoustician Professor Geoff Leventhall in June 2011 at NHMRC Workshop: "***noise annoyance symptoms are the same as wind turbine syndrome symptoms***" and are "***the stress effects from audible noise"***

WAUBRA FOUNDATION

What We Already Know

1982 - 7 – Kelley, et al and Hubbard (NASA)

- ***Impulsive infrasound & low frequency noise*** from a variety of sources ***directly caused annoyance symptoms*** in field and laboratory studies
- The dose of sound energy may be ***amplified*** inside homes by the resonance effects on the building structure
- ***Small rooms*** facing the sound source the "***worst***"
- Impacts worse with ongoing exposure – "***sensitisation***"
- Sources of ILFN include gas turbines, wind turbines, and military aircraft

WAUBRA FOUNDATION

What We Already Know

- "Annoyance" symptoms can be caused by excess sound energy, and include ***sleep disturbance*** and ***physiological stress*** responses, as well as psychological stress effects
- ***Chronic sleep deprivation*** and ***chronic stress*** are both well known to cause serious adverse consequences for physical and mental health
- ***Sudden acute physiological stress*** can also cause serious problems eg adrenaline surge pathology can cause cardiomyopathy / "heart attacks" and dangerously high blood pressure

WAUBRA FOUNDATION

New Evidence – Direct Physiological Impact in Brain

- **2014 - 5 – Inagaki et al, Japan**

Small study of 15 Japanese wind turbine workers

Exposed to reproduced wind turbine noise from 600 kW wind turbine in a laboratory study

EEG studies showed changes consistent with brains being “unable to achieve a relaxed state”

In other words, the sound energy induced a physiologically stressed state directly in the brain, visualised on objective EEG studies

WAUBRA FOUNDATION

What Are The Consequences Of Inagaki et al's Study?

- The "annoyance" symptoms of physiological stress are ***directly caused by*** the impacts of (wind turbine) sound energy on the brain
- The "nocebo effect" hypothesis **does not explain the annoyance symptoms** reported by workers, residents, and wind turbine hosts
- In other words, the ***nocebo hypothesis is "dead and buried" as an explanation for the annoyance symptoms reported by residents***

WAUBRA FOUNDATION

Who Predicted The Inagaki EEG Results Showing Physiological Stress?

- **2003/4 – Tharpaland Buddhist Monks, UK** – ***could not attain a meditative state near operating wind turbines***, report of a field investigation with experienced monks in Scotland
- **February 2011 – Waubra Foundation** called for EEG / sleep studies in homes of impacted residents, based on clinical histories of severe sleep disturbance and "***waking up suddenly in an anxious frightened panicked state***"

WAUBRA FOUNDATION

Who Predicted The Inagaki EEG Results Showing Physiological Stress?

- **November 2011** – **Steven Cooper**, after visit to Capital Wind Development. In an email to a psychologist who conducts EEG's, he stated the following:

  "***I have hypothesised that what the residents are receiving is low frequency noise that is affecting their brain functions and in turn their sleep patterns and their health"***

- **December 2011 – Rob Rand and Steve Ambrose** were the first to specifically hypothesise this effect publicly in their report of the Bruce McPherson Acoustic survey, Falmouth USA (pp 32-33)

WAUBRA FOUNDATION

What Clues About Physiological Stress Do We Have From Animal Studies?

- **Salt's** recent work on guinea pig cochlea – ***infrasound stimulation of afferent nerves from the outer hair cells to the brain resulted in an "alerting response"*** (the fight flight response) which Salt suggested could explain the repeated sleep disturbances experienced by rural residents, especially in a quiet background noise environments

WAUBRA FOUNDATION

What Clues About Physiological Stress Do We Have From Animal Studies?

- **Nishimura 1988** – infrasound (16 Hz, 120 dB) stimulation ***"appears to induce sympathetic – dominant responses early in the exposure period, due to stimulation of the sympathetic nervous system by the hypophysis* directly, or indirectly via the adrenal glands"***

** Hypophysis = Pituitary gland*

Therefore rare clinical reports of conditions resulting from acute adrenaline surges with no usual cause are highly relevant - ***transient ILFN pulse pressure peaks could explain these acute episodes***

WAUBRA FOUNDATION

Which Adrenaline Surge Pathologies are being Reported?

- **Acute Hypertensive Crisis** –can be caused by adrenal tumour called “phaeochromocytoma” and commonly presents with either incidental markedly elevated blood pressure or classic symptoms of an acute crisis
- **Tako Tsubo Cardiomyopathy** – usually caused by a sudden severe emotional shock. Sometimes named Tako Tsubo “Heart Attacks” – the clinical presentation with chest pain can be very similar to that of blocked coronary arteries

WAUBRA FOUNDATION

Clues From Clinical Cases

Case 1 – Farmer from Waubra with **Acute Hypertensive Crisis** whilst working outdoors

- Overcast day, turbines operating, working approx 1km from nearest turbine cluster (128 in total)
- Sudden onset symptoms – severe headache, felt "heart was going to leap out of his chest", severe nausea, felt very unwell - so went home.
- Checked blood pressure – over 200 systolic (normally 120), BP stayed elevated for days, and farmer felt jittery, nauseous, and anxious

WAUBRA FOUNDATION

Clues From Clinical Cases cont.

Case 1 continued

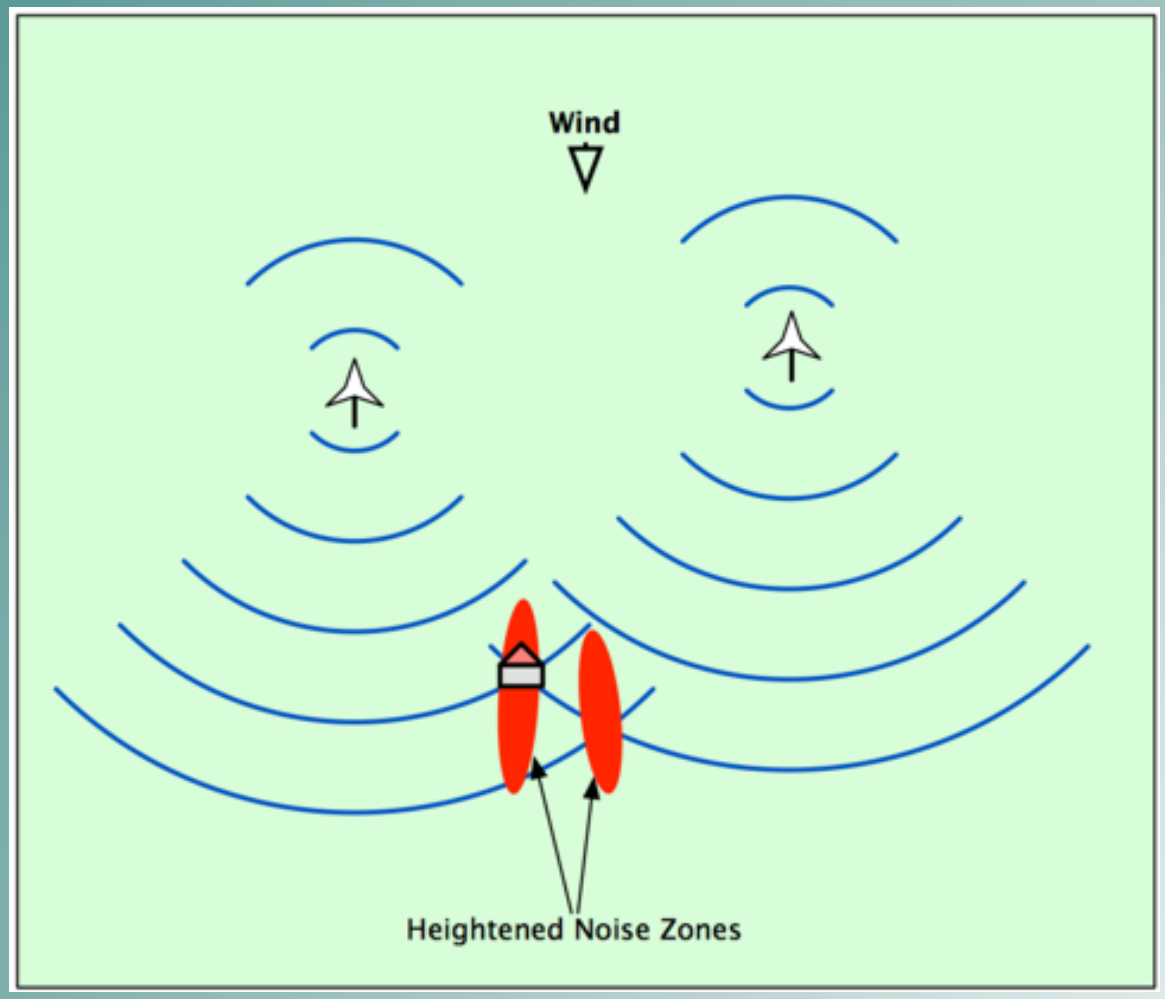
Diagnosis – Symptoms consistent with Acute Hypertensive Crisis BUT ***no underlying adrenal tumour found with subsequent investigations***

Cause of symptoms – *unknown*

Hypothesis – he was hit by the ***convergence of infrasound pulse pressure peaks*** from multiple turbines (*convergence from multiple wind turbines was described by Pierpont 2009, Thorne 2010, Rapley, Bakker & Thorne 2011, Bell 2014*)

WAUBRA FOUNDATION

Convergence of Sound Waves – Heightened Noise Zone (Bakker & Rapley, 2011)



WAUBRA FOUNDATION

Clues From Clinical Cases cont.

Case 2 – Farmer (light work outside), Waubra

- Overcast day, turbines operating nearby
- Felt unwell, chest pain and nausea (but ***not*** severe, central crushing chest pain)
- Went home, and when symptoms failed to resolve went to hospital. **Tako Tsubo Cardiomyopathy "heart attack"** diagnosed by cardiologist. No usual precipitant for symptoms (eg intense emotion) was present

WAUBRA FOUNDATION

Waubra

WAUBRA
FOUNDATION

Clues From Clinical Cases cont.

Case 3 – Widow resting in her home at night

- Sudden onset chest pain – wind turbines operating, location of house - downwind of a line of turbines, operating at the time
- **Tako Tsubo Cardiomyopathy** subsequently diagnosed in hospital by cardiologist
- No usual precipitant cause
- 2 other family members had heart attacks at same location, one fatal

WAUBRA FOUNDATION

Clues From Clinical Cases cont.

Case Cluster of Tako Tsubo "heart attacks"

- Location – Cumbo Valley, Hunter Valley, New South Wales, (Australia) near multiple open cut coal mines over 5 km away
- Cluster of multiple residents with Tako Tsubo heart attacks over a period of months – usually between 1 – 3 am on cold frosty nights, in residents reporting "noise annoyance" symptoms and perceptions of vibration inside homes
- Cardiologists could not explain the cluster of Tako Tsubo cases occurring overnight from this region

WAUBRA FOUNDATION

Hunter Valley, NSW

WAUBRA FOUNDATION

Comment from Cardiologist, Expert in Takotsubo Cardiomyopathy, July 2014

"I have not encountered, nor am I aware, of any literature on low frequency sound as a possible trigger for takotsubo cardiomyopathy. ***In my opinion, any physiologic stress (including sound) which causes a substantial increase in plasma catecholamines might serve as a trigger for this condition. There are a substantial proportion of patients (perhaps 20%) in whom we cannot identify a specific trigger"***

Dr Scott Sharkey, MD, Cardiologist, Minneapolis

WAUBRA FOUNDATION

Case with Concurrent Infrasound Measurement

Final Case – "***Pressure Bolt Sensations***"

- Resident at Macarthur – gave evidence in Cherry Tree Court Case about sudden onset of pressure bolt sensations perceived in the back of his head, whilst sitting relaxing in his home
- Mr Les Huson – acoustician – coincidentally collected concurrent infrasound measurements at the same time – to which the resident was "blinded" (ie unaware of pressure pulse peaks subsequently identified in the data)

WAUBRA FOUNDATION

Case with Concurrent Infrasound Measurement cont.

Mr Les Huson's expert opinion

"***Industrial infrasound levels of 0.5 Pa peak-peak at 12.5 Hz have caused recognised and accepted nuisance complaints. Pressure transients exceeding 5 Pa peak-peak have been observed that correlate with observation of Mr G…… that causes him concern. Other lower amplitude peak-peak pressure transients have also correlated with Mr G……'s diary logs with an overall correlation of 86% "***

WAUBRA FOUNDATION

The Next Steps – Infrasound Dosimeters and Physiological Data

Future Research Priorities:

1. **Physiological data** (EEG, heart rate, non invasive blood pressure studies and biomarkers) with ***concurrent full spectrum acoustic measurements inside homes*** to

- ***confirm direct causation*** of physiological stress,
- ***establish triggers*** (frequencies & threshold) for ***acute sleep disturbance episodes***, and
- ***validate infrasound sensation perception thresholds*** established by Kelley (1985) and Cooper (2014) of 50 dB 4-5 Hz narrow band for chronically sensitised residents - 6 years exposure at Cape Bridgewater

WAUBRA FOUNDATION

The Next Steps – Infrasound Dosimeters & Physiological Data

Future Research Priorities

2. **Infrasound Dosimeters** – wind turbines

- occupational exposures (farmers, wind turbine workers, acousticians)
- measure exposures during acute adrenaline surge events
- measure individual exposures for severely impacted people

WAUBRA FOUNDATION

The Next Steps – Infrasound Dosimeters & Physiological Data

Future Research Priorities cont.

3. **Infrasound Dosimeters** – other applications

   a wide range of other ILFN sources – mines, gas and coal fired power stations, aircraft, trains, passenger ferries and other shipping with large diesel engines where ILFN related pathology is also being reported (ie symptoms of noise annoyance/WTS or "ILFN Syndrome", and vibroacoustic disease)

WAUBRA FOUNDATION

Contact Details

Email: sarah@waubrafoundation.org.au

Phone: 61 474 050 463

Website: www.waubrafoundation.org.au

WAUBRA FOUNDATION

Biographical Details

Author: Sarah Laurie, CEO Waubra Foundation

Bachelor Medicine, Bachelor Surgery, Flinders University, 1995

Former Rural General Practitioner

Former Fellow and Clinical Examiner for Royal Australian College of General Practitioners

Former Fellow Australian College Rural and Remote Medicine

Former Member State Council, South Australian branch Australian Medical Association

WAUBRA FOUNDATION

References

Stepanov, K ***"Health Risk Factors of Low Frequency Noise Oscillation below 20 Hz"*** http://waubrafoundation.org.au/wp-content/uploads/2015/04/stepanov-dr-vladimir.pdf

National Institute of Environmental Health Sciences, USA 2001 "***Infrasound, Brief Review of Toxicological Literature***" http://waubrafoundation.org.au/resources/infrasound-brief-review-toxicological-literature/

WAUBRA FOUNDATION

References

Alves Pereira N, Castelo Branco N 2006 "***Vibroacoustic disease: Biological effects of infrasound and low-frequency noise explained by mechanotransduction cellular signalling***" http://waubrafoundation.org.au/resources/vibroacoustic-disease-biological-effects-infrasound-alves-periera-castelo-branco/

Alves Pereira M, Castelo Branco N "***Vibroacoustic disease: the need for a new attitude towards noise***" http://waubrafoundation.org.au/resources/alves-pereira-castelo-branco-vad-need-for-new-attitude-towards-noise/

WAUBRA FOUNDATION

References

Professor Geoff Leventhall's comments to the **NHMRC Workshop in June 2011** that "noise annoyance" symptoms are the same as "wind turbine syndrome" symptoms, and are a stress effect (from audible noise): http://waubrafoundation.org.au/resources/leventhall-g-comments-nhmrc-june-2011-wind-turbine-syndrome-symptoms-same-as-noise-annoyance/

Leventhall G, (assisted by **Benton, Pelmear**) 2003 Report for UK Department of Food and Rural Affairs: *"**A Review of Published Research on Low Frequency Noise and Its Effects**"* ***http://waubrafoundation.org.au/resources/review-published-research-low-frequency-noise-leventhall/***

WAUBRA FOUNDATION

References

Hubbard, H "***Noise Induced House Vibrations and Human Perception***" 1982
http://waubrafoundation.org.au/resources/hubbard-h-1982-noise-induced-house-vibrations-human-perception/

Kelley N et al "***A Methodology for Assessment of Wind Turbine Noise Generation***" 1982
http://waubrafoundation.org.au/resources/kelley-et-al-methodology-for-assessment-wind-turbine-noise-generation-1982/

WAUBRA FOUNDATION

References

Kelley N et al "***Acoustic Noise Associated with the MOD-1 Wind Turbine: Its Source, Impact and Control***" 1985 Prepared for the US Department of Energy http://waubrafoundation.org.au/resources/kelley-et-al-1985-acoustic-noise-associated-with-mod-1-wind-turbine/

Kelley, N "***Problem with Low Frequency Noise from Wind Turbines Scientifically Identified***" 1987 Presented to the American Wind Energy Association Conference, 1987, California http://waubrafoundation.org.au/resources/1987-problem-with-low-frequency-noise-from-wind-turbines-scientifically-identified/

WAUBRA FOUNDATION

References

Effects of chronic sleep deprivation – see **WHO Night Noise Guidelines for Europe 2009** http://waubrafoundation.org.au/resources/who-night-noise-guidelines-for-europe/

Capuccio et al "***Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies***" European Heart Journal Feb 2011 http://waubrafoundation.org.au/resources/sleep-duration-predicts-cardiovascular-outcomes/

WAUBRA FOUNDATION

References

McEwen, B "***Protective and Damaging Effects of Stress Mediators***" New England Journal of Medicine 1998, 338 171–179

Vitiliano, P et al ***"A Path Model of Chronic Stress, the Metabolic Syndrome, and Coronary Heart Disease***" 2002 Psychosomatic Medicine 64: 414-435 http://www.uned.es/psico-doctorado-envejecimiento/articulos/Rupert/Vitaliano_etal_2002.pdf

WAUBRA FOUNDATION

References

Inagaki T, Li Y & Nishi Y "***Analysis of aerodynamic sound noise generated by a large scaled wind turbine and its physiological evaluation"*** International Journal of Science and Technology 2015 12: 1933 – 1944 http://waubrafoundation.org.au/resources/ingaki-et-al-analysis-aerodynamic-sound-noise-generated-by-large-scaled-wind-turbines/

Tharpaland "***Three Wind Farm Studies and an Assessment of Infrasound: Executive Summary***" 2003 https://www.wind-watch.org/documents/three-windfarm-studies-and-an-assessment-of-infrasound/

WAUBRA FOUNDATION

References

Waubra Foundation Submission to First Australian Federal Senate inquiry into Rural Wind Farms Feb 2011 http://waubrafoundation.org.au/resources/waubra-foundation-submission-federal-senate-inquiry-into-rural-wind-farms-2011/

Ambrose, S & Rand R "***Bruce McPherson Infrasound and Low Frequency Noise Study***" December 2011 (pp 32 – 33) http://waubrafoundation.org.au/resources/bruce-mcpherson-infrasound-low-frequency-noise-study/

WAUBRA FOUNDATION

References

Salt, A Lichtenhan J "***How Does Wind Turbine Noise Affect People"*** Winter 2014 Acoustics Today (p 24 section 3 "***Excitation of Outer Hair Cell Afferent Nerve Pathways***")
http://waubrafoundation.org.au/resources/salt-n-lichtenhan-j-t-how-does-wind-turbine-noise-affect-people/

Nishimura, K "***Effects of Infrasound on Pituitary Adrenocortical Response & Gastric Microcirculation in Rats***" Journal of Low Frequency Sound and Vibration Vol 7 no 1 1988 (20 – 33)
http://waubrafoundation.org.au/resources/nishimura-k-effects-infrasound-pituitary-adrenocortical-response-gastric-microcirculation-rats/

WAUBRA FOUNDATION

References

Sharkey, S et al "***Takotsubo (Stress) Cardiomyopathy***" Circulation – Cardiology patient page http://circ.ahajournals.org/content/124/18/e460.full#sec-5

Pacak, K "***Phaeochromocytoma: a catecholamine and oxidative stress disorder"*** 2011 Endocr Regul. 2011 Apr; 45(2): 65–90. http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3414427/

WAUBRA FOUNDATION

References

Pierpont, N "***Wind Turbine Syndrome – Report of a Natural Experiment***" 2009 p109

"*Coming from several towers at once, these low frequency air pressure fluctuations may synchronize and reinforce, depending on the orientation of the towers and house and the timing of the individual turbines*"
http://waubrafoundation.org.au/resources/dr-nina-pierpont-submission-australian-senate-inquiry/

Thorne R, "***The Dean Report***" 2010
http://waubrafoundation.org.au/resources/thorne-r-dean-wind-farm-report-waubra-wind-farm/

WAUBRA FOUNDATION

References

Bakker, H.H.C. and B.I. Rapley, ***Sound, Noise, Flicker and the Human Perception of Wind Farm Activity***. Palmerston North*:*

Atkinson & Rapley Consulting (2010)

Bell, A Technical Note "***Constructive Interference of Tonal Infrasound from Synchronised Wind Farm Turbines: Evidence and Implications"*** Acoustics Australia Vol 42 No 2 Dec 2014 https://www.wind-watch.org/documents/constructive-interference-of-tonal-infrasound-from-synchronised-wind-farm-turbines-evidence-and-implications/

WAUBRA FOUNDATION

References

Gardner, Andrew Statement of Evidence for Cherry Tree case, 2013 re **pressure bolt sensations** experienced at home at Macarthur Wind Development, Victoria http://waubrafoundation.org.au/resources/gardner-statement-vcat-cherry-tree-hearing/

Huson, L Expert Opinion for Cherry Tree case, 2013 http://waubrafoundation.org.au/resources/huson-l-expert-evidence-at-vcat-cherry-tree-hearing/

WAUBRA FOUNDATION

References

Cooper, S "***The Results of An Acoustic Testing Program at Cape Bridgewater Wind Farm***", December 2014 for Pacific Hydro http://waubrafoundation.org.au/resources/cooper-s-acoustic-group-results-cape-bridgewater-acoustic-investigation/

See also the **Waubra Foundation** summary of the Cooper study and its implications http://waubrafoundation.org.au/resources/acoustic-engineering-investigation-at-cape-bridgewater-wind-facility/

WAUBRA FOUNDATION