Wind Turbine Syndrome

A Report on a Natural Experiment

Nina Pierpont, MD, PhD

"Impressive. Interesting. And important."

> —Robert M. May, PhD, Professor Lord May of Oxford OM AC Kt FRS. President of the Royal Society (2000-05), Chief Scientific Advisor to the UK government (1995-2000). Lord May is currently at the forefront of global warming research and is considered a pioneer in epidemiological research.

"Dr. Pierpont has clinically defined a new group of human subjects who respond to low frequency, relatively high amplitude forces acting upon the sensory and other body systems. Her rigorous clinical observations are consistent with reports of the deleterious effects of infrasound on humans, including, but not limited to, the low frequency sonar effects on divers. There are clinical conditions (such as dehiscent superior semicircular canals) that might explain some of Dr. Pierpont's clinical symptom review, but this relatively rare condition cannot explain all of her observations.

"Dr. Pierpont's astute collection of observations should motivate a well-controlled, multi-site, multi-institutional prospective study."

> —F. Owen Black, MD, FACS, Senior Scientist and Director of Neuro-Otology Research, Legacy Health System, Portland, Oregon. Dr. Black is widely considered to be one of the foremost balance, spatial orientation, and equilibrium clinical researchers in America.

"Like so many earlier medical pioneers exposing the weaknesses of current orthodoxy, Dr. Nina Pierpont has been subject to much denigration and criticism. It is a tribute to her strength of character and conviction that this important book has reached publication. Her detailed recording of the harm caused by wind turbine noise

will lay firm foundations for future research. It should be required reading for all planners considering 'wind farms.'"

—Christopher Hanning MD, FRCA, MRCS, LRCP. Dr Hanning, a founder of the British Sleep Society, is a leading sleep clinician and researcher. He recently retired as Director of the Sleep Clinic and Laboratory at Leicester General Hospital, one of the largest sleep disorder clinics in the UK.

"This is an extraordinary book. It is personal and passionate, which makes it compelling reading. But it is much more—authoritative, meticulous, and scholarly. The descriptions of anatomy, physiology, and the pathophysiology of how noise affects health are bang on. It clearly takes its place as the leading work on the topic.

"In addition to Dr. Pierpont's detailed clinical accounts, there is accumulating evidence of adverse health effects from Japan, New Zealand, the UK, USA, and Canada. There are also some 357 organizations from 19 European countries demanding an enquiry by the European Union about health and many other adverse effects of wind farms. At a minimum, the EU would be wise to consult with Dr. Pierpont.

"This book is a must-read for all health care professionals, especially those in clinical practice. One cannot but hope that politicians and policy makers at all levels heed the wake-up call that there are serious consequences to precipitant decisions relating to so-called green energy."

—Robert Y. McMurtry, MD, FRCS (C), FACS. Former Dean of Medicine and Dentistry at the Schulich School of Medicine & Dentistry, University of Western Ontario. Dr. McMurtry has had a long and distinguished career in Canadian public

health policy at both the federal and provincial level, including as founding Assistant Deputy Minister of the Population and Public Health Branch of Health Canada, and currently as a member of the Health Council of Canada.

"Dr Pierpont has made an important contribution to a debate about wind turbines that should be conducted not between champions and opponents of renewable energy, but within the community of those who want this country to behave in an environmentally responsible way. That we can and should do."

—Editorial board of The Independent (UK), August 2, 2009

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This study is dedicated to the memory of Dudley Weider, MD, Professor of Otolaryngology at the Dartmouth-Hitchcock Medical Center, who sent me to Alaska, diagnosed and cured my husband, and taught me about migraine and dizziness. We miss him.

Contents

ONE:

By way of explaining why on earth I wrote this book

I wrote this report because I saw a medical problem that few clinicians were paying attention to or, for that matter, seemed to understand. Dr. Amanda Harry in the United Kingdom led the way in recognizing the cluster of symptoms people experience around wind turbines.[1] I, myself, began encountering the problem from numerous e-mails and telephone calls I began receiving in 2004, shortly after wind developers turned up in my community and my husband and I started investigating industrial wind turbines.

The uniformity of the complaints quickly became apparent. It didn't take long to realize the potential for a relationship between these complaints, on the one hand, and *migraine, motion sickness, vertigo, noise and visual and gastrointestinal sensitivity, and anxiety* which, taken together, form a coherent and interconnected neurologic complex in medical practice.

The breakthrough came in early 2006, when I interviewed a couple who were about to move out of their home because of their own and their children's symptoms. The interview supported the

[1] Harry, Amanda. 2007. Wind turbines, noise, and health. 32 pp. www.windturbinenoisehealthhumanrights.com/wtnoise_health_2007_a_barry.pdf

relationship between turbine-associated symptoms and migraine/motion sensitivity. Best of all, the interview introduced me to the curious phenomenon of vibration or pulsation felt in the chest. It was this element that caught the attention of the National Academy of Sciences in its 2007 report to Congress, *Environmental Impacts of Wind-Energy Projects*. The authors wanted to learn more about this effect of low frequency noise.[2]

This study is my answer to their question.

As I have worked to understand these complaints, I have benefited from new research allowing us to better understand neurologic phenomena like spatial memory loss and fear reactions in people with balance problems—symptoms that often "bored and baffled" clinicians, as one of my referees put it.[3] Wind developers and acousticians have been even less charitable.

> It's…worth noting that studies have shown that a person's attitude toward a sound—meaning whether it's a "wanted" or "unwanted" sound—depends a great deal on what they think and how they feel about the source of the sound. In other words, if someone has a negative attitude to wind turbines, or is worried about them, this will affect how they feel about the sound. However, if someone has

[2] National Research Council. 2007. Environmental Impacts of Wind-Energy Projects. The National Academies Press, Washington, DC. 185 pp, p. 109 (Prepublication Copy). "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. Although there are opposing views on the subject, it has recently been stated (Pierpont 2006) that 'some people feel disturbing amounts of vibration or pulsation from wind turbines, and can count in their bodies, especially their chests, the beats of the blades passing the towers, even when they can't hear or see them.' More needs to be understood regarding the effects of low-frequency noise on humans" (from "Impacts on Human Health and Well-Being: Noise Levels," pp. 108-9, Prepublication Copy).

[3] I review and discuss this research in the Discussion section, pp. xx.

a positive attitude toward wind energy, it's very unlikely that the sounds will bother them at all.[4]

Their patients [people living near wind turbines and reported on by Drs. Osborne and Harry] may well have been experiencing adverse symptoms, but we have to keep in mind that people who have failed, for whatever reason, in strong objections to a development, build up in themselves a level of unfulfilled expectations and consequent stress, which peaks after the failure and can overload their coping capabilities. This leads them to lay the blame on whatever straw they can clutch. This is especially so in group activities, where mutual support may turn to a mutual, interacting misery, which worsens the situation….The very low levels of low frequency noise and infrasound which occur from wind turbines will not normally cause problems. If problems have occurred, it is possibly for some other stress-related reason.[5]

Brian Howe, a consulting engineer in acoustics for 20 years for HGC Engineering, said Ontario's guidelines for turbine noise are adequate and consistent with Health Canada studies. Most people near wind turbines aren't complaining about the noise, Howe said. In some cases, noise complaints could reflect higher anxiety levels from people who had unrealistic expectations of hearing virtually no sound, he said.[6]

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[4] Noble Environmental Power, LLC. Wind fact sheet #5: Are modern wind turbines noisy? p. 2. www.noblepower.com/faqs/documents/06-08-23NEP-SoundFromWindTurbines-FS5-G.pdf.

[5] Leventhall, Geoff. 2004. Notes on low frequency noise from wind turbines with special reference to the Genesis Power Ltd. Proposal near Waiuku, NZ. Prepared for Genesis Power/Hegley Acoustic Consultants, June 4, p. 7.

[6] Rennie, Gary. 2009. Wind farm noise limits urged. The Windsor (Ontario, Canada) Star. February 24.

Responses like these are a pity. They're rubbish. There is nothing "psychosomatic" or malingering about it. The physiologic pathway flows from physical forces (air pressure changes, noise, vibration) to physical sensations (chest pulsations, internal vibration, tinnitus, headache, ear fullness) to brain integration of sensory signals to distortions of brain functioning (sleeplessness, concentration and memory deficits, physical symptoms of anxiety)—not the reverse. Research clearly shows there are precise and definable neurologic connections that explain how distorted sensory signals can derail normal psychological and cognitive function and, in fact, trigger physical symptoms. (It's worth pointing out that our understanding of brain function has progressed by leaps and bounds in the last 25 years, radically changing the landscape of psychology and psychiatry and, of course, neurology.[7] Much of the research on vestibular function, whereon I draw, is even more recent, conducted within just the last 10-15 years.)

Leaving the pop psychology behind us, let's move on to evidence-based science. In the world of medicine my study is properly called a "case series," defined as *a descriptive account of a series of individuals with the same new medical problem*. Let me be clear: a case series is a standard and valid form of medical research. New illnesses are often introduced with case series whose role is to define an illness, suggest causation, and alert the medical and research profession to its existence. (This being one of the chief reasons for this report.) After an illness is defined and awareness raised, it becomes more feasible to do larger, more expensive studies to explore etiology (causation), pathophysiology, and epidemiologic characteristics.

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[7] See, for example, Schore, Allan N. 1994. Affect Regulation and the Origin of the Self: The Neurobiology of Emotional Development. Lawrence Earlbaum Associates, Hillsdale, NJ. 700 pp.

meetings, on the Internet, in Letters to the Editor, in courtrooms—it is routinely ridiculed. I speak from experience.

Wind energy is being promoted by every state and national government I know of, under intense lobbying by wind development companies generally owned or otherwise capitalized by powerful investment banks which in turn take large tax write-offs and reap large government subsidies for their wind farm projects. These companies turn around and sell carbon credits (green credits). Perhaps this helps explain why no provision is made for clinical caution?

And perhaps this goes some way toward explaining why a pediatrician in rural NYS and a general practitioner in Cornwall, England—along with a handful of rank-and-file, community physicians elsewhere in the UK, USA, Australia, and who knows where else—are the ones funding this research and writing these reports.

Then so be it.

Three poems by Gail Atkinson-Mair, who has lived every page in this book.

The Moles

You call me to the window, not quite sure,
"I really get the feeling we've got fewer moles
—must be the cat." An end to an unending war,
you grin and raise your glass. You're right. The holes
that spotty-dicked the grass and made me think
of crazy golf have by some miracle grown rare. I
frown and look away, then crash the dishes in the sink
and fumble, ill at ease. Alarm bells ring—but why?
There's something not quite right today—

a smooth expanse of light rich green and not one
mole hill to be seen; a thousand velvet diggers gone.
We look at one another and although
our mud-filled brains urge us to stay
our guts tell us—it's time to go.

Home

She's like the flies that buzz around inside
the house, alight on window, table, chair
and then take off. She stands, she sits, she looks
around a moment, then she's off. Eyes wide
she searches, checks, then stops. Smoothes hair
from face, swipes dust from books.
She's pulled the plugs and fixtures out,
switched off the mains, "Not there," she said.
She's gone outside and come back in,
It isn't there. You know it's not! I want to shout
and make her stop. The buzzing in her head
will drive her mad. She grabs the radio and plugs it in
then plugs her ears. Her face is grey
"Stop it now," she screams at me, "and make it go away."

My Back Yard

I had to come before I go insane.
The plant you built has side effects: I vomit, weep,
have dizzy spells and I'm depressed. The pain
from pressure in my ears keeps me from sleep—
I wake up drenched, have jitters, palpitations.
Your "silent" noise impairs my concentration—
I think you call that torture.
I no longer have a garden or a view, your
symphony of turbines has drowned the song of nature.
You say you've done what is required by law
but tell me where do people feature?

How old are you, Ms May? Aha, the menopause…
We call this problem, "NIMBY," I think you'll find…
Damn right, you are. It's not in your back yard—it's mine.

TWO:

The Report, for clinicians

Abstract

This report documents a consistent and often debilitating complex of symptoms experienced by adults and children while living near large industrial wind turbines (1.5-3 MW). It examines patterns of individual susceptibility and proposes pathophysiologic mechanisms. Symptoms include sleep disturbance, headache, tinnitus, ear pressure, dizziness, vertigo, nausea, visual blurring, tachycardia, irritability, problems with concentration and memory, and panic episodes associated with sensations of internal pulsation or quivering that arise while awake or asleep.

The study is a case series of 10 affected families, with 38 members age <1 to 75, living 305 m to 1.5 km (1000 to 4900 ft) from wind turbines erected since 2004. All competent and available adults and older teens completed a detailed clinical interview about their own and their children's symptoms, sensations, and medical conditions (a) before turbines were erected near their homes, (b) while living near operating turbines, and (c) after leaving their homes or spending a prolonged period away.

Statistically significant risk factors for symptoms during exposure include pre-existing migraine disorder, motion sensitivity, or inner ear damage (pre-existing tinnitus, hearing loss, or industrial noise

exposure). Symptoms are not statistically associated with pre-existing anxiety or other mental health disorders. The symptom complex resembles syndromes caused by vestibular dysfunction. People without known risk factors are also affected.

The proposed pathophysiology posits disturbance to balance and position sense when low frequency noise or vibration stimulates receptors for the balance system (vestibular, somatosensory, or visceral sensory, as well as visual stimulation from moving shadows) in a discordant fashion. Vestibular neural signals are known to affect a variety of brain areas and functions, including spatial awareness, spatial memory, spatial problem-solving, fear, anxiety, autonomic functions, and aversive learning, providing a robust neural framework for the symptom associations in Wind Turbine Syndrome. Further research is needed to prove causes and physiologic mechanisms, establish prevalence, and to explore effects in special populations, including children. This and other studies suggest that safe setbacks will be at least 2 km (1.24 mi), and will be longer for larger turbines and in more varied topography.

Introduction and Background

Policy initiatives in the United States and abroad currently encourage the construction of extremely large wind-powered electric generation plants (wind turbines) in rural areas. In its current format, wind electric generation is a variably regulated, multi-billion dollar a year industry. Wind turbines are now commonly placed close to homes. Usual setbacks in New York State, for example, are 305-457 m (1000-1500 ft) from houses.[1] Developer statements and preconstruction modeling lead communities to

[1] Town of Ellenburg, NY, wind law—1000 ft (305 m); Town of Clinton, NY, wind law—1200 ft (366 m); Town of Martinsburg, NY, wind law—1500 ft (457 m). For other examples in and outside NY State, see *Wind Energy Development: A Guide for Local Authorities in New York*, New York State Energy Research and Development Authority, October 2002, p. 27. http://text.nyserda.org/programs/pdfs/

believe that disturbances from noise and vibration will be negligible or nonexistent.[2,3,4] Developers assure prospective communities that turbines are no louder than a refrigerator, a library reading room, or the rustling of tree leaves which, they say, easily obscures turbine noise.[5]

Despite these assurances, some people experience significant symptoms after wind turbines are placed in operation near their homes. The purpose of this study is to establish a case definition for the consistent, frequently debilitating, set of symptoms

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[2] "The GE 1.5 MW wind turbine, which is in use in Fenner, New York, is generally no louder than 50 decibels (dBA) at a distance of 1,000 feet (the closest we would propose siting a turbine to a residence). Governmental and scientific agencies have described 50 dBA as being equivalent to a 'quiet room.' Please keep in mind that these turbines only turn when the wind blows, and the sound of the wind itself is often louder than 50 dBA. Our own experience, and that of many others who live near or have visited the Fenner windfarm, is that the turbines can only be heard when it is otherwise dead quiet, and even then it is very faint, especially at a distance." Letter from Noble Environmental Power, LLC, to residents of Churubusco (Town of Clinton), New York, 7/31/2005.

[3] "Virtually everything with moving parts will make some sound, and wind turbines are no exception. However, well-designed wind turbines are generally quiet in operation, and compared to the noise of road traffic, trains, aircraft, and construction activities, to name but a few, the noise from wind turbines is very low....Today, an operating wind farm at a distance of 750 to 1,000 feet is no noisier than a kitchen refrigerator or a moderately quiet room." *Facts about wind energy and noise*. American Wind Energy Association, August 2008, p. 2. www.awea.org/pubs/factsheets/WE_Noise.pdf

[4] "In general, wind plants are not noisy, and wind is a good neighbor. Complaints about noise from wind projects are rare, and can usually be satisfactorily resolved." *Facts about wind energy and noise*. American Wind Energy Association, August 2008, p. 4. www.awea.org/pubs/factsheets/WE_Noise.pdf

[5] "Outside the nearest houses, which are at least 300 metres away, and more often further, the sound of a wind turbine generating electricity is likely to be about the same level as noise from a flowing stream about 50-100 metres away or the noise of leaves rustling in a gentle breeze. This is similar to the sound level inside a typical living room with a gas fire switched on, or the reading room of a library or in an unoccupied, quiet, air-conditioned office....Even when the wind speed increases, it is difficult to detect any increase in turbine sound above the increase in normal background sound, such as the noise the wind itself makes and the rustling of trees." *Noise from wind turbines: the facts*. British Wind Energy Association, August 2008. www.bwea.com/ref/noise.html

experienced by people while living near wind turbine installations, and to place this symptom complex within the context of known pathophysiology. A case definition is needed to allow studies of causation, epidemiology, and outcomes to go forward, and to establish adequate community controls.

This set of symptoms stands out in the context of noise control practice. George Kamperman, P.E., INCE Bd. Cert., past member of the acoustics firm Bolt, Beranek and Newman (USA), wrote, "After the first day of digging into the wind turbine noise impact problems in different countries, it became clear that people living within about two miles from 'wind farms' all had similar complaints and health problems. I have never seen this type of phenomenon [in] over fifty plus years of consulting on industrial noise problems. The magnitude of the impact is far above anything I have seen before at such relatively low sound levels. I can see the devastating health impact from wind turbine noise but I can only comment on the physical noise exposure. From my viewpoint we desperately need noise exposure level criteria."[6]

I named this complex of symptoms "Wind Turbine Syndrome" in a preliminary fashion in testimony before the Energy Committee of the New York State Legislature on March 7, 2006. My observation that people can feel vibration or pulsations from wind turbines, and find it disturbing, was quoted in the brief section, "Impacts on Human Health and Well-Being" in the report *Environmental Impacts of Wind-Energy Projects* of the National Academy of Science, published in May 2007. No other medical information was cited in this report. The authors asked for more information to better understand these effects.[7]

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[6] George Kamperman, personal communication, 2/21/2008. See www.kamperman.com/index.htm.

[7] National Research Council. 2007. Environmental Impacts of Wind-Energy Projects. The National Academies Press, Washington, DC. 185 pp, p. 109.

In a continuation study that involved interviewing participants, Pedersen found that some people had moved out of their homes, rebuilt their homes in an attempt to exclude turbine noise, or begun legal proceedings because of problems associated with turbine exposure.[212] Pedersen and Persson Waye also found informants who were sensitive to both noise and blade motion, felt violated or invaded by turbine noise, and found their houses to be places where they could no longer find restoration[213]—qualitative similarities to the current study.

Van den Berg, Pedersen, and colleagues conducted another survey study of noise and annoyance in the Netherlands in 2007.[214] They mailed questionnaires to 1960 households within 2.1 km (1.3 mi) of at least two adjacent 0.5 to 3 MW turbines, with 725 responses (37% response rate). The questionnaire asked about visual and auditory perceptions, economic benefit, annoyance, chronic diseases, current symptoms, psychological stress, and sleep disturbance, and looked at variation in these factors (as in the Swedish study) against modeled A-weighted noise levels.

Though it contained several questions about health, this study was not properly constructed to sample health in an accurate or realistic way. The evidence for this is found in the study results themselves, which contain significant bias or skew relative to known health parameters.

For example, 2% of respondents in this study indicated that they had chronic migraine disorder.[215] The population prevalence of migraine disorder is remarkably stable across countries and time

[212] Pedersen 2007

[213] Pedersen and Persson Waye 2007

[214] van den Berg et al. 2008b

[215] van den Berg et al. 2008b, p. 48.

when controlled for age, sex, and definition of the disease, being 5-6% for males and 15-18% for females.[216,217] A finding of 2% is an underestimate, indicating that something about this study's method of sampling migraine prevalence was awry.

Sampling and sampling error occur at several levels, such as the level of selecting respondents and the level of sampling the respondents' thoughts through questioning. Potential flaws at each level can be identified in this study.

First, the researchers attempted to elicit objective health information with just two questions in this survey, one on past or underlying health and one on current symptoms. (Separate questions addressed sleep disturbance). This is the single question about underlying health:

> 37. Do you have any long term/chronic disease? (no → 38, yes). *If yes, which chronic disease do you have?* (diabetes, high blood pressure, tinnitus, hearing impairment, cardiovascular disease, migraine, other viz:)[218]

This is a very brief and superficial question, and it is not surprising that it failed to capture all the diagnoses of migraine that should have been present in a random population sample. In medical research, in contrast, the presence or absence of a diagnosis in a subject is established by multiple proven and validated questions directly tied to the formal definition of the illness, administered by a trained interviewer. Even in clinical practice, which is less

[216] Lipton RB, Bigal ME, Diamond M, Freitag F, Reed ML, Stewart WF; AMPP Advisory Group. 2007. Migraine prevalence, disease burden, and the need for preventive therapy. Neurology 68(5): 343-49.

[217] Stewart WF, Simon D, Shechter A, Lipton RB. 1995. Population variation in migraine prevalence: a meta-analysis. J Clin Epidemiol 48(2): 269-80.

[218] van den Berg et al. 2008b, Appendix p. 5.

formal, an accurate review of systems still requires a series of specific screening questions and the knowledge of when and how to question in further depth. No clinician or health researcher would rely on a question like the above to elicit full and accurate information about the past health history.

The same question also failed to elicit accurate prevalence figures for tinnitus. Tinnitus prevalence among survey respondents was 2%, whereas 4% is the likely population-level figure for the respondents' average age of 54.[219] Tinnitus prevalence also did not show age differences in this sample,[220] whereas in reality tinnitus has a well-documented pattern of increasing prevalence with advancing age.[221]

The question's time frame is also unclear. Were the authors trying to find out about baseline susceptibilities (health conditions before turbines) or did they hypothesize that exposure to wind turbines might alter the prevalence of these chronic conditions? Though they never state it explicitly, their analysis makes it clear they hypothesized that health effects due to wind turbines, if they exist, would present as higher levels of the listed chronic diseases closer to wind turbines.[222] To think that they might find such an effect with this type of sample size and mode of study verges on silly, it is so far outside the parameters of how such issues are studied (see, for example, studies cited in footnotes 171-177 , above). As a result, this study's failure to find such an effect is meaningless.

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[219] National Institute on Deafness and Other Communication Disorders, USA, website, "Prevalence of chronic tinnitus." 2009. www.nidcd.nih.gov/health/statistics/prevalence.htm

[220] van den Berg et al. 2008b, p. 47.

[221] National Institute on Deafness and Other Communication Disorders, "Prevalence of chronic tinnitus." 2009.

[222] van den Berg et al. 2008b, p. 50.

There were also sampling problems at the level of subject selection. First, the study has no control population that is not exposed to turbine noise. It samples within 2.1 km (1.3 mi) of turbines, using the unspoken assumption that the people at the outer edge of this radius will not be exposed to significant amounts of turbine noise and can therefore act as a control group. An epidemiologic study, in contrast, would have a control group of households subjected to all the same procedures for household selection, questioning, and noise modeling as the study group, but without turbines present.

Second, uncontrolled subject selection processes occurred at the level of the household. Once questionnaires reached households, what happened? Nearly 2/3 of households declined to respond. The researchers studied a subset of non-responders using a very brief questionnaire that yielded a modestly higher (48%) response rate. The brief questionnaire showed that non-responders were similar to responders in their average degree of annoyance at wind turbine noise, but did not address the issue of whether non-responders differed from responders in health parameters.

An additional process of self-selection occurred within responder households, since only one individual replied and only answered questions about himself. The householders chose who replied. On a very mundane and human level, we can imagine how this process might have selected against migraineurs in the sample, if the person with a headache the day the survey arrived asked someone else to fill it out.

The survey's second question about health concerned current symptoms, as follows:

> 38. Have you been troubled by the following symptoms during the last months? ((almost) never, at least once a month, at least once a week, (almost) daily) [sic]

Headache
Undue tiredness
Pain and stiffness in the back, neck or shoulders
Feeling tense or stressed
Depressivity
Not very sociable, wanting to be alone
Irritable
Resigned
Fearful
Concentration problems
Nausea
Vertigo
Mood changes
Other, namely: *(please indicate what)*[223]

This is an odd list of "symptoms"—an undifferentiated mix of physical and psychological, with a few simple "feeling words" thrown in. It does not make sense as a symptom list—not without more detail and structuring into symptom groups. As with the chronic disease question, above, medical researchers and clinicians know that accurate and complete information cannot be elicited in this format, especially about delicate subjects like mood states and health. This question, too, is unclear about timing—pre-existing vs. during exposure, while near turbines or away from them.

This question in fact yielded little information that was useful to the researchers. In their analysis, the only reference to the health symptoms question is as follows:

> Respondents who did not benefit economically from wind turbines reported more chronic diseases and health symptoms than those who benefited….The observed

[223] van den Berg et al. 2008b, Appendix p. 6.

> differences between the sub-samples regarding chronic diseases and health symptoms could be due to age effects; respondents who did not benefit economically were older than those who benefited.[224]

Otherwise, through a long and detailed statistical analysis of stress, sleep disturbance, noise, annoyance, and chronic disease, the health symptoms question does not appear again.

The researchers expanded their questioning on mood states by incorporating a screening interview for mental illness used in general medical practice, called the General Health Questionnaire.[225] Despite the name, it is not a health questionnaire, nor is it a measure of psychological stress (which is how the authors use it). The GHQ-12 is a screening tool for mental illness, used to help a physician figure out which of his presenting patients need assessment for psychiatric illness. It was validated (meaning compared against other effective means of diagnosis to see if it identified the right people) for its declared purpose, not as a measure of psychological stress. The authors present it as a "validated instrument" for "measuring 'perceived health,'"[226] then use it in their analysis as a measure of "psychological stress," morphing the question set from one purpose to another to another without justification.[227]

In the Dutch survey study results, owners of turbines lived the closest to turbines and were able to turn them off if they or their

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[224] van den Berg et al. 2008b, p. 49.

[225] Goldberg DP, Hillier VF. 1979. A scaled version of the General Health Questionnaire. Psychol Med 9(1): 139-45. The 28-item GHQ may be found at http://scholar.google.com/scholar?hl=en&rlz=1T4GGIH_enUS225US225&q=author:%22Goldberg%22+intitle:%22General+health+questionnaire%22+&um=1&ie=UTF-8&oi=scholarr and the 12-item GHQ (used by van den Berg et al.) at www.webpoll.org/psych/GHQ12.htm

[226] van den Berg et al. 2008b, p. 20.

[227] van den Berg et al. 2008b, p. 47.

neighbors were bothered by the noise—a key difference between the Netherlands and other countries. These closer respondents tended to be farmers and to benefit economically from the turbines. They were on average younger, healthier, and, as it happens, better educated than the respondents living farther from turbines.

Sleep disturbance, annoyance, and questionnaire measures of stress were correlated with noise levels among people who did not benefit economically from turbines. Annoyance occurred at lower dBA noise levels than for road, rail, or air traffic noise, as in the similar Swedish study. Being awakened from sleep was associated with higher noise levels, and difficulty falling asleep and higher stress scores were associated with annoyance. "Respondents with economic benefits reported almost no annoyance,"[228] though they lived closest to the turbines and experienced the highest modeled noise levels. If turbine owners were turning the turbines off when they were bothered or during sleep, then the modeled noise levels would not have accurately represented real noise levels close to the turbines.

Despite health being inadequately sampled in this study, the authors still draw conclusions that are interpreted popularly as evidence against health effects by wind turbines, in sentences like this one from the authors' summary: "There is no indication that the sound from wind turbines had an effect on respondents' health, except for the interruption of sleep."[229] Though it is downplayed in this sentence, sleep interruption is in fact of great significance to health. The authors are remiss in failing to acknowledge that the study methods do not have the power to detect other health effects.

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[228] van den Berg et al. 2008b, Summary, p. ii.

[229] van den Berg et al. 2008b, Summary, p. ii.

The authors would have more accurately captured the survey's health results had they written, "Sleep disturbance or interruption, an effect of profound importance to health, was correlated with turbine noise levels. Unfortunately, the survey could not effectively address other health questions due to bias introduced at the level of data collection. An important finding is the possibility of biased responses from respondents benefiting economically from turbines, yet it is equally possible that turbine owners are in the habit of turning turbines off at critical times, thus avoiding both annoyance and sleep disturbance."

Recommendations

For physicians practicing near wind turbine installations, I suggest incorporating proximity to turbines into the personal and social history in a neutral and non-suggestive way, especially for the types of symptoms described in this report.

With regard to turbine setback from dwellings: In Table 1B we see that the subjects in the current study lived between 305 m (1000 ft) and 1.5 km (4900 ft or 0.93 mi) from the closest turbine. There were three severely affected families at 930-1000 m (3000-3300 ft) from turbines. This study suggests that communities that allow 305-457 m (1000-1500 ft) setbacks from homes, like those in New York State, may have families who need to move after turbines go into operation.

All turbine ordinances, I believe, should establish mechanisms to ensure that turbine developers will buy out any affected family at the full pre-turbine value of their home, so that people are not trapped between unlivable lives and destitution through home abandonment. By shifting the burden of this expense to turbine developers, I would hope that developers might have a stronger incentive to improve their techniques for noise prediction and to accept noise level criteria recommended by such agencies as

Family Table A2 (page 1 of 2)

Person
Mrs. A

Age
33

Pre-exposure health status
Good. Pregnant during exposure and delivered at term 4 days before moving.

Health history
Polycystic ovarian syndrome and metabolic syndrome. Caesarian section for first delivery.

Previous noise exposure
Worked at biomedical chemical plant for 5 yrs with 1-2 hrs/wk exposure to noisy areas.

Time to onset of symptoms
Immediate with progression

	Pre-exposure	During exposure*	Post exposure **
Sleep	Normal. Sleeps through noises other than children.	Frequent awakening	Normal, resolved
Headache	Rare, mild	Occasional headache	At baseline
Cognition	Concentration "great," works as accountant	Noticed concentration problem at work when training someone; working to focus; trainee had to help	Resolved
Mood	Good, including during and after first pregnancy	Irritable	Resolved
Balance/ equilibrium	Gets seasick but not carsick	Slight unsteadiness	Resolved
Ear/hearing	Normal hearing. Persistent middle ear fluid in late 20's, resolved. Tinnitus in past when emerging from noisy plant.	Repetitive popping in ears and decreased hearing for first 3 weeks, then tinnitus began. Tinnitus varied with exposure and worsened over time.	Tinnitus resolved, but has new difficulty understanding conversation in a noisy room. Has to watch speaker's face.
Eye/vision	Wears glasses. Eyes water if strained.	No change	No change
Other neurological	Normal, no concussion	No change	No change
Cardiovascular	Normal except h/o temporary stress-related hypertension at age 22.	Normal	Normal
Gastrointestinal	Nausea and GER during pregnancy	No change	Resolved after delivery

FOUR:

The Report all over again, in plain English for non-clinicians

Abstract and Background

I interviewed 10 families living near large (1.5 to 3 MW) wind turbines, all of which were built since 2004. This gave me 38 people, from infants to age 75. Their symptoms formed a cluster. (See Glossary for clinical terms.)

1) sleep disturbance
2) headache
3) tinnitus (pronounced "tin-uh-tus": ringing or buzzing in the ears)
4) ear pressure
5) dizziness (a general term that includes vertigo, lightheadedness, sensation of almost fainting, etc.)
6) vertigo (clinically, vertigo refers to the sensation of spinning, or the room moving)
7) nausea
8) visual blurring
9) tachycardia (rapid heart rate)
10) irritability

11) problems with concentration and memory
12) panic episodes associated with sensations of internal pulsation or quivering, which arise while awake or asleep

People in these families noticed that they developed new symptoms after the turbines started running near their homes. They noticed that when they went away, the symptoms went away. When they came back, the symptoms returned. Eight of the 10 families eventually moved away from their homes because they were so troubled by the symptoms, sometimes abandoning their homes.

Hence the definitive result of my report is that wind turbines cause the symptoms of Wind Turbine Syndrome (WTS). I show this in the common-sense way described above.

Let's clarify something immediately. Not everyone living near turbines gets these symptoms. As a solo, unfunded researcher I could not get the samples needed to figure out what percentages of people at what distances get the symptoms. This needs to be done next. But I could (and did) look at the question of why some people are susceptible and others not, plus who is susceptible, and I used these patterns to explore the *pathophysiology of Wind Turbine Syndrome* (what's going on inside people to cause these specific symptoms).

I would like readers to look at this study—including the detailed accounts I provide of people's experiences around turbines and

their health backgrounds—and be able to make their own decisions about whether they should be exposed to these machines.

That said, I was able to prove mathematically that people with pre-existing migraines, motion sensitivity (such as car-sickness or seasickness), or inner ear damage are especially vulnerable to these symptoms. Equally as interesting, I was able to demonstrate that people with anxiety or other preexisting mental health problems are not especially susceptible to these symptoms.

This contradicts wind industry literature, which argues that people who worry about or otherwise dislike the turbines around their homes are the ones getting ill. I show this to be complete nonsense.

Here is what's going on, as I piece together the evidence. *Low frequency noise or vibration tricks the body's balance system into thinking it's moving.* Like seasickness. (It's vital to understand that the human balance system is a complex brain system receiving nerve signals from the inner ears, the eyes, muscles and joints, and inside the chest and abdomen. Because the eyes are involved, visual disturbance from the blades' shadow flicker adds to the balance disturbance.)

Let me repeat this, because its significance is huge. *Low frequency noise or vibration from turbines deceives the body into thinking it's moving.* So what, you say? Not so fast! Research within the last 10 years has demonstrated conclusively that *the way our bodies register balance and motion directly affects an astonishing array of brain functions.*

How? By direct neurologic linkages connecting the organs of balance to various, seemingly unrelated brain functions.

I'll rephrase this, since it's critical to the argument of this report. *The way our bodies perceive balance and motion in turn influences a host of brain functions which at first glance might appear to be entirely unrelated to balance and motion.* As I said, this is what the latest "balance" research tells us—more accurately, balance research combined with psychiatric, neurologic and cognitive research.

Incidentally, the people specializing in this kind of research are called *otoneurologists* (Europe) and *neurotologists* (United States). (From *oto* for ear, and *neuro* for brain.)

And what are these seemingly unrelated brain functions affected by our perception of balance and motion?

a) *Automatic or reflex muscle movements.* These are the well-known vestibulo-ocular reflex, which makes eye movements compensate automatically for head movements, and the vestibulo-collic and vestibulo-spinal reflexes, which dynamically adjust muscle tone in the neck and back to maintain posture during movement.
b) *Alerting:* attention, alarm, and awakening.
c) *Spatial processing and memory.* Spatial processing is the image-based or pattern-based thinking we use constantly to:

    a. picture things,
    b. remember where things are or where they go,
    c. remember how to get somewhere,
    d. understand how things work,
    e. picture how we want something to turn out,
    f. figure out how to put something together or fix it,

g. figure out the most efficient order and timing of something (such as work around the kitchen, farm, fishing boat, property, or a series of errands),

h. remember what we're looking for when we get someplace (such as errands in town),

i. understand math concepts,

j. and a host of other critical thinking functions.

d) *Physiologic manifestations of fear.* This means fast-pounding heart, increased blood pressure, sweating, nausea, trembling, and hyper-alertness.

e) *Aversive learning.* This is a type of reflex learning whose function is to make creatures avoid potentially harmful things. A classic illustration in both animals and people is vomiting after eating a particular kind of food. We avoid that food for a long time afterwards, even if the food itself was not the cause of the vomiting, and even if it happened only once. (Remember that experience as a child?) This type of learning is so imprinted and automatic that even the environment associated with this experience can trigger the feeling of nausea—like smelling or seeing the particular food, or even approaching the same restaurant. It's an old evolutionary reflex, designed to keep mammals and birds from eating toxic things (with some very interesting consequences for butterfly evolution, but that's another story). What is important here is that we are hard-wired to avoid things that make us nauseated.

Okay. *Muscle contractions in eyes and neck and spine, alerting/awakening, spatial processing and memory,* the *physiological manifestations of fear*, and *aversive learning*. All five brain functions are profoundly affected by our sense of balance and motion. All five

get messed up when our sense of balance and motion is thrown off.

Back to wind turbines. Open any online newspaper article discussing Wind Turbine Syndrome and you almost invariably discover that someone has posted a comment ridiculing the whole idea for the obvious reason that there's no conceivable way such a disparate range of health problems—memory deficits, spatial processing deficits, anxiety and fear and panic, and aversive learning—could possibly be triggered by a wind turbine, of all things. Preposterous! Clearly, continues our brilliant blogger, people who live near turbines and report these symptoms are making them up (probably because they don't like the darn things), and just as clearly the doctor who takes these seriously (that would be me) is a piker and huckster.

To which I respond: Clearly the authors of these brilliant gems of logic are neither neurobiologists nor clinicians—nor are they experiencing the symptoms which are clearly, unambiguously reported by many people living in the shadow (as it were) of industrial wind turbines.

Back to real medicine. The symptoms outlined above occur together *because humans are hardwired to exhibit this precise constellation of symptoms when their balance and motion sensors are dis-regulated*—as happens to many people living near wind turbines.

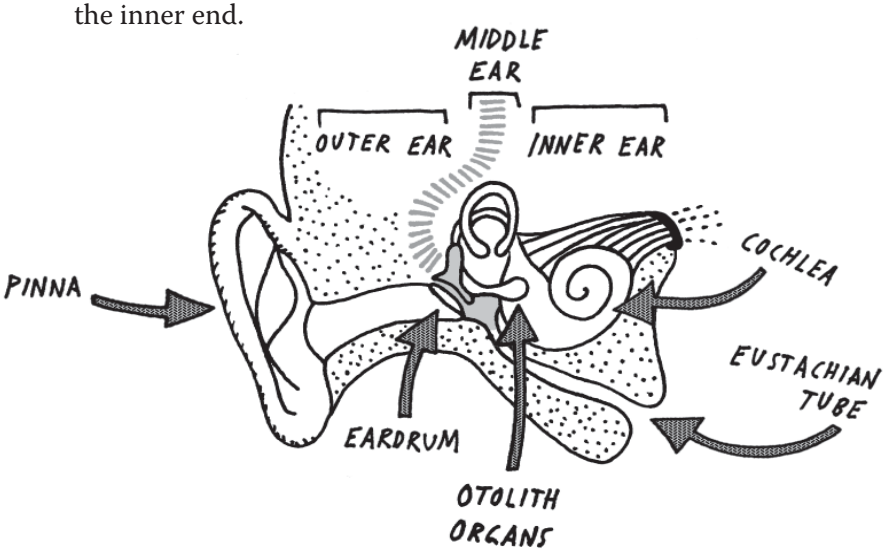
It's important to emphasize, these symptoms are not psychological (as if people are fabricating them); they are neurological. People have no control whatsoever over their response to the turbines. It happens automatically. One can't turn on and turn off these symptoms.

We can be emphatic about this because *balance signals* (called *vestibular* signals) *are the one kind of sensory signal we simply cannot tune out.* You can tune out (ignore) what you see and hear, but not what comes in from your sense of balance. Call it a law of nature, if you like.

And what provides our sense of balance? I'm glad you asked. Balance comes from a combination of signals. I'll rephrase this: balance comes from *clusters of signals from different body organs*. One source being, of course, the inner ear.

Stop. We need to review the anatomy of the inner ear. It's essential to understanding Wind Turbine Syndrome.

Start with the weird flap of skin on the side of your head , necessary for holding up your glasses and earrings. This is not the outer ear; it's the pinna. (Boxers get cabbage pinna.) The outer ear is where you put Q-Tips and where your two-year-old stores beads and other treasures. It's where earwax lives and where water gets lodged when you shower, and you have to shake it out. The outer ear is a blind pouch ending at the eardrum, sealing off the pouch at the inner end.



Next comes the middle ear. The place between the eardrum and what's called the oval window. This is the part of the ear that gets infected in little kids. (Moms, remember all those times you took Johnny to the doctor and she said, "Yup, Johnny has an ear infection." This, after Johnny woke up screaming in the night, after having a cold for three days.) The middle ear is open to the air, through the Eustachian tube (pronounced "U-station") from the back of the throat (up behind the nose).

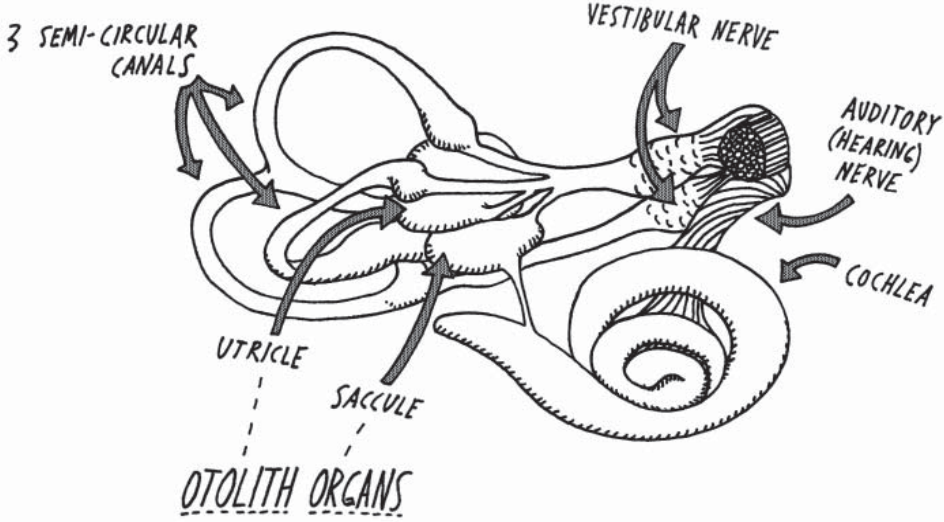
The middle ear houses those three wonderful little bones, incus ("ink-us"), malleus ("mal-ee-us"), and stapes ("stay-peas"), that are linked in a chain. Incus, malleus, and stapes transmit the energy of the vibrating eardrum to the inner ear.

This brings us to our destination. The inner ear (or membranous labyrinth), which consists of the semicircular canals (which you remember from high school biology) and the so-called otolith organs (which you probably don't remember from high school biology).

The otolith organs are key to understanding Wind Turbine Syndrome. They consist of two little membranous sacs, the utricle ("you-trick-ul") and saccule ("sack-ule"), which are attached to the cochlea ("coke-lee-ah," the spiral-shaped, membranous organ that transduces the mechanical energy of sound into neural signals) and to the semicircular canals (membranous organs which make a semi-circle in each of the three planes of movement—vertical forward, vertical sideways, and horizontal—and transduce angular acceleration: when your head is nodding or turning, they detect it).

Embedded in the two otolith organs are—believe it or not—rocks. (*Oto* = ear and *lith* = rock. Remember when your teacher declared you must have rocks in your head?) Well, not really rocks. They're tiny. In fact they're microscopic crystals of calcium carbonate

(like calcite or oyster shells), called otoconia ("oto-cone-ia"), stuck together in a mass on top of the patch (macula, pronounced "mack-you-la") of movement-sensing hair cells. The weight and mass of these stones allows the hair cells to detect gravity and linear acceleration.

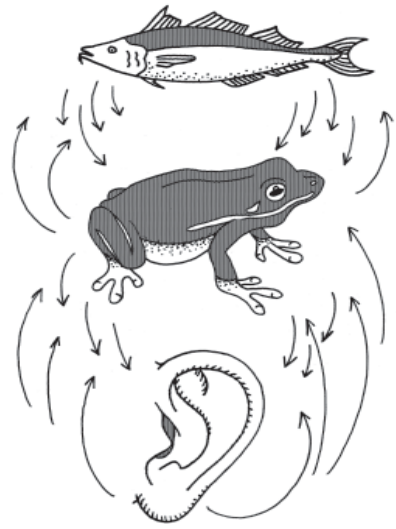


Things now get truly beautiful. Imagine God "with his broad sculptor-hands leaf[ing] through the pages in the dark book of the beginning," showing us the blueprints for the semicircular canals and otolith organs.[1] Structures so fundamental to brain function that they are shared by fish, amphibians, and (so-called) higher vertebrates. Yes, including us. In each of these creatures these organs perform a function not only older than the mind can grasp, but so profound it has come to define what mind itself is. (Note: The cochlea, the organ we use for hearing, evolved much later in mammals.)

We are in the presence of a master key to the mammalian mind. (Not just mammalian, but the entire backboned animal world.)

[1] Rilke, Rainer Maria. 1991. "The Angels," trans. Snow. The Book of Images: A Bilingual Edition, rev. ed. North Point, NY, p. 31.

It is this master key, dear reader, that is counterfeited by the low frequency noise from the massive, spinning wind turbine outside your window.



We're in the presence, here, of truly ancient anatomical structures. Many millions of years old. Fish, amphibians, and "higher" vertebrates all have semicircular canals and otolith organs.

Consider this. Teleost fish, such as cod, hear with their otolith organs. Their otolith organs are their detectors of sound and vibration, such as the movements of nearby predators or prey. Their otolith organs also detect gravity (which way is up) and acceleration (if the fish moves or turns). Atlantic cod otolith organs are so sensitive to water perturbations from infrasound (at 0.1 Hz, or one wave every 10 seconds) that the fish may be able to use seismic sounds from the Mid-Atlantic Ridge or the sounds of waves breaking on distant shores to guide them during migration, hundreds of miles away.

Consider this. In frogs, the saccule (one of the otolith organs) remains the part of the ear most sensitive to substrate-borne vibration. Both the saccule and a newly evolved part of the frog ear, the basilar papilla, detect both sound and vibration, with the saccule capturing lower frequencies and the papilla higher frequencies.

All by way of laying the groundwork for the idea that our own otolith organs have been, ancestrally, detectors of sound, vibration, and low-frequency sound, in addition to detecting gravity and

body movements. Human otolith organs have retained some of these functions, it turns out: they respond to noise or vibration by sending out vestibular signals.

If stimulated by a loud click or abrupt tone, normal human vestibular organs trigger a measurable, specialized reflex: an electrical signal to muscles in the front of the neck (called the "vestibular evoked myogenic potential" or VEMP). Let me rephrase this, since it's important: a noise, delivered to the ear without any movement of the head or body, sets off a rapid (neural) chain of events that changes neck muscle tone. This neck muscle signal is part of the vestibulo-collic reflex (*collic* meaning "neck," like *collar*). The purpose of the vestibulo-collic reflex is to stabilize the head during body or head movement. *A noise, albeit a loud and distinctive type of noise, sets off a reflex chain of events showing that the vestibular system thinks the body or head is moving, even when it is not. Yes, in normal, healthy adult humans.* (Wind developers, are you reading this?)

Noise doesn't necessarily come in via the air, eardrum, and middle ear, however. Vibrations or "bone-conducted sound" can reach the inner ear directly through the bone in which the inner ear is sculpted. To do this in experiments or as a clinical test, a vibrating object is put against the skin over the mastoid bone behind the ear. It takes less energy (a lower decibel level) to trigger the vestibular response when the signal comes in through bone conduction than when it comes in through the air-middle ear route. Bone conduction also works better at lower sound or vibration frequencies.

Most exciting, *it was shown in 2008 that the normal human vestibular system has a fish- or frog-like sensitivity to low-frequency vibration*. In this experiment, a vibrating rod was applied to the skin over the mastoid bone, using carefully calibrated force. Subjects could hear the vibrations as tones, and the researchers detected

vestibular responses by measuring electrical signals coming from the subjects' eye muscles. Interesting that this response has a distinct tuning peak at 100 Hz, meaning there is a much bigger vestibular-eye muscle response at 100 Hz than at higher or lower frequencies. (By way of comparison, 100 Hz is equivalent to G-G#, 1½ octaves below middle C. That is, keys 23-24 on a piano.) *At this tuning peak the vibration still produced a measurable vestibular response (eye muscle electrical signals) when the vibration intensity had been reduced so much that the subjects could no longer hear the tones. In fact, the power of the vibration that produced a vestibular response was only about 3% of the power the subjects could hear (15 dB lower).*

This means that some part of the vestibular organs in the inner ear is more sensitive to vibration or bone-conducted sound than the cochlea is. The authors of this study think it's the utricle, one of the two otolith organs, and some special, vibration-sensitive hair cells and nerve fibers that occur mixed in with the other hair cells in the utricle and other vestibular organs.

This is amazing. (It would be heretical if it hadn't been shown in a well-conducted experiment). It has been gospel among acousticians for the past 70 years that if a person can't hear a sound, it's too weak for it to be detected or registered by any other part of the body. We can now write this as follows: ~~If a person can't hear a sound, it's too weak for it to be detected or registered by any other part of the body.~~ Because it turns out it's wrong. (It also means that using the A-weighted network for community noise studies is probably outdated. See below.)

> And silent be,
> That through the channels of the ear

May wander like a river
The swaying sound of the sea.

—W.H. Auden, from "Look, Stranger."

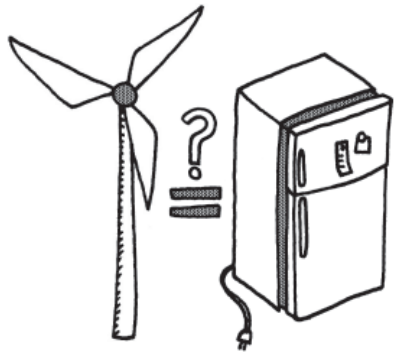
Back, now, to what provides us with our sense of balance. I said balance comes from a combination of signals, and I just explained how some of them originate in the inner ear. Besides the inner ear, the eyes also send motion and position signals to the brain. So, too, do muscles and joints all over the body, involving what are called "stretch" receptors, telling us where we are in space.

And lastly, we maintain our balance by newly discovered stretch and pressure receptors in the chest and abdomen. These tiny receptors use various organs, including blood vessels and the blood in them, as weights or masses to detect the body's orientation to gravity and other forms of acceleration.

The foregoing is the proper context for studying people's health complaints from wind turbines. Health complaints that are routinely dismissed by the wind industry as nonsense. (Not unlike the tobacco industry dismissing health issues from smoking.) The wind industry, however, is not composed of clinicians, nor is it made up of people suffering from wind turbines.

My hope is that researchers will soon be able to measure and correlate wind turbine audible and sub-audible noise, and vibration, with the symptoms people experience in real time—that is, while they're actually experiencing the symptoms. (This has been done for similar complaints in published cases, as described below.) Until that happens, I offer this report as a pilot study.

Introduction and More Background



Developers say turbines are quiet. No louder than a household refrigerator. With this patently false claim, they easily convince local governments it's okay to erect turbines mere hundreds of feet from people's homes. Nearly in their backyards, in many instances.

Wind turbine setbacks, in other words, are wind industry-driven. There is virtually no government regulation.

This is where my phone (and email) starts ringing. People from around the world contacting me to say, often with great emotion in their voice, that they haven't slept well (if at all) since the turbines were installed 1500 feet (and more) from their back door. Not just insomnia, but a host of health issues, again, since the turbines in the neighbor's field began operation.

For over four years I've been listening to these complaints. People describing symptoms that are remarkably consistent, person to person. Consistent and, often, debilitating. Symptoms, I began realizing, that suggest people's balance systems are getting scrambled.

I realized what's needed is a clinical definition of the way people are getting sick when they live near wind turbines. If the symptoms form a coherent cluster that makes physiologic sense, we're in a better position to figure out,

a person has or does not have tinnitus when exposed to turbines. I compare that to whether they do or don't have a history of industrial noise exposure. I discovered, in this particular example, that a significant relationship does exist.

We'll come back to this in the Results section, below.

Results

My study demonstrated the following to be the core symptoms of Wind Turbine Syndrome.

1) First, *almost everyone had disturbed sleep*. Two particularly interesting patterns emerged in the disturbed sleep.

    a. The first was a "fear" pattern of arousal or awakening, including childhood night terrors and adults waking up alarmed and hyper-alert. These adults felt they had to check to see if someone had broken into the home, even though they knew they had been awakened by turbine noise. Some adults woke up with a racing heart at night or feeling not able to breathe.

    b. The second was a tendency to urinate a lot at night. For adults this meant getting up frequently, and for one child it involved bed wetting (which resolved whenever she was away from the turbines).

    I didn't look for risk factors for sleep disturbance since virtually everyone interviewed had disturbed sleep.

2) *Headaches.* Slightly more than half the study subjects had headaches that were worse than what that person normally experienced before and after turbine exposure (what we

call "at baseline"). The headaches were more frequent, more severe, and lasted longer than that individual's usual headaches (the person's baseline headaches).

Half of the subjects who had worsened headaches were people with pre-existing migraine disorder (i.e., a hereditary tendency to get severe headaches along with dizziness, nausea, visual changes, or avoidance of light, noise, or movement during headaches). All the children in the study who got headaches during turbine exposure either had migraine disorder themselves or were the children of parents with migraine disorder.

About half the adults who got headaches during exposure had no risk factors for headache that I could identify. This suggests that anyone can get severe headaches when exposed to turbines.

3) *Ear symptoms.* Tinnitus was a dominant symptom during exposure. Tinnitus: ringing, a tone, buzzing, or a waterfall noise from one or both ears, or even a buzzing that seems to be inside the head. Risk factors for tinnitus during exposure were:

    a. having some tinnitus before exposure (the tinnitus during exposure was worse)
    b. having some hearing loss before exposure
    c. a previous industrial noise exposure

All these suggest previous damage to the inner ear, which could come from noise exposure, chemotherapy, certain antibiotics, or other causes.

People also experienced pain and popping and a feeling of pressure in their ears, and some shifts in hearing.

4) The fourth core symptom I am calling VVVD, for *Visceral Vibratory Vestibular Disturbance*. This is a new symptom to medicine, I believe. Before reading further, you should read the VVVD symptom accounts in the Report for Clinicians (pp. xxx) , so you have a mental picture of what people say they experience. Once you've looked over those accounts we can move on to consider how the symptoms of VVVD can occur together, the symptoms being:

    a. A feeling of internal pulsation, quivering or vibration. For some, breathing feels controlled or restricted.
    b. Nervousness or jitteriness. Fear. The urge to flee. The urge to check the house for safety.
    c. Shaking
    d. Rapid heartbeat
    e. Nausea

    VVVD is essentially the *symptoms of a panic attack associated with feelings of movement inside the chest in people who have never had panic attacks before* (none of my subjects had).

    Because VVVD is so similar to panic attacks, I looked for a correlation between VVVD and a history of any other kind of anxiety or depression or mental health disorder. I found no such relationship. However *there was a highly significant correlation between VVVD and pre-existing motion sensitivity* (i.e., people who get car-sick, seasick, or had a history of repeated episodes of vertigo).

Out of the 21 adults (age 22 and up) in the study, 14 had VVVD. The two toddlers in the study looked like they had something similar. Though we don't know exactly what they felt, they woke up screaming several times per night, and were inconsolable and hard to get back to bed or to sleep. The two 5-year-olds in the study also awoke fearful in the night.

5) *Concentration and memory.* Almost everyone in the study had some kind of problem with concentration and memory. The more severe concentration problems were linked with a general loss of energy and motivation. What's noteworthy among many of my subjects is the degree to which they lost basic skills they had prior to turbine exposure, and the way teachers noticed new problems with kids' schoolwork and sent notes home. (Be sure you read the Concentration and Memory symptom accounts in the Report for Clinicians, pp. xxx, and the accounts of recovery from these symptoms, pp. xxx.)

   For some people, these problems with thinking resolved as soon as they got away from the turbines, or even if the turbines turned in another direction. For others, they did not resolve immediately but improved gradually over time. Sleep deprivation undoubtedly plays a large role in the memory and concentration difficulties, but these patterns of recovery suggest an additional influence, which may be the direct influence of vestibular disturbance on various forms of thinking (see the Discussion, below).

6) The remaining core symptoms were *irritability and anger*, which occurred in most of my subjects, including the children. Often it was the children's behavior and school problems, their irritability and loss of social coping skills,

that drove families to move out of their homes and away from the turbines.

7) Most subjects had *fatigue*—sometimes a distinctly leaden feeling—*and loss of enjoyment and motivation for usual activities*. For most this cleared up soon after they got away from the turbines.

8) Finally, I listed clusters of symptoms that subjects told me about, but would require other modes of study (including physical exams and testing, and a case-control format) to find out if they are connected to turbines. These symptoms occurred in low numbers in my study. They included *lower respiratory infections* (bronchitis, pneumonia, pleurisy) that were unusual for the people who got them, *worsened asthma, unusual middle ear fluid or infections,* and *ocular stroke*.

   Though my study cannot prove a connection, I think they are worth attention in a large-scale study of wind turbine health effects.

Discussion

This section is about how I think Wind Turbine Syndrome works, and the ideas I got from the medical literature and my referees. This is the most interesting section—where we join the dots.

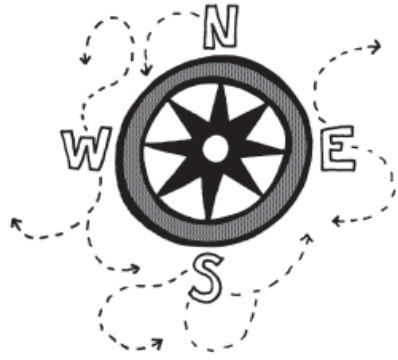
I originally recognized the symptoms of Wind Turbine Syndrome as being something coherent—something that hangs together—because I already knew about what's called *migrainous vertigo* or *migraine-anxiety associated dizziness*.

motion sickness. Balance testing tends to be abnormal in people with migraine disorder compared to people who get other kinds of headaches, especially if the migraine patient is one who gets dizziness or vertigo. The balance problems in migraine disorder, incidentally, are sometimes based in the inner ear vestibular organs and sometimes in the brain.

Anxiety problems are also associated with migraine, sharing a common thread in the serotonin systems of the brain. *Space and motion* discomfort is common in people with anxiety disorders. Balance testing shows that anxiety patients have higher vestibular (inner ear) sensitivity than people without anxiety problems. When balance testing is done in people diagnosed with panic attacks or agoraphobia (fear of leaving the house), a high number are found to have abnormalities of vestibular (inner ear) function—more than 80% in some studies. This is especially true if the people have episodes of dizziness between panic attacks.

In sum, *there is a robust clinical and experimental literature supporting a biological connection between balance disturbance and anxiety, and between balance problems and panic attacks.* Thus it makes eminent clinical sense that *disturbing a person's balance system can lead to fear, alerting, and panic*, including physical symptoms like fast heartbeat.

Next, thinking and memory. Current research demonstrates that these, too, depend on coherent vestibular signaling. If you don't know which way is up, literally, at all times, your brain can't figure out a multitude of things related to position in space. This can be:



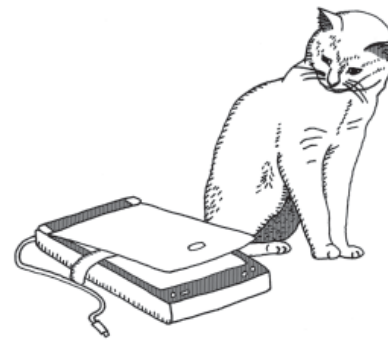
a) *position in real space*, like

    a. remembering how to get somewhere or
    b. figuring out how to put something together, or

b) *position in conceptual space*, like

    a. the distance between two numbers or
    b. the position of events in time or
    c. the categorization of objects in memory

Neuroscientists have recently shown that nerves from the vestibular system follow a direct, two-neuron path to the hippocampus, a brain structure critical for memory in general and spatial learning in particular. People with no inner ear input to the brain at all (the nerves having been cut years before to remove tumors) cannot do experimental tasks involving navigation and spatial memory, and their hippocampi (plural of hippocampus) are smaller than normal. (Conversely, taxicab drivers in London have extra-large hippocampi, the size depending on how many years they have been driving and storing in their brains their personal map data of locations, shortcuts, and one-way streets.)



Functional MRI and PET scans (PET scans don't scan your pet, just as CAT scans don't scan your kitty ; see *Abbreviations*) now allow researchers to see which parts of the brain are used for different tasks by awake humans while they are doing things. Stimulating the vestibular (inner ear balance) system lights up many areas in the

brain, including those used for mental representations of space and mathematical thinking.

If the vestibular input is distorted (for example, by putting ice water in one ear), people make more mistakes in purely mental spatial tasks like imagining a certain object in detail or imagining rotating it. These people were sitting still when they were tested, eyes closed, just thinking, not trying to keep their balance or having to judge where they were in space at all. Nonetheless, when signals came from one inner ear indicating movement—signals out of whack with all the other signals their balance centers were receiving—they remembered the objects less accurately and made mistakes when imagining them in different positions.

In other words, *disordered signaling from the inner ear degrades both spatial memory and the efficiency and accuracy of spatial thinking*. We call the quality of efficiency and accuracy of thinking *concentration*.

A cluster of brain centers that receive signals from the inner ear (meaning, they become active on functional MRI or PET studies when the vestibular organs are stimulated) are in the parietal ("par-rye-et-al") lobes of the brain. There can be some very weird outcomes if the right-sided parietal centers are lost to a right-sided stroke. Called "hemineglect" (*hemi* = "half" + *neglect*: meaning neglect of half the body and half of space), these poor souls can have so much unawareness of the left side of space that they can be unaware that their left arm is paralyzed or the left side of their body undressed. Vestibular stimulation, however, temporarily reverses the neglect, so that they become aware of the left side again in a more normal way.

People with hemineglect make certain types of errors on visual search and visual memory tasks, with answers biased away from

owners are in the habit of turning turbines off at critical times, thus avoiding both annoyance and sleep disturbance."

Recommendations

George Kamperman and Rick James, two independent American noise control engineers with decades of experience working with industrial noise and communities, recommend a noise standard based on quietest background ambient noise, using C-weighted as well as A-weighted measurements so that the low frequency components are controlled. Their specific recommendations—for how noise measurements should be done and how procedures should be spelled out in a local ordinance—were presented at the annual conference of the Institute of Noise Control Engineering/USA in 2008 and are posted on the Wind Turbine Syndrome website at www.windturbinesyndrome.com/?p=925. An important outcome of Kamperman and James's method is that as turbines get larger, setbacks will have to be greater.

The simple answer is: *Keep wind turbines at least 2 km (1¼ miles) away on the flat, and 3.2 km (2 miles) in mountains. These are minimum distances. Kamperman and James's methods will likely recommend larger setbacks, especially in rural areas that are very quiet at baseline.* Secondly, all wind turbine ordinances should hold developers responsible for a full price (pre-turbine) buy-out of any family whose lives are ruined by turbines—to prod developers to follow realistic health-based rules and prevent the extreme economic loss of home abandonment.

A 2 km setback would have prevented this.[3]

[3] Personal communication, April 6, 2009.

> My husband is seeing a doctor for depression. I have a daughter who is seeing a specialist for serious stomach problems. I have had endless sleepless nights since the wind turbines went up. I constantly have feelings of anxiety. My children have complained of headaches and not sleeping well.
>
> Let me ask you, What would you do?

What would I do? I admit I'd be driven into doing what she has done:

> I have been forced to make a decision I never thought I'd have to make. My husband and I have decided to walk away from our property. I can't stand it here for another day. I can't leave soon enough. You may be able to put turbines up behind our home, but that doesn't mean I am going to do nothing when it affects my family's health and my animals' well-being.
>
> It's too late for me to take any more chances. I have kids I need to get through college. I don't know how I'll do it. I just know it's not good to live in this house any more. This property I once loved and was so proud to own is of no use to me.
>
> I have worked 60 hours a week for years, only to find myself with nothing. But my health as well as my family's cannot be sacrificed.
>
> So, as you read this, I do not know where we are going to live, but I do know it won't be under a wind turbine or anywhere near one. The safest bet would be to find a house right next door to the people who determine these

> setbacks, because no matter what they decide, it seems they are never the people affected.

She closed her letter: "Ann Wirtz, N11957 Highway YY, Oakfield, Wisconsin 53065 (temporarily)."

Consider the pain of that final word. *Temporarily.* In parentheses. Like quiet despair. "The heaviness of life," offered Rilke, "is heavier even than the weight of things."[4]

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[4] Rilke, Rainer Maria. 1981. "The Neighbor." Selected Poems of Rainer Maria Rilke: A Translation from the German and Commentary by Robert Bly. Harper & Row, NY, p. 93.

Referee Reports

Dr. Pierpont's report deserves publication. Although the case numbers are not large, the careful documentation of serious physical, neurological, and emotional problems provoked by living close to wind turbines must be brought to the attention of physicians who, like me, were unaware of them until now.

By a well devised questionnaire/interview the author has been able to obtain data demonstrating the correlation of symptoms induced by active wind turbines, the improvement/resolution of symptoms when the interviewees have moved away, and the re-emergence of the same symptoms when returning to their homes near the turbines.

With the pressure on our governments to go "green," eliminating coal-powered sources of electricity, the United States Environmental Protection Agency in conjunction with Dr. Pierpont and this report should expand this investigation and establish the necessary guidelines for creating wind turbine "farms" and protect those near to them.

JEROME S. HALLER, MD, Professor of Neurology and Pediatrics (retired 2008), Albany Medical College, Albany, New York. Dr. Haller is a member of the American Academy of Pediatrics, the American Academy of Neurology (Child Neurology Section), and the Child Neurology Society.

June 10, 2008

Dr. Pierpont's study addresses an under-reported facet of Noise Induced Illnesses in a fashion that is detailed in its historical

documentation, multi-systemic in its approach and descriptions, and painstakingly and informatively referenced.

The study provides a scientific underpinning for viewing symptom complexes that are generally unappreciated and difficult to comprehend for the great majority of medical practitioners who have to rely, in their daily practice, on identifying anatomical or chemical abnormalities in order to establish a diagnosis. This approach opens up an avenue to diagnosis and comprehension that was exciting to me, and, I feel, would excite the interest of a large group of practitioners who are open to looking at the patient as a person, rather than as a machine. It will encourage physicians to listen carefully to their patients and place their patients in the environment rather than the lab.

Dr. Pierpont's study is particularly important because of the present energy crisis (and the role of environment-changing technologies to address it), it is very readable, extremely well referenced and most informative. The patients described are true "sufferers" (the root of the word patient) whose lives have been seriously disrupted. As I mentioned above, it is particularly relevant at a time when wind energy technology and its applications are growing worldwide. It alerts the medical profession to the potential for illness caused by low frequency vibrations. It encourages the medical profession to scrutinize other, new energy technology for potential side effects.

It is my hope that this study, when published, will stimulate research not only on the deleterious effects of low frequency vibration on the human species, but also on its effects upon the animal world in general. I would also hope that the symptom complexes that are described will be studied more intensely so as to gain a greater understanding of the human body as regards its physiology and pathophysiology. I am convinced that successful analysis of the physical forces that impact on humans will add an important

dimension to our understanding of physiology and disease states. This study opens up the area of low frequency vibration to the medical community. Other physical forces, both mechanical and electrical, could play a role in certain human diseases. This study could encourage recognition of the research accomplishments in analyzing disease states through analysis of these physical forces.

Since the analysis of these forces is presently outside of the medical model of disease diagnosis, many of these sufferers have been labeled as having a purely psychological problem. The author has provided a basis to describe such a group of symptom complexes as pathophysiological, and I applaud her.

JOEL F. LEHRER, MD, Fellow of the American College of Surgeons, Clinical Professor of Otolaryngology, University of Medicine & Dentistry of New Jersey. Formerly Professor of Otolaryngology, Mt. Sinai School of Medicine, New York, New York.

June 29, 2008

I congratulate you on your case-series investigation on Wind Turbine Syndrome. That is, the conception, the data gathering, the analysis and the write-up. As an epidemiologist I fully appreciate your truly remarkable effort, one that smacks of being well done and with a full respect for honest inquiry. Given your initial suspicions on this matter, your high level of scientific integrity is revealed both in your design decisions and in your writing, both of which are of the highest order.

What you have accomplished is, at once, both remarkable and limited (as you fully appreciate). I see several noteworthy outcomes of your admirable and remarkable presentation of this case-series

report on Wind Turbine Syndrome from your perspective as a concerned, practicing physician from the community.

1) Creation of a case-definition for Wind Turbine Syndrome. You have initiated a critical first step needed to convert "an issue of concern" into a "researchable topic" by your putting forth a clear case-definition of Wind Turbine Syndrome, including the recognition and development of a newly defined symptom which you document and call Visceral Vibratory Vestibular Disturbance (VVVD).
2) Creation of a thoughtful list of future research suggestions into Wind Turbine Syndrome. By your deep and obvious commitment to get at the truth of this matter, you have proposed a thoughtful and rich list of directions for others to pursue in this line of inquiry, something that involved investigators can uniquely do as a result of the depth of their intellectual investment in the line of inquiry.
3) Candidly presented an insightful list of the limitations of your case-series study. It instills confidence in the reader that you, indeed, conducted a study aimed at discovering the truth of the matter, which always demands candor and insights from the investigator who best knows the range of limitations, from minor up to major (if any), in one's own study.

As you fully appreciate, the biggest overall limitation of your work is the lack of "generalizability" of the specific findings to broader populations due to the specific (but both appropriate and necessary) eligibility criteria for subjects in your case-series. This is nothing to worry about, merely something to appreciate and build upon, as this limitation is inherent to any early-stage epidemiologic investigation into an evolving subject area.

You have laid a remarkable, high quality, and honest foundation for others to build upon with the next stages of scientific investigation. In doing so, you have made a commendable, thorough, careful, honest, and significant contribution to the study of (what we can now call) Wind Turbine Syndrome.

RALPH V. KATZ, DMD, MPH, PHD, Fellow of the American College of Epidemiology, Professor and Chair, Department of Epidemiology & Health Promotion, New York University College of Dentistry

October 5, 2008

Dr. Pierpont has gathered a strong series of case studies of deleterious effects on the health and well being of many people living near large wind turbines. Furthermore she has reviewed medical studies that support a plausible physiological mechanism directly linking low frequency noise and vibration, like that produced by wind turbines, which may not in itself be reported as irritating, to potentially debilitating effects on the inner ear and other sensory systems associated with balance and sense of position. Thus the effects are likely to have a physiological component, rather than being exclusively psychological.

More extensive and statistically controlled observations may be needed to discover just how far from the turbines the deleterious effects occur, and in what proportion of the population. However, it is already clear that many people are affected at far greater distances than the minimum set-backs currently allowed between turbines and residences. Accordingly, it would be prudent to establish much longer set-backs from houses as a criterion for siting new turbines, pending further studies on this newly documented

"wind turbine syndrome." Documentation of the syndrome itself is strong evidence that current set-backs are woefully inadequate.

HENRY S. HORN, PHD, Professor of Ecology and Evolutionary Biology, and Associate of the Princeton Environmental Institute, Princeton University

October 17, 2008

About the Author

I am a New Englander by many generations, growing up in a family of teachers and writers. My grandfather, like me, was a physician and ecologist. After being blessed by a fine elementary school (New Canaan Country School, 1970) and high school (Milton Academy, 1973), I attended Yale on a National Merit Scholarship, graduating in 1977 with a B.A. in biology. I earned a Ph.D. (1985) in behavioral ecology at Princeton (training that I use substantially in my work in behavioral pediatrics), did a post-doctoral fellowship in ornithology at the American Museum of Natural History (NYC) and, as an over-the-hill woman of thirty-two, went to the Johns Hopkins University School of Medicine, where I earned the M.D. degree (1991).

I wanted to give my ecology training a human face. I chose the face of a child, becoming a pediatrician by completing internship at the Children's National Medical Center, Washington, D.C., and residency at the Dartmouth-Hitchcock Medical Center, Lebanon, NH (because my husband, a country lad, detested Washington).

Despite his feelings toward Washington, and his improbable name (Calvin Luther Martin), my husband is a respectable man (retired Rutgers University professor and author of well-known scholarly books). Our two children (my stepchildren) are grown and have made us grandparents.

I am 54 years old.

I am an unabashed lover of wildness. I did my Ph.D. research living in a tent in the Amazon jungle for several years, studying bird behavior. In pursuit of wildness and native cultures, my husband and I lived for another several years with Yup'ik Eskimos on the Alaska tundra, near the Bering Sea, where I became chief of pediatrics at

a native-run hospital. Likewise, we spent a summer living on the Navajo reservation, as I did a sub-internship in medical school.
For three years I ran a general pediatrics practice in Malone, Franklin County, NY (poorest county in the state), where I was, as well, the pediatrician for the St. Regis Mohawk Nation (Hogansburg, NY). For the next three years (2000-03) I was Senior Attending in Pediatrics at Bassett Healthcare, Cooperstown, NY (and, must confess, never darkened the door of the Baseball Hall of Fame). Bassett is a teaching hospital of Columbia University, and I was Assistant Clinical Professor of Pediatrics at Columbia's College of Physicians & Surgeons.

I am a board certified pediatrician licensed in the State of New York and Fellow of the American Academy of Pediatrics. These days I limit my practice to behavioral medicine, seeing both adults and (chiefly) children, drawing my patients from an extensive area of rural upstate New York. I have had considerable post-graduate training in behavioral medicine, which I have been able to integrate with my doctoral training in behavioral ecology.

My research on Wind Turbine Syndrome is the offspring of behavioral medicine married to behavioral ecology.

Most of all, I love what I do. I believe in compassion and grace and get tremendous pleasure and joy out of my patients. (To children's delight, I carefully count their toes.) I run my practice out of my home as an old-fashioned doctor's office. Cheerful, light, airy, perhaps the faint smell of my husband's burnt toast wafting through the house. Norman Rockwell's America.