Case series don't typically have control groups. Nevertheless, I saw I needed a comparison group of similar, though unexposed, people to distinguish which symptoms were due to turbine exposure. The most similar unexposed people, of course, were my study subjects themselves prior to turbine exposure and after the end of exposure. I therefore set up a *before-during-after* study format, interviewing families who had already moved out of their homes due to symptoms or who were planning to move and had already spent periods away from home, during which turbine-associated symptoms abated.

This format served a three-fold purpose:

1) it ensured there was an "after" phase for each family,
2) it guaranteed that at least one member of each family was severely affected, enough to need to move, and
3) it provided validation for participant statements, since one can hardly discount the gravity of symptoms that force a family to vacate its home or perform expensive renovations aimed solely at noise exclusion.

Which brings us to what is known in science as a "natural experiment": *a circumstance wherein subjects are exposed to experimental conditions both inadvertently and ecologically (within their own homes and environments).* Obviously, it would be unethical to expose people deliberately to potentially harmful interventions. Hence natural experiments, while less controlled, have an important role in clarifying the impacts of potentially toxic, man-made exposures.

The ecological dimension in the phrase *natural experiment* is worth emphasizing, since many elements of an exposure may not be reproducible in a laboratory, such as round-the-clock exposure, a real estate deal than to leak the news that one's home is toxic.) There is also the matter of relationships and family ties within small, close-knit communities, where folks are often reluctant to reveal a problem because, let's say, the turbines on your cousin's land happen to be the source of it.

In this manner has the wind industry both shattered many rural communities and thwarted research like mine.

Despite what I see as the virtues of my approach, this study has clear limitations. One being that it was conducted entirely by clinical interview, over the telephone. On the one hand this had the benefit of allowing me to have an international group of subjects. On the other it limited the type of data I could collect. As a result, my ability to say that *a certain symptom during exposure is due to turbines* is confined to medical conditions which are diagnosable by medical history. (A medical history is *all the information a patient tells the doctor about his illness, his past health and experiences, and his habits.*)

As an aside, non-clinicians should realize that in medicine many conditions (ailments) are diagnosed mostly by medical history. This includes migraine and other headaches, tinnitus, and sleep disturbance. (Medical diagnosis is not all x-rays and MRI's and lab tests.) It stands to reason that your doctor can't tell objectively (by any sort of clinical test) if you have a headache, tinnitus, or sleep problem, and much of what your doc figures out about the causes of these symptoms will come from the other questions he asks you. This is the part I could credibly do by telephone.

My study subjects also told me about other kinds of problems which seemed to worsen during exposure, including asthma, pneumonia, pleurisy, stroke, and changes in coagulation or blood sugar. I did not include these in Wind Turbine Syndrome, since my method of study did not allow me to determine whether in fact wind turbines played a role in these conditions during exposure. These conditions would require other kinds of study over and above the clinical interview and case series. (I have included them in a separate section of the *Results* in the REPORT FOR CLINICIANS because I think they may need attention from the medical research community.)

This study also does not tell us how many people are affected within a certain distance of wind turbines. But it does offer a framework for what to pursue in such a study (meaning, the next phase: epidemiologic studies), such as what symptoms to study and what aspects of the exposure to measure.

Shifting, now, to the format of the book. I wrote the REPORT FOR CLINICIANS as a (long) scientific article, beginning with an *Abstract* or brief summary, followed by an *Introduction* to the problem and background information, a description of the *Methods* used (including study sample selection), a presentation of the *Results* (which are the data secured during the study and its analysis), and finally *Discussion* of the results with interpretation of their meaning in the context of current medical knowledge. Data are compiled in *Tables* (numbered 1A, 1B, 1C, 2, and 3) included within the *Results* section.

REFERENCES are footnoted in the text and listed together towards the end of the book. I added a GLOSSARY of medical and technical terms to make the book more intelligible to non-medical readers, and a list of ABBREVIATIONS.

The CASE HISTORIES (A1 through J4) present the raw narrative data—each individual subject's symptoms and statements—in table format, one person per table with separate columns for *before*, *during*, and *after* exposure, and separate rows for each organ or

A second disclaimer. Readers should understand that Wind Turbine Syndrome is not the same as Vibroacoustic Disease.[10] I say this because the two are often equated in the popular media. The proposed mechanisms are different, and the noise amplitudes are probably different as well.

Wind Turbine Syndrome, I propose, is mediated by the vestibular system—by disturbed sensory input to eyes, inner ears, and stretch and pressure receptors in a variety of body locations. These feed back neurologically onto a person's sense of position and motion in space, which is in turn connected in multiple ways to brain functions as disparate as spatial memory and anxiety. Several lines of evidence suggest that the amplitude (power or intensity) of low frequency noise and vibration needed to create these effects may be even lower than the auditory threshold at the same low frequencies. Re-stating this, it appears that even low frequency noise or vibration too weak to be heard can still stimulate the human vestibular system, opening the door for the symptoms I call Wind Turbine Syndrome. I am happy to report there is now direct experimental evidence of such vestibular sensitivity in normal humans.[11]

Vibroacoustic Disease, on the other hand, is hypothesized to be caused by direct tissue damage to a variety of organs, creating thickening of supporting structures and other pathological changes.[12] The suspected agent is high amplitude (high power or intensity) low frequency noise. Given my research protocol, described above, my study is of course unable to demonstrate whether wind turbine exposure causes the types of pathologies

[10] Castelo Branco NAA, Alves-Pereira M. 2004. Vibroacoustic disease. Noise Health 6(23): 3–20.

[11] Todd NPMc, Rosengren SM, Colebatch JG. 2008. Tuning and sensitivity of the human vestibular system to low-frequency vibration. Neurosci Lett 444: 36–41.

[12] Castelo Branco and Alves-Pereira 2004.

found in Vibroacoustic Disease, although there are similarities that may be worthy of further clinical investigation, especially with regard to asthma and lower respiratory infections.

Moving on, I have been asked if Wind Turbine Syndrome could be caused by magnetic or electric fields. I have no reason to think so. There has been extensive epidemiologic research since 1979 on magnetic fields and health, comparing people who live close to high power lines or work in electrical utilities or work in other industries where magnetic field exposure is likely to be high, to people who do not.[13] This substantial body of research has produced no good evidence that magnetic field exposure causes cancer in children or adults, cardiac or psychiatric disease, dementia, or multiple sclerosis.[14,15] After three decades of research, there is still no experimental evidence for a physiologic mechanism for any of the proposed effects of magnetic fields.[16]

This makes it difficult to do epidemiologic studies, since researchers don't know what exposure to measure, or what exposure period (e.g., last week or five years ago) might be relevant.[17] An association has been shown between higher magnetic field exposure in utility workers and amyotrophic lateral sclerosis (ALS), a neurodegenerative disease, but this is most likely due to more frequent electric shocks in these settings, not to the magnetic

[13] Ahlbom IC, Cardis E, Green A, Linet M, Savitz D, Swerdlow A; INCIRP (International Commission for Non-Ionizing Radiation Protection) Standing Committee on Epidemiology. 2001. Review of the epidemiologic literature on EMF and health. Environ Health Perspect 109 Suppl 6: 911–33.

[14] Ahlbom et al. 2001.

[15] Johansen C. 2004. Electromagnetic fields and health effects: epidemiologic studies of cancer, diseases of the central nervous system and arrhythmia-related heart disease. Scand J Work Environ Health 30 Suppl 1: 1–30.

[16] Ahlbom et al. 2001.

[17] Ahlbom et al. 2001.

fields.[18] Claims that voltage and frequency irregularities in household alternating currents (what some refer to as "dirty electricity") create a wide, non-specific swath of medical problems—from ADHD to rashes to diabetes to cancer—are completely unsubstantiated, and also have no plausible biologic mechanisms.[19]

A few words about peer review. Peer review is quite simple, contrary to the mystique it has acquired among wind developers (most of whom probably have a fanciful idea of what it is). Peer review *consists of sending a scholarly manuscript to experts in that particular field of knowledge, who are asked to judge whether it merits publication.* Simple as that. The identity of reviewers (also called "referees") can be either known to the author (with book manuscripts, authors are routinely asked by editors to submit a list of recommended referees) or kept confidential.

If the referees (usually consisting of two or three) manage to convince the editor that the manuscript is not worthy of publication, the editor contacts the author and rejects the manuscript. If, on the other hand, the referees feel the manuscript merits publication subject to certain revisions and perhaps additions, the editor will forward their reports to the author and ask for a response. "Are you willing to make these changes? Do you agree with these criticisms? If not, give me compelling reasons why not."

The author then revises the manuscript accordingly, except where she feels her referees are wrong—and manages to convince the

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[18] Johansen 2004.

[19] I have asked Prof. Magda Havas, Environmental and Resource Studies, Trent University, Ontario, Canada, to remove references to Wind Turbine Syndrome from her PowerPoint presentation on hypothesized wind turbine health effects, because these references are inaccurate.

have no basis in research on safety and health, and they make no clinical sense.

For those who read this report and recognize their own symptoms, the appropriate medical specialist to consult would be a neurotologist (or otoneurologist), who is an otolaryngologist (ear, nose, and throat doctor) who specializes in balance, the inner ear, and their neurological connections. When I sent this report out for critical review, these were the physicians who recognized a remarkably similar symptom complex from cases familiar to them—such as certain inner-ear pathologies.

To those of you living near turbines and recognizing your own symptoms within these pages: you are not crazy and not fabricating them. Your symptoms are clinically valid—and unnecessary. While wind developers rush headlong into yet more projects, you unfortunates will have to exercise patience as the medical profession catches up with what is ailing you. Meanwhile, my advice is, speak out. In *The Tyranny of Noise*, Robert Alex Baron calls for an end to "our passive acceptance of industry's acoustic waste products."[27]

This will happen only when the suffering refuse to be silenced.

By the time I finished interviewing and moved on to data analysis (February 2008), six of my ten families had moved out of their homes because of turbine-associated symptoms. Three months later (May 2008), when the first draft was complete and I contacted the families for their approval and permission to publish the information on them, two more had moved out because of their turbine-associated symptoms—bringing the total to eight of the ten. The ninth family could not afford to move, but had done extensive renovations in an

[27] Baron, Robert Alex. 1970. *The Tyranny of Noise: The World's Most Prevalent Pollution, Who Causes It, How It's Hurting You, and How to Fight It.* St. Martin's Press, New York, p. 12.

One third (1/3) octave band studies are used to describe sound pressure levels by frequency, and are presented as a graph rather than a single number. One third (1/3) octave bands can also be measured linearly or with weighting networks.

Methods

The study design is a case series of affected families, interviewed by telephone. I used a broad-based, structured interview including a narrative account, symptom checklist, past medical and psychiatric history, personal and social history, selected elements of family history, and review of systems. This is the "history" in the standard physician's "history and physical," with specific questions oriented towards the problems in question. The core of the syndrome consists of symptoms such as sleep disturbance, headache, tinnitus, dizziness, nausea, anxiety, concentration problems, and others which are typically diagnosed by medical history more than physical exam.

Limited medical records were provided by the adults of families A and B (A1, A2, B1, B2) and by a young man in family C (C4). I requested records for all families through F, but since no more were forthcoming, I stopped asking, and pursued those parts of the study not dependent on physical examination or test results, and for which I had a uniform study tool, the interview.

The study design includes comparison groups in two ways: 1) I obtained information for each symptom before exposure, during exposure, and away from or after the end of exposure, so that each subject acted as his or her own control in the "natural experiment" of living in a home under a certain set of conditions, having wind turbines added to those conditions, and then moving or going away and again experiencing an environment without turbines. Subjects also noted how their symptom intensity varied in concert with the type and loudness of noise, the direction turbine blades were turned, the rate of spin, or the presence or absence of shadow flicker. A positive symptom is one that emerged from the within-subject comparison as distinctly worse during exposure than before or after (generally both). For example, a subject was considered to have headaches due to turbine exposure only if his (her) headaches were more frequent, severe, or longer-lasting during turbine exposure than his own headaches before being exposed to turbines and after ending the exposure. 2) I obtained information on all household members, not only the most affected, so that I could compare more affected to less affected subjects, all of whom were exposed, to evaluate individual risk factors with regard to age, sex, and underlying health conditions.

Families were selected to conform to all of the following: 1) severity of symptoms of at least one family member; 2) presence of a "post-exposure" condition, in which the family had either left the affected home or spent periods of time away; 3) quality of observation, memory, and expression, so that interviewed people were able to state clearly, consistently, and in detail what had happened to them under what conditions and at what time (all but one individual were native English speakers); 4) residence near recently erected turbines (placed in operation 2004–2007); 5) short time span between moving out and the interview, if exposure had already ended (six weeks was the maximum); and 6) family actions in response to turbine noise showing how serious and debilitating the symptoms were (moving out, purchasing a second home, leaving home for months, renovating house, sleeping in root cellar).

Most families who met these criteria and were willing to be interviewed lived outside the United States. In the course of the study, I received direct evidence that participation by Americans was limited by non-medical factors such as turbine leases or neighbor contracts prohibiting criticism, court decisions restricting gave their permission verbally at the beginning of the interview. I made a confidentiality statement and informed subjects that they would have the opportunity to review the data presented about them prior to publication. Follow-up interviews were done with families C, D, and G. Other families have kept in touch by email and telephone about further developments. All ten families have reviewed the information presented about them and signed permission for anonymous publication.

I use simple statistical tests (2x2 χ^2) to examine associations among symptoms and between pre-existing conditions and symptoms during exposure.[30] Degrees of freedom (df) are 2 for all the χ^2 results in this report. Children were excluded from the analysis of adult symptoms if no child younger than a certain age had the symptom in question. Study children were categorized into developmental-age blocks (see Table 1C). When I excluded children from an analysis, I excluded all the children in that age block and below. Excluding children from adult symptom analyses avoided inflating the no symptom/absent pre-existing condition box of the 2x2 χ^2 contingency tables, which could artificially increase the χ^2 value.

Results

I interviewed 23 adult and teenage members of 10 families, collecting information on all 38 adult, teen, and child family members. One family member was a baby born a few days before the family (A) moved out, so there are no data for this child on sleep or behavior during exposure (which was in utero). Thus the sample size of subjects for whom we have information about experiences or behavior during exposure is 37.

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[30] Sokal RR, Rohlf FJ. 1969. *Biometry.* W. H. Freeman, San Francisco.

Residence status and family composition are detailed in Table 1A; turbine, terrain, and house characteristics in Table 1B; and the age and sex distribution of subjects in Table 1C. Twenty subjects were male and 18 female, ranging in age from <1 to 75. Seventeen subjects were age 21 and below, and 21 subjects were age 32 and above. There is a gap in the 20's and a preponderance of subjects in their 50's. Wind turbine brands to which study subjects were exposed included Gamesa, General Electric, Repower, Bonus (Siemens), and Vestas.

Individual accounts of baseline health status and pre-exposure, during exposure, and post-exposure symptoms or absence of symptoms are presented in the Case Histories for families A through J, with a separate sub-table (A1, A2, A3, etc.) for each individual. I encourage the reader to read these, because they highlight the before-during-after comparisons for each person, show how the symptoms fit together for individuals, reveal family patterns, and provide subjects' own words for what they feel and detect. When individuals are referred to in the text, the letter and number in parentheses (e.g., A1, C2) refers to the Case History table in which that subject's information is found.

Baseline conditions

Eight adult subjects had current or history of serious medical illness, including lupus (1), breast cancer (2), diabetes (1), coronary artery disease (2), hypertension (1), atrial fibrillation with anticoagulation (1), Parkinson's disease (1), ulcer (1), and fibromyalgia (2). Two were male (age 56–64) and six female (age 51–75). Other past and current medical illnesses are listed in Table 2. Four subjects smoked at the beginning of exposure, and five others had smoked in the past (Table 2). There were no seriously ill children in the sample.

Seven subjects had histories of mental health disorders including depression, anxiety, post-traumatic stress disorder (PTSD), and bipolar disorder. Three were male (age 42–56) and four female (age 32–64). One of these men (age 56) also had Alzheimer's disease. There were no children with mental health disorders or developmental disabilities in this sample.

Eight subjects had pre-existing migraine disorder (including two with previous severe sporadic headaches that I interpreted as migraine). Four were male (age 19–42) and four female (age 12–42). An additional seven subjects, age <1 to 17, were children of migraineurs who had not experienced migraines themselves at baseline.

Eight subjects had permanent hearing impairments, defined subjectively or objectively, including mild losses, losses limited to one ear, or impairments of binaural processing. Six were male (age 32–64) and two female (age 51–57).

Six subjects had continuous tinnitus or a history of multiple, discrete episodes of tinnitus prior to exposure. Four were male (age 19–64) and two female (age 33–57).

Twelve subjects had significant previous noise exposure, defined as working in noisy industrial or construction settings; working on or in a diesel boat, truck, bus, farm equipment, or aircraft; a military tour of duty; or operating lawn mowers and chain saws for work. Not included were home or sporadic use of lawn mowers and chain saws, commuting by train or airplane, urban living in general, or playing or listening to music. Nine of the noise-exposed subjects were male (age 19–64) and three female (age 33–53).

Eighteen subjects were known to be motion sensitive prior to exposure, as defined by carsickness as a child or adult, any episode of seasickness, or a history of two or more episodes of vertigo. Ten were male (age 6–64) and eight female (age 12–57).