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turning out right and how to fix it, planning steps of tasks efficiently in time and space, not forgetting steps.

J1 Paying bills. *Mathematics, memory for objects and services purchased, mental calculation of future needs.*

These are not all the tasks people said they were having trouble with, but they are the majority. Making sense? *Balance signals messed up, spatial thinking full of errors and inefficiencies, and people are enormously frustrated over normal, common sense things they suddenly can't do efficiently.* ("Common sense" has a big spatial thinking component, too.) Early school learning is thrown off, as well as reading and certain higher memory and problem-solving tasks in adults.

Interference of noise with reading and children's learning is not a new discovery; there is an extensive literature on it. In brief, environmental noise, like airport or traffic noise, makes children learn to read more slowly. In these studies, large numbers of children were studied in carefully controlled exposed and non-exposed groups, by choosing school districts at different locations relative to airports. Children were exposed to the extra noise both in school and at home.

In one study, a city closed an old airport and built a new one, and researchers had the opportunity to follow the reading skills of both sets of children over time. The ones living near the airport that closed showed improvements in their reading. The ones near the new airport showed slower learning after planes started flying in and out.

One study looked at children living in an apartment building next to a busy highway. Those on the higher floors, where it was quieter, had better reading scores and better ability to tell word sounds apart.

The effects of noise on reading ability go beyond the distracting effects of noise, and are linked to problems with language processing—like differentiating between sounds in noisy environments.

Noise can affect thinking in adults, too, at loudness levels nowhere near the levels that harm hearing. In one study, industrial workers worked on psychological tests while exposed to 50 dBA broadband noise (like white noise or machine noise) with or without low frequency components. The noise with low frequency components interfered with test performance more than the noise without the low frequencies, especially in individuals who rated themselves as sensitive to low frequency noise. Neither type of noise

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was considered more annoying than the other, nor did subjects become accustomed or sensitized to the noise.

Many environmental noise studies look at effects on sleep, stress hormone (adrenalin, cortisol) output, blood pressure, and cardiovascular risk factors in general. Noise at night can significantly disturb sleep even when the person does not remember waking up. Since the sorting and storage of daily memories occurs during sleep, especially dreaming or what's called REM sleep (rapid eye movement), sleep disturbance by noise, even without known awakening, interferes with memory and learning.

In children, nighttime low frequency (rumbling/vibrating) noise from trucks has been shown to produce more stress hormone at a time of night when it's not usually produced (i.e., the wrong time of night), than gets produced in the same children exposed to regular nighttime car traffic noise. *In other words, low frequency nose stimulates elevated stress hormone production in children during nighttime sleep.* (Elevated cortisol levels are also known to harm memory and learning, reducing the survival of new hippocampal memory cells, as in chronically abused children.) High adrenalin or cortisol levels elevate blood sugar and increase blood pressure, increasing cardiovascular risk.

Interestingly, the levels of noise that disturb sleep are quite low. Noise events of 32 dBA cause people to move in sleep, showing a low level of arousal. Noise events of 35 dBA cause arousals that can be seen on a brain wave study (EEG). Conscious awakenings occur at 42 dBA. This is why the World Health Organization (WHO) recommends 30 dBA as an acceptable indoor nighttime noise level.

I don't present noise analyses in this paper—something that clearly needs to be done, but requires resources I didn't have—but I find that published descriptions of people's experiences in documented low frequency noise are very similar to what my study subjects noticed and described to me. If you haven't already done so, I recommend you read the section of clinical text called "Low-frequency noise" (pages xxx-xxx).

First, I quote Dr. Birgitta Berglund (the dean of community noise studies and lead editor of the 1999 World Health Organization *Guidelines for Community Noise*) on the reasons she thinks many of the adverse effects of noise in general are due to its low frequency components. She calls attention to how low frequency noise travels farther than other noise without losing its power, travels through walls and hearing protectors, rattles objects, sets up vibrations and resonances in the human body, and is linked to motion sickness even when vibration is not present. The lower frequencies can make it hard to

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distinguish sounds at higher frequencies, like speech. Noise with low frequency components is experienced as louder and more annoying than noise at the same dBA level without low frequency components. All this is discussed in the "Low frequency noise" section in the clinical text. Again, it's well worth reading.

It's important to remember that the term "annoyance" in community noise surveys is used as a shorthand for a variety of negative reactions. Some of them severe. "Apart from 'annoyance,'" states the WHO, "people… exposed to community noise… report anger, disappointment, dissatisfaction, withdrawal, helplessness, depression, anxiety, distraction, agitation, or exhaustion."

In the clinical report, I quote as well several other small studies of situations wherein people were exposed to documented low frequency noise. For instance, the symptoms that healthy young men felt when exposed to high amplitude low frequency noise, for only 2-3 minutes, in a NASA test facility in the 1960s, included fatigue, reduced efficiency at performing tasks, tickling in the ear, chest vibrations, and a feeling of fullness in the throat—all symptoms I heard about from my study's participants.

Indeed a case report from Germany in 1996 may well be Wind Turbine Syndrome, since the source of the low frequency noise (actually infrasound, below 10 Hz) was never identified. It's an especially interesting story. The couple's symptoms and the intensity of noise below 10 Hz both varied with the wind and weather, and were worse in winter. Their symptoms were,

a) sleep disturbance
b) headache
c) ear pressure
d) not feeling well in a general way
e) decreased ability/efficiency in doing things
f) chest symptoms described as shortness of breath and a tingling/crawling sensation

Symptoms occurred when the sound pressure level at 1 Hz was 65 dB, well below the couple's own hearing thresholds measured in a sound lab. All the frequencies responsible for the symptoms, which were all below 10 Hz, had sound pressure levels below 80 dB.

We now know that sound levels near turbines easily fall within these ranges, as measured by a Dutch physicist several years ago.

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The 1996 German case, above, and another series of cases, also by German noise control officials, both *emphasize how the symptoms and the degree to which the people were bothered increased over time after they moved into the home or apartment with low-frequency noise. They did not get used to the noise. In fact, the opposite: they became sensitized to it over time.* At first it wasn't so bad, but it grew worse and worse.

My study subjects said the same thing, as they compared turbine noise to other types of noise, like traffic, that they easily got used to. Many said that wind turbine noise would not sound loud to people who did not live with it, but several also mentioned visitors being bothered if they spent the night. When they moved away from their turbine-exposed homes, all the families moved into towns and villages with more traffic noise, but no risk of turbines being build next door.

Hence, glib claims that "you will get used to wind turbine noise," are contradicted both by people who struggle to live with it, and by clinical evidence.

Both German case studies focused on the ability of low frequency noise, with its long wavelengths, to pass through walls and then reverberate or set up resonances inside rooms. The authors of the case series measured the difference in low frequency noise intensity near walls and away from walls, picking up nodes of higher intensity away from walls, like a standing wave in a stream.

In my study, Mr. and Mrs. G (G1 and G2) both identified a spot in one room where they got symptoms, a feeling of internal vibration for Mrs. G and the beginnings of nausea for her husband. They could not feel any vibrations with their hands if they touched walls or furniture. I think this was one of those places where the low frequency sound (air pressure) waves overlapped in such a way, as they bounced around the room, that they made a stable spot or standing wave of increased intensity.

Swedish researchers verified in a survey study of hundreds of households that the amount of noise needed for a wind turbine to cause severe annoyance was much lower than the amount of noise road traffic, airplanes, or trains would have to make to be severely annoying to as many people. "Amount of noise" was measured in dBA, which filters out the effect of any low-frequency components, and averaged over time. Fifteen percent of people were highly annoyed at 38 dBA of wind turbine noise, compared to 57 dBA for aircraft, 63 dBA for road traffic, and 70 dBA for trains. By the time the wind turbine noise level

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reached 41 dBA, 35% of people were highly annoyed. Sixteen percent reported sleep disturbance over 35 dBA of outdoor turbine noise.

When these researchers interviewed some of the people surveyed, they found the same sorts of problems I encountered in my study, including people who had moved out of their homes because of the noise or rebuilt their homes to try to exclude the noise. Some reported feeling invaded or violated by turbine noise, being sensitive to blade motion as well as noise, and the loss of their ability to rest and feel restored at home.

From this one can reasonably conclude that, for wind turbines, perhaps unlike other sources of noise, *community standards allowing 45-55 dBA outside neighboring homes are asking for trouble.*

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 and using C-weighted as well as A-weighted measurements, so that the low frequency components are also controlled. Their specific recommendations—for how the noise measurements should be done and how the 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 http://www.windturbinesyndrome.com/?p=925. An important part of Kamperman and James's method is that as turbines get larger, setbacks will have to be longer.

But 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 in all likelihood recommend longer 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.

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Table 1B: Cases: physical attributes

Case	Distance to closest turbine	# turbines	MW per turbine	Year placed in operation	Hub height	Total height	Terrain	Configuration of turbines	House construction
A	1000 m (3281 ft)	10	3	2007	90 m	135 m	Hilly with rocky ridges	10 in line point at house at hub level	Wood frame
B*	1000 m (3281 ft)	10	3	2007	90 m	135 m	Hilly with rocky ridges	10 in line point at house at hub level	Wood frame
C	305 m (1000 ft)	17	1.8	2004-05	80 m	125 m	Rocky peninsula	On three sides	Wood frame
D	548 m (1798 ft)	22	1.8	2006	78 m	117 m	Flat farmland	Group on one side	Wood frame
E	423 m (1388 ft)	45	1.5	2006	87 m	120 m	Flat farmland, swamp	On three sides	Wood frame with stone front
F	930 m (3051 ft)	8	2	2006	59 m	100 m	Flat farmland	5 in line point at house	Brick on cement slab
G	596 m (1955 ft)	32	3	2006	80 m	125 m	Rocky hills	Above house on three sides	Stone cottage, walls 2 ft. thick
H	1500 m (4921 ft)	11	2.3	2005	80 m	121 m	Rocky hills	Above house on three sides	Stone cottage, cement slab
I	350 m (1148 ft)	10	2	2006	78 m	121 m	Rocky hills	Across valley at higher elevation	Wood frame
J	732 m (2400 ft)	40	2	2007	80 m	123 m	Ridges and valleys	6 in L above house on two sides	Wood frame

*Families A and B are related and own separate homes on the same property

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Table 1C: Cases: demographics

Age	Male	Female	Total
<1	1	1	2
1-3	1	1	2
4-6	2	1	3
7-11	3	0	3
12-15	1	2	3
16-21	2	2	4
22-29	0	0	0
30-39	2	2	4
40-49	3	2	5
50-59	4	5	9
60-69	1	1	2
70-79	1	0	1
Totals	21	17	38

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Family Table A1 (page 1 of 2)

Person
Mr. A
Age
32
Pre-exposure health status
Good
Health history
No significant
Previous noise exposure
Diesel fishing boat from childhood
Time to onset of symptoms
Immediate with progression

	Pre-exposure	During exposure*	Post-exposure**
Sleep	Good but always easily awakened by noise.	"I didn't really." Hard to fall asleep. Frequent awakening due to child's frequent awakening.	Good, at baseline. Child sleeping through night.
Headache	Rare, mild	Continuous headache at home which resolved after several hours away and resumed several hours after return, with onset 3 wks into turbine start-up process. OTC and prescription analgesics, addition of glasses not helpful.	Resolved
Cognition	Normal. Runs own fishing business. Mild difficulty with memory, especially for names and faces.	Memory problems: "You'd think I was 99." When arriving at a store or storage building, could not remember what he had come to get without a list.	Partial recovery: self-rated memory 80-85% at baseline, 2% during exposure, and 10% at 6 weeks after moving
Mood	Good. Usually does not show annoyance.	Loss of usual energy and enjoyment for spring fishing season. Mildly irritable.	Anger about home abandonment, otherwise resolved.
Balance/equilibrium	Normal, never carsick or seasick	"A little shaky on feet every now and then" at home.	Resolved

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Family Table A1 (page 2 of 2)

	Pre-exposure	During exposure*	Post-exposure**
Ear/hearing	Mild subjective hearing loss attributed to diesel engine exposure, no tinnitus.	Repetitive popping in ears for first 3 weeks. Tinnitus started several weeks after headache onset and worsened over time.	Resolved
Eye/vision	Normal without glasses	Burning sensation in eyes. When headache and tinnitus were severe, eyes "felt like they were going to fall out on the table if you looked down." Had normal eye exam.	Resolved
Other neurological	Normal except mild concussion age 14	No change	No change
Cardiovascular	Normal including BP (110-120/80 in 2006)	Mild diastolic hypertension on one reading (128/94 on 4/4/07)	No further BP measurements obtained.
Gastrointestinal	Normal	Nausea when headache was severe. No vomiting or other gastrointestinal changes.	Resolved
Respiratory	Normal except smokes	No change	No change
Other		Symptoms were present in all wind directions, better during rain, and worse with wind from direction of turbines or from the 180 degree opposite direction.	
		"You feel different up there, draggy, worn out before you even start anything." "It was a chore to walk across the yard."	When visiting family 100 km away, "I felt better all over, like you could do a cartwheel." Feels well at new house.

*Exposure period 5 months.

**Interviewed 6 weeks after move.

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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

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Family Table A2 (page 2 of 2)

	Pre-exposure	During exposure*	Post-exposure**
Respiratory	Normal, no asthma or smoking.	Lower respiratory infection for 6 weeks not treated until after delivery and move.	Resolved
Other		"Not noisy like a chainsaw, more like pulsating annoyance. To another person it wouldn't sound loud."	

Animals	Dog barks at windmills and up more at night	Improved dog behavior

*Exposure period 5 months.

**Interviewed 6 weeks after move.

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Family Table A3

Person
Son A
Age
2½
Pre-exposure health status
Good
Health history
Term birth, normal growth and development.
Previous noise exposure
No significant
Time to onset of symptoms
Immediate

	Pre-exposure	During exposure*	Post-exposure**
Sleep	Slept through night 12 hrs without awakening. Always a good sleeper.	Night terrors 2-5 times each night, 30 min to calm down and return to quiet sleep.	At baseline. Night terrors resolved. Awakes once briefly for drink and goes back to sleep.
Headache	None	No apparent headaches.	None
Cognition	Good speech development with lots of words and no sound confusion.	Began to confuse *t* with *k* sounds and *w* with *l* sounds.	Vocabulary, sentences, and conversational skills are good but still confusing sounds.
Mood	Good-natured, sensitive, bright, listened well for age.	Oppositional, cranky, "a completely different kid for a few months."	"Instantaneous" resolution when moved, resumed former behavior.
Balance/equilibrium	Normal for age.	No change	No change
Ear/hearing	Normal hearing test at birth. One episode of otitis media.	Pulled ears and got cranky synchronously with adult episodes of headache and tinnitus.	Resolved
Eye/vision	Normal	No change	No change
Other neurological	Normal	No change	No change
Cardiovascular	Normal	No change	No change
Gastrointestinal	Normal without h/o GER.	No change	No change
Respiratory	Normal without h/o asthma.	No change	No change

*Exposure period 5 months, age 27-32 months.

**Information provided by parents 6 weeks after move.

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Family Table B1 (page 1 of 2)

Person
Mr. B
Age
55
Pre-exposure health status
Good
Health history
Surgery 4 times for benign prostatic hypertrophy, once for hand injury
Previous noise exposure
Diesel fishing boat since childhood
Time to onset of symptoms
Immediate with progression

	Pre-exposure	During exposure*	Post-exposure**
Sleep	Good	Delayed onset and repeated awakenings; prescribed sleep aid.	Resolved
Headache	Rare, mild	Continuous, head and ears "sizzling." "It got in your head and would dang well stay there." Started "at back of head, then down sides, then affected right eye." Prescription and non-prescription analgesics minimally helpful.	At baseline
Cognition	Normal	"Trouble remembering;" "a little problem concentrating" blamed on sleep deprivation	"Pretty good, a little problem still."
Mood	Good	Stress, "lots, pretty near more'n I could take, it just burnt me, the noise and run-around"; prescribed anxiolytic.	Improved, still takes some anxiolytic.
Balance/equilibrium	Normal, never seasick or carsick, no vertigo.	Wobbly, staggering, off-balance "like had drunk." No falls. Occasionally felt dizzy.	Resolved, on roof shingling without problems.
Ear/hearing	Normal hearing on left and mild sensorineural loss at 4kHz on right in 2006. Intermittent left tinnitus since 2005.	Tinnitus continuous and bothersome, "ringing and sizzling," and interfering with conversation comprehension. Ears popped "like an airplane." Ear wax increased.	Resolved
Eye/vision	Normal with reading glasses.	Intermittent right eye pain "like a force on it, like pressure on the eye, the inside part, in the head." No change in vision. Eye pain/pressure synchronous with headache.	Resolved

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Family Table B1 (page 2 of 2)

	Pre-exposure	During exposure*	Post-exposure**
Other neurological	Normal, no concussion	No change	No change
Cardiovascular	Normal with BP 126/82, 126/88, 112/70 in 2006	Mild BP elevation 140/80, 132/90, 152/92. After started anxiolytic, BP 128/84.	Resolved, BP 110/68
Gastrointestinal	Normal, no GER, not prone to nausea.	Frequent nausea.	Resolved
Respiratory	Slight asthma as child. Never smoked.	Two episodes of feeling of weight on chest while lying on couch, which resolved when he stood up. Lower respiratory infection in 5th month of exposure.	Normal
Rheumatologic	Osteoarthritis	No change	No change
Other	Little road traffic or other noise	"That stuff [turbine noise] doesn't get out of your head, it gets in there and just sits there - it's horrible."	Not bothered by "all kinds of traffic" at new location; "after a while you don't hear it."
		He felt pulsation in ears and chest when there was fog in the valley between the turbines and the house and he was outside.	
		Hum heard and felt in double glazed picture window when turbines running.	
		Spent more time at shore at boat, away from house and property, for symptom relief.	

*Exposure period 5 months.

**Interviewed 6 weeks after move.

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Family Table B2 (page 1 of 2)

Person
Mrs. B
Age
53
Pre-exposure health status
Good
Health history
Hysterectomy and cholecystectomy, 4 births
Previous noise exposure
Diesel fishing boat intermittently for decades
Time to onset of symptoms
Several weeks, with progression

	Pre-exposure	During exposure*	Post-exposure**
Sleep	Good	Delayed onset, repeated awakening, difficulty going back to sleep, nocturia. Ear plugs somewhat helpful.	Resolved
Headache	Rare, mild	Continuous except when left property or wind in favorable direction.	Resolved
Cognition	Normal	Concentration disturbed; confused if went on errands without list, had to return home.	Partly resolved at 6 wks, up to remembering three things without a list.
Mood	Good, hard worker, not moody.	Anxiety, guarding against irritability, upset and "in a turmoil" when symptoms worse.	Resolved
Balance/equilibrium	Normal, never carsick or seasick.	Some unsteadiness and gait change.	Resolved
Ear/hearing	Normal hearing test in 2005, no tinnitus.	Tinnitus and ear pain continuous except when left property or wind in favorable direction. Ear irrigation at clinic worsened tinnitus.	Resolved
Eye/vision	Normal with glasses	Eyes irritated, burning, runny. Ebb and flow of eye symptoms synchronous with headache and tinnitus.	Burning resolved but visual blurring noted when chemotherapy started.
Other neurological	Normal, no concussion	No change	No change
Cardiovascular	Normal including BP	Mild BP elevations 132-140/80-90	Unknown
Gastrointestinal	GER and post-tussive vomiting.	No change	Worsened with chemotherapy

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Family Table B2 (page 2 of 2)

	Pre-exposure	During exposure*	Post-exposure**
Respiratory	Chronic cough secondary to GER and smoking.	Breath "short every once in a while, like [while] falling asleep, breathing wanted to catch up with something, hard to explain."	Resolved, normal breathing pattern.
Oncologic	Felt well though had undiagnosed breast cancer.	Breast cancer diagnosed. Mastectomy 4 wks before end of exposure.	Chemotherapy started.
Other		Left house repeatedly to get relief of symptoms, interrupting work and tasks.	Resolved

Machines	Refrigerator quiet	Refrigerator became loud and was replaced, but new one was also loud.	New refrigerator was moved to new house and is quiet.
	Furnace quiet	Furnace became loud. Circulator was replaced and the furnace was still loud.	

*Exposure period 5 months.

**Interviewed 6 weeks after move.

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Family Table C2 (page 1 of 2)

Person
Mrs. C
Age
42
Pre-exposure health status
Good
Health history
Migraine disorder, 6 healthy term pregnancies without hypertension
Previous noise exposure
No significant
Time to onset of symptoms
Immediate when first turbines operational, with progression

	Pre-exposure	During exposure*	Post-exposure**
Sleep	Good	Delayed onset, frequent awakening, hyperalert when awakened, nocturia; "no good rest in 10 months."	Resolved including nocturia.
Headache	Migraine frequency varied, never awoke her at night; headache onset in childhood.	Headache onset day or night, 5-6 nights/wk at maximum.	Resolved, no migraines.
Cognition	Normal, very organized mother of 6 children, "ready a month in advance for birthday parties."	Disorganized; could not handle as many things at once; difficult to plan and track cooking; "I thought I was half losing my mind"	Resolved including ability to multitask.
Mood	Good, lots of energy.	Tired, anxious, irritable.	Improved, but still sadness and stress related to loss of home and living with parents.
Balance/equilibrium	Lifelong motion sensitivity in cars, boats, swings, standing on wharf seeing boats go up and down. No vertigo.	Frequent dizziness, vertigo, and nausea preceding headaches.	Resolved.

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Family Table C2 (page 2 of 2)

	Pre-exposure	During exposure*	Post-exposure**
Ear/hearing	Normal hearing, no tinnitus.	Tinnitus began when first 2 turbines operational; no change in hearing.	Hyperacusis
Eye/vision	Normal, no glasses.	Nystagmus, subjective blurring.	Persistent subjective blurring
Other neurological	Normal, no concussion.	No change	No change
Cardiovascular	Normal including BP during pregnancies and at other times.	Hypertension and episodes of tachycardia.	Persistent BP elevation 180/102, started medications. Rare palpitations.
Gastrointestinal	Normal	Frequent nausea with dizziness and headache.	Resolved
Respiratory	Normal, never smoked.	Pneumonia with pleurisy twice in first 3 months of exposure to all turbines.	Resolved
Other	Hand and foot eczema	Exacerbation	Persistent increased itching.
		• At sunset, strobe effect inside or moving shadows outside triggered dizziness, nausea, and headache. • Occasional sensation of vibration in feet and legs outside house.	Resolved

*Exposure period 15 months to all turbines, 21 months to at least 2 operating turbines. Interviewed 2 weeks before move and 18 and 21 months after move.

** Limited ongoing exposure of several hours per week when goes to house to get things, but stopped going to house by 25 months after moving.

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Family Table D1 (page 1 of 3)

Person
Mr. D
Age
64
Pre-exposure health status
Disabled due to injury to back and neck in industrial accident, without paralysis
Health history
Ulcer age 61; current medications Tylenol #3, omeprazole, docuset, senecot, lovastatin
Previous noise exposure
Heavy industry age 16-37, including weaving mills, turbine and jet engine production
Time to onset of symptoms
Sleep disturbance immediate. Palpitations/tremors by 4-6 wks. Retinal stroke at 11 weeks. Diarrhea and GI bleeding by 4 months.

	Pre-exposure	During exposure*	Post-exposure**
Sleep	No sleep problems. One Tylenol with codeine at bedtime for back pain. Did not awaken or get up to urinate until morning.	Feels pulsation as soon as he lies down in bed. Frequent awakening, 6-12 per night. Nocturia 2-3 per night. "The worst sleep you ever heard of, up half the night." Gets to sleep using self-hypnosis he was taught for pain (counting backwards), but has to start at a higher number and count longer.	Sleeps well away from home, without nocturia.
Headache	Rare/mild. No migraine or sinus problems.	Not headache, not painful, but a "kind of numbness which sets over the head" [see below, Balance/equilibrium]	Does not occur away from home.
Cognition	Concentration and memory good. 2-year college degree in industrial engineering.	More difficulty remembering what he reads. In last 2-3 months "I notice a little more each time." "Once I had real fast recall, but now I have to think about things."	No information
Mood	No depression, anxiety, panic, or anger problems.	Frequent need to "calm down." Angry, including in night when awakened. "I can get real aggressive now and I never used to. If something doesn't go my way, I get real flustered, and then start with that nervousness and I have to go calm myself down." Irritable. Anxious about his own and wife's health and well-being.	When away for weekend, "you get all relaxed and all of a sudden you're back in the same thing again." "Getting away calms you down."

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Family Table D1 (page 2 of 3)

	Pre-exposure	During exposure*	Post-exposure**
Balance/equilibrium	Never carsick but badly seasick once as a child. Avoided water ever after and disliked crossing bridges. No vertigo.	After retinal stroke, episodes of "numbness coming over my head. It seems to be my brain. Light-headed, not dizzy, I don't stagger. I can hear, I can talk, everything works for me properly, it's just that I get light-headed." No vertigo.	Does not occur away from home.
Ear/hearing	Some hearing loss but no difficulty understanding conversation. Skillfully differentiates machine noises in all settings. Has background tinnitus.	Background tinnitus is louder and higher, a "squeal," when turbines in operation. Drops in pitch when turbines are off and changes intensity when turbines change direction. When louder, the tinnitus interferes with hearing. No other sensations in ears.	Tinnitus at baseline when away from home.
Eye/vision	Wears glasses and has early cataracts.	Painless retinal stroke at night during sleep. Lost over half of vision in left eye. Confirmed by ophthalmologist, who talked to Mr. D about muscles squeezing off blood vessels in his eye. Normal CT.	No change
Other neurological	Normal without history of seizure or tremor.	After 16 mos: "Right arm jumps all over on its own...it just sits and bounces...hand shaking fierce just hanging onto the phone...started with feeling of satin or silk between the fingers...feels like it's wore out, like you're grabbing something real tight all the time...muscle spasms"; had nerve conduction studies [results unknown] and normal MRI of brain.	Arm calmed down during 5 days away and worsened on return.
Cardiovascular	Normal including BP, no palpitations.	Episodic tachycardia: "My heart feels like it's starting to race like crazy and I have these tremors going through my body and I was getting into a light pain on the left side of my chest." Symptoms exacerbated by nitro spray. Stress test terminated in 30 seconds. Scheduled for cardiac imaging test.	Does not occur away from home.
Gastrointestinal	Uses laxative to counteract opiate effect. Ulcer 2 years before while taking aspirin.	Stool again positive for blood; omeprazole started, endoscopy scheduled; bowels too loose or too firm.	No information.
Respiratory	Normal except smoking age 15-44, no asthma.	Pants or hyperventilates when tremor and tachycardia occur, and consciously slows his breathing when calming down.	Does not occur away from home.
Endocrinologic	No diabetes or other problem.	No change.	No change.

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Family Table D1 (page 3 of 3)

	Pre-exposure	During exposure*	Post-exposure**
Rheumatologic	Persistent neck and back pain due to injury at age 37. Two Tylenol with codeine daily, rarely more. No other joint problems.	No change.	No change
Other	Spent his time outside with ponies and traveled to Florida with wife for 6 weeks in winter.	"Now I don't go outside at all." At f/u interview, the couple had not taken their next winter trip to Florida because of Mr. D's health problems.	No information.
		"When turbines get into a particular position (facing me), I get real nervous, almost like tremors going through your body…it's more like a vibration from outside…your whole body feels it, as if something was vibrating me, like sitting in a vibrating chair but my body's not moving." Occurs day or night, but not if the turbines are facing "off to the side." If outside, "I come in, sit down in my chair and try to calm myself down. After an episode like that, I'm real tired."	Does not occur away from home.
		Two months of static electric charge in yard: hair on arms would stand up when he stood in a certain area.	Static charge resolved.
		F/u interview: had bought his own sound meter, registers 50-70 dB all the time.	
Animals	Ponies well trained for riding, jumping, and pulling cart.	Riding pony refused to leave barn, go up road, or go in field over jumps. Cart pony broke into sweats, trembled, ran uncontrolled through gates and fences with cart and harness attached. Both ponies were sold 8 wks into exposure period.	No information.
	Dog had 4 litters previously and did well.	Puppies 3 days old: mother had killed one large healthy puppy; she was staying with puppies and tolerating nursing but not licking or caring for pups.	No information.

*Exposure period 6 months by first interview and 16 months at f/u interview. Information is from first interview unless otherwise noted.

**Had purchased second house but not yet moved at f/u interview; away only for weekends or short trips.

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Family Table E2 (page 1 of 2)

Person
Mrs. E
Age
56
Pre-exposure health status
Fibromyalgia vs. reflex sympathetic dystrophy
Health history
4 term births, appendectomy, hysterectomy with "nerve damage" at age 38
Previous noise exposure
No significant
Time to onset of symptoms
Immediate with progression

	Pre-exposure	During exposure*	Post-exposure**
Sleep	Normal except after hysterectomy	Onset delayed up to 3 hours, multiple awakenings, nocturia (no glucosuria). At times awake all night, worse when blades facing NW.	Sleeps well, no nocturia
Headache	Rare, mild. Only one previous similar headache, when landing in a jet with nose and ears plugged from allergy.	Headache whenever turbines were generating. "In the wintertime, the strobing in the house and on property built up such pressure in my head you'd think it was going to blow off the top."	No headaches.
Cognition	Normal: retired teacher, organizes community activities	When blades facing house, could not spell, write letters, or keep her train of thought on the telephone, but was able work when blades not facing house.	Resolved; no concentration or memory difficulties.
Mood	Mild anxiety with chronic low-dose anxiolytic at bedtime	Episode of depression.	At baseline.
Balance/equilibrium	Never carsick or seasick. Vertigo twice in past, each episode 1-2 weeks.	"Lightheadedness, head kind of swimming." Less steady on feet depending on direction blades facing, especially outside	Resolved.
Ear/hearing	Normal, tested	Occasional sensation like insect crawling in ear; no tinnitus or change in hearing	Resolved.
Eye/vision	Normal, glasses for reading only	No change	No change
Other neurological	Painful right leg and abdomen ascribed to nerve damage, uses TENS unit; no concussion	Pain worse, increased use of TENS unit	Resolved when away even for short periods.
Cardiovascular	Normal including BP	"Heart synchronized to rhythm of blades." When lying on back, felt "ticking" or "pulsing" in chest in rhythm with swish of the blades. Could make it stop by getting up and moving around, but started again when she lay down. Occurred more at night. No change in BP.	Resolved.

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Family Table E2 (page 2 of 2)

	Pre-exposure	During exposure*	Post-exposure**
Gastrointestinal	GER resolved with diet intervention.	Nauseated when she had a pounding headache.	Resolved.
Respiratory	Normal, never smoked. Soprano in church choir.	More coughing illnesses as opposed to URIs, one lasting 6 weeks. Lost ability to sing.	Both resolved.
Rheumatologic	Fibromyalgia; osteoarthritis in hands	Diffuse muscle aches, "thought my fibromyalgia had really flared up."	Resolved when away even for short periods
Animals	Anxious dog	Dog did not sleep, wet floor 9/10 nights	Dog dry and no longer anxious

*Exposure period 17 months.

**While away on trips of 12 days to 3 weeks and after final move 1 month before interview.

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Family Table J1 (page 1of 2)

Person
Dr. J
Age
49
Pre-exposure health status
Good
Health history
Broken nose repair as teen; thyroglossal duct cyst excision as child
Previous noise exposure
Uses tractors and chain saws on property with hearing protection
Time to onset of symptoms
Immediate with progression

	Pre-exposure	During exposure*	Post-exposure**
Sleep	Long-term difficulty with returning to sleep started during medical training, had been improving	Delayed sleep onset and frequent awakening when turbines running fast; awakens with racing heart; can't get back to sleep; taking prescription sleep aid.	Improved sleep, no need for sleep aid
Headache	Infrequent sinus headache, no migraines	Bilateral temporal-parietal headaches 3-4 times a week; may follow a "jittery" episode.	No headaches
Cognition	Good; specialist physician	Difficulty with focus and mental energy after nights of poor sleep; marked concentration problem when doing accounts/bills at home.	Concentration seemed fine but demand low
Mood	Good, no history of anxiety or depression	"Jittery" episodes begin with sensation of "internal quivering" or awakening with rapid or pounding heart; gets "real anxious"; has to stop outdoor or family activities and go indoors; at night has to move to basement where the turbines cannot be heard or felt; on arriving home from work, he can judge whether symptoms will be triggered by the rotational speed of the turbines or the noise/feeling of vibration in the garage; increased irritability; taking two anti-anxiety medications.	No "jittery" episodes or anxiety when away or at work; no need for prn anxiety medication.

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Family Table J1 (page 2of 2)

	Pre-exposure	During exposure*	Post-exposure**
Balance/equilibrium	Good, seasick once in life	3 episodes of transient vertigo/dizziness while in tree stands late in day	No dizziness or vertigo
Ear/hearing	Slight left hearing loss on test 10 years prior; tinnitus during sinus infections	No subjective change in hearing; occasional tinnitus outdoors when turbines spinning rapidly.	At baseline; no tinnitus
Eye/vision	Normal with glasses	Developing presbyopia (expected for age)	No change
Other neurological	Normal with mild concussion age 7	No change	No change
Cardiovascular	Normal including BP; no palpitations.	BP normal but not measured during "jittery" episodes; awakens with rapid or pounding heart and "jittery" sensations when turbines noisy.	No "jittery" episodes
Gastrointestinal	Normal without GER or nausea	Queasiness and reduced appetite in evening with onset as he arrives home from work	No nausea, appetite good
Respiratory	Normal without asthma; smoked age 18-23	No change	No change
Other	Farming, building, and hunting activities for relaxation at home	Home more stressful than work; driven inside from farming activities, picnics, playing with sons, and hunting by turbine noise provoking symptomatic episodes.	Able to relax outdoors

Animals	Horse, 5 beef cattle, ducks unaffected	

*Interviewed after 9 months of exposure. Family has not moved.

**Away for vacation for 2 weeks during the first 3 months of exposure and 10 days during the month before the interview.

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Family Table J2 (page 1 of 2)

Person
Mrs. J
Age
47
Pre-exposure health status
Good
Health history
Two term births
Previous noise exposure
Aircraft during medical evacuations
Time to onset of symptoms
1-3 mos to headaches; 1-3 mos to concentration and memory problems; 4-5 mos to continuous palpitations; 6 mos to exacerbation of irritable bowel.

	Pre-exposure	During exposure*	Post-exposure**
Sleep	Slept well under any circumstances	Falls asleep easily; if awakened, can usually go back to sleep	Slept well
Headache	No headaches	Evening headache at least every 2 wks requiring ibuprofen	No headaches
Cognition	Good; acute/critical care nurse; teaches nursing at university; organized mother; no problem with focus or memory.	Noticeable trouble focusing and remembering at home; has to write down what children tell her or any item to be picked up at store; easily distracted; started vitamins and supplements	Improved memory when away but not at baseline (also less demand)
Mood	Happy, energetic, busy, "up" person	Marked decrease in energy and motivation at home; frustrated; "on edge"; feels rejuvenated at work	Felt great, lots of energy
Balance/equilibrium	Never carsick or seasick, no h/o vertigo	No change	No change
Ear/hearing	Normal, tested yearly; no tinnitus	No change, no ear symptoms	No change
Eye/vision	Normal, wears contact lenses	No change	No change
Other neurological	Normal, no concussion	No change	No change

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Family Table J2 (page 2 of 2)

	Pre-exposure	During exposure*	Post-exposure**
Cardiovascular	Normal BP except during first pregnancy; dysrhythmia (trigeminy) 10/06 resolved with caffeine restriction.	Continuous palpitations began 10/07 and did not respond to caffeine restriction or trials of two medications; evaluated including electrophysiology; right ventricular focus.	Decreased frequency of palpitations
Gastrointestinal	Irritable bowel (cramping and diarrhea) since young adulthood with exacerbations before exams; normal colonoscopy x 2.	Continuous symptoms for 3 months before interview, except during week after return from vacation	Symptoms unchanged while away in tropical country
Respiratory	Normal, no asthma, never smoked	No change	No change
Other		• Feels vibration in feet/lower legs when stands still in house or barn, which feels like it is coming from vibrations in the structure; worse in barn, which is not insulated; does not feel this outside/on the ground. • Sounds like helicopter starting up or jet circling house every 3-4 seconds	

*Interviewed after 9 months of exposure. Family has not moved.

**Away for vacation for 2 weeks during the first 3 months of exposure and 10 days during the month before the interview.

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