

Wind turbines: Vacated/abandoned homes – Exploring research participants' descriptions of adverse health effects and medical diagnoses provided by their physicians and physician specialists

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Abstract

Introduction: The risk of harm associated with living within 10 km of industrial wind turbines (IWTs) is unresolved and continues to be debated internationally. While sources such as judicial proceedings, scientific literature, social media, and Internet websites report that some neighbors contemplate leaving their homes, research on this topic is limited. This study continues to explore why they contemplated such a housing decision.

Methodology: The ethics-reviewed study used the qualitative Grounded Theory (GT) methodology and interviewed 67 consenting participants, 18 years or older, who had previously lived, or were currently living, within 10 km of IWTs. Audio files were transcribed to text and the data were coded and analyzed using NVivo Pro (v. 12.6) software.

Objectives: The objective of this manuscript is to explore participants' descriptions of their medical diagnoses provided by their physicians and physician specialists.

Results: Data analysis revealed primary and subthemes associated with environmental interference and altered living conditions. Of the 67 participants, eight described their diagnoses of medical conditions as given by their physicians and physician specialists. Descriptions of conversations with participants' health-care providers were also surveyed.

Discussion: Medical diagnoses, descriptions of comments by health practitioners and the commonality of globally reported adverse health effects (AHEs), support the potential risk of locating IWTs near residential areas. It is recommended that members of the public, government authorities, policy makers, researchers,

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health practitioners, and social scientists with an interest in health policy and disease prevention acknowledge this risk and advocate for the immediate, effective, and timely resolution for affected neighbors. **Conclusions:** The GT methodology was used to develop a substantive theory regarding the housing decisions of participants living within 10 km of a Wind Power Plant. Results from the interviews indicate that these decisions were motivated by the potential for, or the experience of, AHEs which they attributed to living in proximity to these installations.

Keywords: Adverse health effects, Grounded Theory, medical diagnoses, vacated homes, wind power plants, wind turbines

INTRODUCTION

The risk of harm associated with living within 10 km of industrial wind turbines (IWTs), is controversial and debated globally.^[1-4] Some neighbors have reported adverse health effects (AHEs) that they associate with living in proximity to Wind Power Plant (WPPs)/IWTs and have contemplated vacating their homes. In some cases, some families have “effectively abandoned their homes, been billeted by wind energy developers or negotiated financial agreements with developers.”^[3]

Reports of AHEs are available through sources such as judicial proceedings including testimony under oath, factums, written submissions, legal arguments, government Environmental Review Tribunals (ERTs) and hearings,^[5a-k,6a-b,7a-c,8,9a-d,10-12] the scientific literature,^[3,13-20] social media, and Internet websites.^[21-24] While some neighbors have reported vacating their homes,^[3,7,8a-c,10,13,17,21-24] research associated with the motivation, decision-making process, and final outcome are limited.

Neighbors living in proximity to WPPs/IWTs report a range of AHEs such as sleep disruption, cardiovascular symptoms, headaches/migraines, stress/anxiety, mood disorders, vertigo, and cognitive dysfunction.^[6-11,13-27] In addition, those working in the vicinity of WPPs/IWTs have reported similar symptoms.^[28-34]

This ethics-reviewed study used the qualitative GT methodology to conduct a community-based study in Ontario, Canada, and explored the events that motivated individuals and families living within 10 km of IWTs to contemplate vacating their homes. To date, four published manuscripts present preliminary results,^[35] an overview of findings,^[36] an exploration of the study’s use of a qualitative methodology, specifically the GT,^[37] and participants’ living experiences associated with Ontario’s Green Energy Act.^[38]

This study explores participants’ descriptions of effects that they associate with living within 10 km of WPPs/IWTs. Some participants describe their medical diagnoses

given by their physicians and physician specialists as well as conversations with their physicians, physician specialists, and nurse practitioners.

Conclusion

The GT methodology was used to develop a substantive theory regarding the housing decisions of participants living within 10 km of a WPP. Results from the interviews indicate that these decisions were motivated by the potential for, or the experience of, AHEs which participants attributed to living within 10 km to these facilities.

METHODOLOGY

Our study methodology conformed to the COREQ (Consolidated criteria for Reporting Qualitative research) checklist. Two additional processes that are not identified in COREQ were included in our methodology to further strengthen study rigor - a process controller and scrutinizer. The process controller documented schedules, the interview process, and data records. The scrutinizer maintained the integrity of the data collected. These processes and the capability to recruit participants, schedule and conduct interviews, and manage participant selection and communications were supported by the logistical coordination managed by the study’s process controller.

To gain an understanding of why some families living in proximity to an IWT facility contemplated vacating their homes, several research questions were identified:

1. What are the particular circumstances that influenced whether to vacate or not vacate a family home?
2. How did families arrive at their decision?
3. Were there consequences related to their decision?
4. Did these circumstances influence physical, mental, and social well-being?

Once the study design and the ethics review were finalized, an interview guide consisting of a single neutral question was piloted. This tapped the events leading to participants’ housing decisions. While the interview question was distinct

from the above research questions, they were aligned. The pilot's outcome supported the use of a semi-structured interview to generate rich participants' descriptions for the GT approach.

The formal study began with purposeful and snowball sampling strategies inviting potential participants who were 18 years of age or older, proficient in the English language, and having lived or currently living within 10 km of a WPP/IWTs to contact the researcher. Invitations were distributed to key informants such as community leaders and neighbors as these individuals were likely to generate rich data.^[39] There were no restrictions on the invitation's distribution.

Residents who responded were provided information about the study's purpose, i.e., to explore the "extent of these occurrences and the impact or lack of impact" of living within 10 km of a WPP/IWTs. They were informed that there would be an opportunity to describe the circumstances that may have influenced "whether to vacate or remain in their home." Before consent, all the participants were advised that even if they had signed the consent form, they could decline to answer any question and decline to continue with the interview. If this occurred, all their information would be immediately destroyed. There were no participant withdrawals and the individual interviews were conducted as scheduled.

With informed consent, face-to-face interviews were held with each participant in their homes with few exceptions. In these cases, travel issues such as travel distances or inclement weather resulted in some interviews being conducted by telephone. Participants were advised the interviews would last 1 h; however, the interviewers did not limit this and some interviews exceeded the proposed estimate.

Trained interviewers began by collecting demographic information. Subsequently, each interview was initiated with a single, nonleading question, i.e., to discuss the events that led them to contemplate vacating their home. If required, probes were used to seek further clarification of participants' descriptions. At the conclusion of the interview, participants were given an opportunity to describe additional insights.

All 67 participants agreed to have their interviews recorded and were offered an audio copy at their conclusion. The audio files were transcribed into text. The use of the NVivo Pro (v. 12.6) software (Available from: QSR International [Americas] Inc., Burlington,

MA, USA. www.qsrinternational.com) facilitated data coding and indexing. The GT's iterative methodology was followed. Data analyses began after the first interview and as new data were introduced, the themes and subthemes evolved.

This sampling approach continuously supported theory development and adjustments in response to the data being collected. Functional requirements such as process/logistical control which was managed by the process controller facilitated maintaining the iterative process. The interviews concluded with the 67th participant when saturation occurred and no new information was forthcoming.

A rigorous and systematic process to transcribe, code, and analyze evolving trends and themes resulted in Figure 1: Themes and subthemes and their relationship to the 5 Elements. Statistical and demographic information and the home status of participants are available at Krogh *et al.*^[36]

Themes, subthemes, and the 5 elements

Strauss and Corbin (1998) proposed a coding paradigm that was intended to help with data analysis by suggesting "what to look for when coding." A version of this approach – the 5 Elements – was provided by Rose *et al.*^[40]

Krogh *et al.* found that the use of this approach and the outcome of using a systematic method to transcribe, code, and analyze the data acquired from the interviews were applicable to the vacated/abandoned home study.^[37]

The application of the 5 Elements is illustrated in *Figure 1: Themes and subthemes and their relationship to the 5 Elements.*^[36]

For this study, the 5 Elements and their relationships to the analyzed data as proposed by Rose *et al.*^[40] are described as follows:

Element 1

The "*central phenomenon*" - the focus of the study is the siting of IWTs within 10 km of participants' homes.

Element 2

The "*causal conditions that contributed to the phenomenon*" include findings of the primary and subthemes of the effects of environmental interference and altered living conditions as described in Figure 1, Element 2.

Element 3

The "*context in which the phenomenon is embedded*" is associated with a government policy resulting in participants becoming

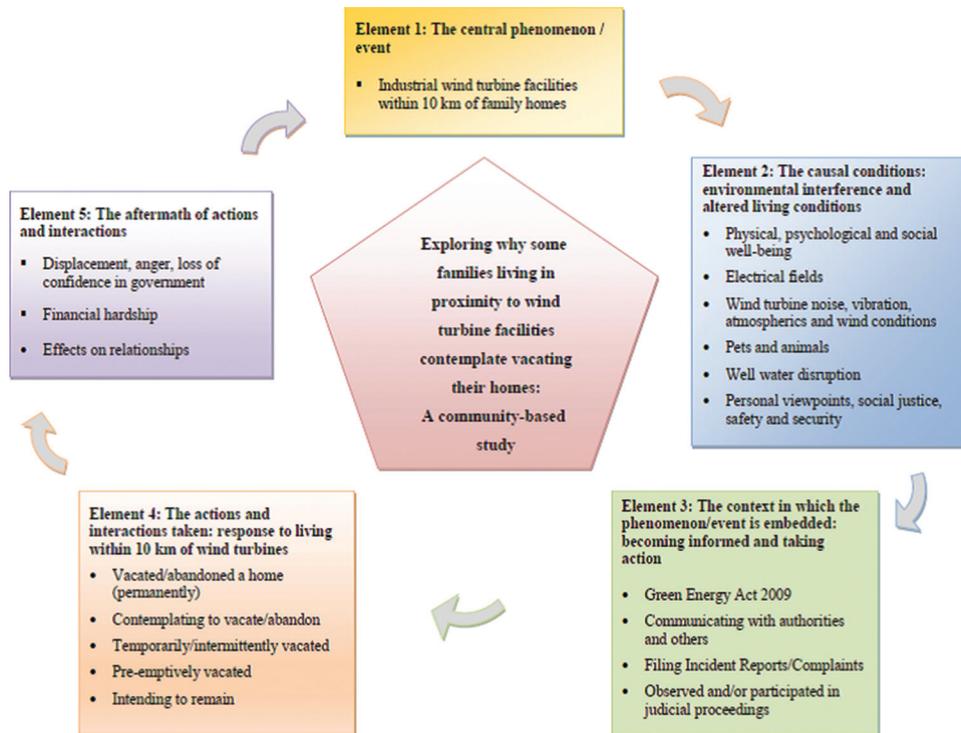


Figure 1: Themes and subthemes and their relationship to the 5 elements^[36]

informed and taking action through government and other processes as described in Figure 1, Element 3.

Element 4

The “actions and interactions taken by people in response to the phenomenon” resulted in participants contemplating housing decisions as described in Figure 1, Element 4.

Element 5

The “consequences of those actions and interactions taken in Element 4” includes an “aftermath” as described in Figure 1, Element 5.

In addition to the medical diagnoses given by their physicians and physician specialists and descriptions of conversations with their health-care providers, this report analyzes the subtheme of “physical, psychological, and social well-being” found in Element 2. The remaining sub themes of Element 2 and those of Elements 4-5 will be addressed in separate manuscripts. As proposed by Castillo-Montoya, every effort was made to accurately represent the voices of participants by the use of verbatim quotations throughout this manuscript.^[41]

To maintain participant confidentiality, the authors have intentionally avoided reporting details that could identify specific individuals, geographical locations, siting distances, or the details of the WPP/IWT projects.

RESULTS AND DISCUSSION

Awareness of the potential for adverse health effects

At the time of the interviews, all 67 participants had lived or were currently living within 10 km of a WPP and were aware of the potential of AHEs.^[35] Some had temporarily/intermittently left during the day and/or night to obtain temporary and/or partial relief from AHEs.^[37]

This awareness includes the four participants who decided to remain in their homes. Each example is by a different participant.

1. *It was talking to people that were in a situation where they wanted to vacate their home or thought they had to vacate their home*
2. *I know people that have vacated their homes because of the side effects*
3. *We started to think about [IWTs]...when it was announced that wind turbines (WTs) were coming...Then after the years we learned more and more about them...We do wonder now whether or not we are experiencing effects from infrasound or not*
4. *My belief is that this turbine issue is going to take a long time for all of the effects to become known.*

The four participants who relocated their homes before IWTs becoming operational were also aware of the potential for AHEs. Each example below is by a different participant.

1. *Basically knowing the health issues...there're indirect health issues...there's a lot of relational stress with the whole situation*
2. *For sure one, possibly two, people [in the home] who could be affected... they (developer) guaranteed us shadow flicker. They said, "Oh yes, you have shadow flicker guaranteed from the tree behind you"*
3. *Probably the first real concern was the health issues, some of the things that we had seen. I felt very depressed after I moved-it was very stressful*
4. *We started to learn a lot more about turbines, and there was a proposed project around our houses. We decided that we were going to sell prematurely, like we were being forced out of our house. That's basically what we went through.*

Table 1 provides the medical diagnosis received by eight participants. Tables 2-6 provide examples of participants' descriptions of effects. While these descriptions are not exhaustive, each example is associated with the topic under discussion and offered by a different participant.

Diagnoses by physicians and physician specialists

Of the 67 participants, eight described their diagnoses of medical conditions that were determined by their physicians and physician specialists. The investigation into the medical workup undertaken to arrive at these diagnoses is beyond the scope of this study See Table 1. A number of diagnostic terms relate to electromagnetic frequency (EMF) including "Electrical Sensitivity," "Electromagnetic Field Hypersensitivity (EHS)," and "Electromagnetic Hypersensitivity." To simplify the discussion, this manuscript uses the term EMF when appropriate.

Table 1: Medical diagnosis received by eight participants

	Number of cases
Takotsubo syndrome	2
Electrical Sensitivity	1
Electromagnetic Field Hypersensitivity (EHS)	1
Electromagnetic Hypersensitivity	1
Infrasound Sensitivity/Electromagnetic Hypersensitivity	1
Vibroacoustic Disease (VAD) from IWT Infrasound, with additional diagnosis of Cluster Headache and Refractory Glaucoma	1
Wind Turbine Syndrome (WTS)	1

Diagnosis of Takotsubo Syndrome

Two participants described their diagnoses by two different cardiologists of *Takotsubo syndrome* (also known as *Broken Heart Syndrome*).

In the first case, two episodes occurred while living within 7 km from IWTs:

I had two Takotsubo attacks...I thought I was having a heart attack and I laid down in the driveway for a while...It was just too stressful for me...I was a very healthy [person] up until the turbines came...I slept in my vehicle away from the turbines and I would recover from all these symptoms. I started staying

at [work] as long as I could in the day...I felt better there than I did at home with these turbines.

In the second case, the participant who was also living approximately within 7 km from a different WPP described a different cardiologist's diagnosis of *Takotsubo cardiomyopathy*. The cardiologist advised the participant that the condition was due to stress, resulting in their seeking medical attention at the hospital. The participant described the interaction with the cardiologist in the following excerpt:

Takotsubo cardiomyopathy...distress causes a section of your heart to get the blood flow blocked off...this is caused by stress...I have no problem writing in the discharge report that this is something that has been brought on by the wind turbines.

The Mayo Clinic^[42] and the Harvard Medical School^[43] provide information on this condition. Takotsubo cardiomyopathy "can mimic" a heart attack and is often brought on by extreme emotions and stressful situations.^[42] It is considered to be induced by stress and symptoms are typically "indistinguishable" from those of a heart attack.^[43]

During an Australian Senate hearing, testimony commented on the occurrences of Takotsubo cardiomyopathies associated with living near IWTs. Some of the cardiologists who had an interest in this condition voiced concerns that some of these cases could be caused by "excessive lower frequency sound energy."^[12]

Other participants described cardiovascular symptoms associated with living within 10 km of IWTs. These examples are provided in Table 2. Cardiovascular symptoms: participants' descriptions of effects.

Table 2: Cardiovascular symptoms: participants' descriptions of effects

- *Mostly it's the palpitations and the headaches.all of a sudden, my heart will just start racing,*
- *I was getting heart palpitations. Never experienced that before*
- *Chest pain compression between the two breast bones.*
- *I had really high blood pressure.*
- *Heart palpitations, both of us had that. Where you get a feeling of panic attack is coming and you don't know how to stop it. There's no way to stop it, and I don't leave the farm very often because that's what my job has been... the first farmer for our home. I'm always there and I'm always exposed to these things.*
- *I had a long, sustained bout of tachycardia arrhythmia which lasted for about three hours. I have arrhythmia anyway, but that was a high 150-190 beats per minute.*
- *I was having intermittent high blood pressure which damages the blood vessels. Now I have heart disease. What have I to look forward to? I'm on a cardiac regime. I'm under the care of a cardiologist.*
- *You can feel your heart rate going a hundred miles [per hour].*
- *When I was home, my blood pressure was significantly high every time.*

Each example is by a different participant and excludes those diagnosed with Takotsubo syndrome. [inserted brackets] indicate where data have been omitted to maintain privacy.

Discussion

In 1973, epidemiological studies found that workers exposed chronically to high noise levels had an increased incidence of hypertension and morbidity.^[44] Since that time, a review by Argalášová-Sobotová *et al.* commented that in addition to the “psychosocial effects of community noise,” there were concerns about the impact of noise on “public health” with major endpoints of “high blood pressure, ischemic heart disease, and myocardial infarction.”^[45] In addition, “chronic noise annoyance” is associated with a risk of cardiovascular symptoms.^[46] Moreover, environmental noise can result in health endpoints of hypertension, myocardial infarction, ischemic heart disease (coronary heart disease), cerebrovascular diseases (stroke), and metabolic syndrome (diabetes mellitus type 2).^[47] During sleep, nonauditory effects may increase the amplitude of finger pulse, heart rate, and blood pressure.^[48]

A review by Münzel *et al.* indicated that environmental noise is associated with an increased incidence of cardiovascular effects and stressed the importance of noise-mitigating strategies.^[49] Hamer *et al.* stated that based on a large population-representative cohort, psychological distress was associated with “increased risk of death due to cerebrovascular disease.”^[50] Researchers from Denmark conducted IWT-specific cardiovascular studies.^[51,52] Poulsen *et al.* did not find conclusive evidence of an association between IWT-related noise and myocardial infarction or stroke. The authors suggested that while cardiovascular events may be triggered by indoor IWT-related noise at night, these events seemed largely unaffected by outdoor nighttime IWT noise. They indicated that the findings were based on a few cases and needed to be reproduced.^[51]

The study by Bräuner *et al.* involved 24,139 nurses that were analyzed for a possible relationship between WT noise and atrial fibrillation (AF). Of these, 20,311 were unexposed to WT noise. Respectively 624, 580, 598, and 594 were exposed to <21.6 dB, 21.6–25.4 dB, 25.4–29.9 dB, and >29.9 dB WT noise (about 2.6% of those analyzed per group).^[50] This study also found that a total of 1,430 participants developed AF. Long-term exposure to IWT noise levels ≥ 20 dB was linked to an increased incidence of AF. The relationship between WTN exposure and AF was characterized by a nonlinear nonmonotonic pattern. Although there was no strong evidence of an exposure–response relationship at noise levels of up to 30 dB, there was an increase in AF at levels from 30 to 35 dB at all the 1, 5, and 11 year WT exposures. When assessing the effects of the 11-year rolling mean night

exposure to WTN (Ln), a 30% statistically significant increased risk of AF (95% confidence interval: 1.05–1.61) was found, compared to up to 20 dB(A) exposure. Evening and day exposure also showed an increased risk of AF.^[52]

In a study of 30 subjects living within 500 m of IWTs, Chiu *et al.* aimed to assess heart rate variability responses to low-frequency noise (LFN) exposure and to evaluate the “LFN exposure (dB, LAeq) inside households.” The authors concluded:

In view of the adverse health impacts of LFN exposure, there should be regulations on the requisite distances of WTs from residential communities for health protection.^[53]

Internationally, physicians have commented on the risk of cardiovascular effects associated with operational IWTs.^[54–58] Reports from Ontario^[6,7,10,14] and internationally^[24–25] describe such occurrences. In a decision by an Ontario ERT, several physicians and a noise researcher were quoted. These witnesses were qualified as experts and testified under oath. They testified to the potential for cardiovascular effects associated with operational IWTs.^[59a–c]

It appears that there is sufficient evidence indicating a potential for cardiovascular effects associated with chronic exposure to environmental noise in general, including noise associated with operating IWTs.

Diagnoses of electromagnetic frequency

Four participants described their physicians’ medical diagnosis related to exposure to EMF. One of the four participants identified additional diagnoses of infrasound exposure and other conditions. For discussion associated with infrasound see Diagnosis of Infrasound Sensitivity and Vibroacoustic Disease (VAD). Descriptions by the four participants who were diagnosed by their physicians are by different participants.

1. *I have been left with a permanent disability of electromagnetic hypersensitivity... This is a direct result of me living 18 months in the line of infrasound, dirty electricity and WiFi... we both [partner] experienced physical symptoms-the emotional symptoms are huge...the hardest thing that anybody should ever have to do is to decide [between] their health or their home and I still feel huge amount of guilt because I left and went to protect myself*
2. *It was dirty electricity or infrasound...there's vertigo...tinnitus, ear pressure, lack of sleep, constant waking up during the night...we were getting shocks. I would touch my truck...I'd be shocked. we measured...The sink was 50 times where it should*

be for dirty electricity coming through the plumbing, 90% of my sockets were overloaded

3. *I was diagnosed with electrical sensitivity in [date], and you become very good at noticing what is changing in your environment... The only thing that had changed in the environment was the turbine going up... I started to feel quite ill in my house with heart palpitations and nerve pain. I recognized those to be symptoms of electrical sensitivity which I had not experienced that way in the house before. After that experience of really intensive arrhythmic tachycardia... my friend... said, "Listen, this is not sustainable. You have to move out." I have not spent a night there ever since.*

The fourth participant described symptoms of stress, head pressure/ache, sleep issues, itchiness, burning sensations, popping ears, earaches, balance problems, and nose bleeds.

Additional examples of the effects of EMF exposure are provided in Table 3. Electromagnetic frequency: participants' descriptions of effects.

Table 3. Electromagnetic frequency: participants' descriptions of effects

- *Being in the house is the worst place you could be. You can actually be in the yard between the house...it's better than being in the house. I had the house actually checked out by a guy for electrical pollution and a few other things and his recommendation, he said, "Get out of there."*
- *We had a lot of electrical pollution. Your whole body just was ill.*
- *One electrician told us, "This is a frequency coming into your home. You need to put a 'for sale' sign up and get out of here."*
- *Even if our electricity was off, it was still coming in through the Bell telephone box and he [person testing] tried to put a grounding wire to alleviate it but honestly it didn't really help.*
- *To start with, we thought that maybe when they first started those things [IWTs], we thought that we were going to be able to get by with them. I got [Name] to come and take a few readings on the junk that was coming in... We couldn't sleep and I developed tinnitus and [partner] developed tinnitus two weeks after me.*
- *We were told that it was similar to living in a microwave.*
- *The humming would start because some of ours was coming in through electrical pollution through the wires. I would sleep in the basement. We turned off the power. But that didn't make any difference at all. Blood pressure was so high, anxiety, exhaustion.*
- *The only way we [two family members] could get some sleep was to shut the hydro off at night. if I go to drive up any road with a big hydro line. tinnitus just goes crazy. I didn't want to leave. if you had any chance of getting out, you had to get out. The torture was unbelievable. Nobody seemed to be interested.*

Each example is by a different participant and excludes those who described their diagnoses from exposure to these fields. [Inserted brackets] indicate where data have been omitted to maintain privacy.

Discussion

Reported IWT related health problems could be associated with exposure to EMFs. For example, during a 2009 Ontario government hearing, neighbors residing in proximity to IWTs described the occurrences of AHEs that they associated with exposure to EMF.^[10a,b] In that same year, researcher Havas, an expert in electromagnetic pollution, radiofrequency radiation, ground current, and dirty electricity is reported to have delivered "alarming warnings about the dangers to human and animal health" posed by IWTs. Havas identified:...

2 significant problem areas that pose substantive threats to the health of those living or working in proximity to WT developments-Infrasound or Low Frequency Sound emitted by the turbines themselves and both Dirty Electricity and stray voltage related to the electricity produced by turbines.^[60]

In 2015, during hearings on radiofrequency (RF) and electromagnetic radiation held by Canada's *House of Commons Standing Committee on Health*, an invited presentation observed that WPPs typically utilize technology-based systems during the generation and distribution of electricity. Emissions of EMF (electromagnetic fields), ELF (extremely low-frequency fields), and RF emissions typically occur through infrastructure and operational support systems such as transformer stations, communication networks, remote data monitoring systems, digital and GIS interfaces, and other mechanisms that utilize WiFi.^[61]

Subsequent to testimony by neighbors living near IWTs, the Australian Senate Committee on WT's recommended that "electromagnetic interference" be addressed.^[62]

Ontario-based research that measured electrical frequencies associated with operational IWTs has shown differing outcomes.^[63,64] In the first case, before and after IWTs initiated operations, the power quality near several Ontario residences where people reported being ill was measured by Havas and Colling. It was found that with the onset of operations, IWTs generated "distortion (spikes on the waveform)." The authors commented that while symptoms have been attributed to IWT-generated sound waves (noise and infrasound), IWTs also generate electromagnetic waves in the form of poor power quality (dirty electricity) and ground current. As a result, electrically hypersensitive individuals can be adversely affected, compelling some families to leave their homes. The described symptoms were consistent with electrohypersensitivity.^[63]

In the second study, McCallum *et al.* measured EMF levels near a WPP involving two substations and various buried and overhead collector and transmission lines. Measurements were taken during three operational conditions: "high wind" (generating power), 'low wind' (drawing power from the grid, but not generating power), and 'shut off' (neither drawing nor generating power)." Findings suggested there was "nothing unique" to IWT-related EMF exposure and that levels were "well below" current regulatory guidelines.^[64]

Neighbors living near another IWT facility reported AHEs associated with a transformer station. The addition of a

second station resulted in worsening effects. Descriptions of the disruption of the family's lives included the father's forced retirement, a daughter's departure from the home due to headaches and other symptoms, and a diminished livestock count due to a sudden "drop in conception and birthrates."^[65] The local Public Health Office responded by conducting an investigation to determine whether a health hazard existed. The resulting literature review and measurements found that:

The overall body of evidence suggests that exposure to extremely low-frequency electric and magnetic fields at exposure levels typically experienced by the public poses very little risk, and exposure to extremely low-frequency electric and magnetic fields is unlikely to be associated with the reported symptoms.^[66]

At the same time, this Public Health Office's literature review acknowledged that the symptoms were corroborated by the family physicians of the two families. One of the physicians emphasized that his patients had experienced a significant degree of sleep deprivation, leaving them with "severe anxiety, mental and physical exhaustion, and an inability to focus and cope with stress." One of the families vacated their home and noted they were feeling increasingly better when away. However, the symptoms returned during visits to their property. A member of the other family retired due to severe sleep disruption and an inability to work. Both families reported changes in the behavior and health of their animals. During a 2-day period, conditions improved and an inquiry to Hydro One – an Ontario electricity transmission and distribution service provider – revealed that the transformer had been "out of service" during that time.^[66]

In the USA, some neighbors believed their families' health problems were associated with living near IWTs resulting in two families vacating their homes. Based on the data collected during testing conducted at area homes, the presence of a "high frequency ground current/voltage issue" was found.^[67]

A 2019 review regarding electromagnetic and RF emissions found that establishing safe limits of exposure may be limited in scope and challenged by its "debate and complexities." A contemporary example of these challenges is related to Canada's Safety Code 6.^[68] The Code's limits apply to "all individuals working at, or visiting, federally regulated sites."^[69] Therefore, the Code does not apply to the population at large including children at all developmental stages (including fetal exposures),

older adults, and those with existing medical conditions and special needs. While previous limits had a range of 3 kHz–300 GHz,^[68] recent limits are now set at 6 kHz to 300 GHz.^[70]

The Code's technical guide states that regarding the 6-min time averaging period of uncontrolled environments, i.e., continuous exposure (24 h/day/7 days/week), the "onus" is under the control of the emitting source. For these environments, limits can be met by controlling exposure duration or the output of the source.^[71] Typically, members of the public lack control and precise knowledge of the duration of exposure and the amount of the source's output.

While IWT-specific electrical-field research is limited, there are global discussions regarding exposure to EMFs-including the deployment of 5G technology. Internationally, authorities,^[72-76] physicians,^[77-88] researchers,^[63,68,89-95] and others^[96-106] have expressed concerns associated with exposure to EMFs in general.

Outcomes of legal proceedings include a 4G antenna in France that was switched off due to health concerns on cows.^[107] Property owners in Germany were found liable for health impacts from "base station antennas" located on their property.^[108] A French Court ordered the removal of a Smart Meter for health reasons^[109] and in Italy, the Court ruled that occupational exposure to a mobile phone induced an intracranial tumor in a worker.^[110]

In 2021, Levitt *et al.* concluded that it was time to "recognize ambient EMF as a novel form of pollution and develop rules."^[93] Effects from EMF exposure have been described as not being "something you can see, smell, taste, or touch" and this makes it difficult to be aware of its presence.^[111] Weller describes the health outcomes from electromagnetic hypersensitivity as:

...completely disabling and in some extreme situations, can lead to hospitalization due to aggravation of pre-existing medical condition(s), development of tachyarrhythmias, which at times can result in a loss of consciousness and other acute effects on the neurological system.^[112]

Since Canada^[113] and the United States of America^[114] regulate worker exposure to non ionizing radiation, it is proposed that these protections be extended to include those who live in proximity to such emissions.

Dr. Bray, an Ontario physician and specialist in environmental health advised political leaders in Ontario including the Premier, the Minister of Health and Long-Term Care, the Chief Medical Officer of Health, and a number of Members of Provincial Parliament that:

A significant impact on human health from IWTs can also result from electromagnetic pollution.

Furthermore...

ground current or stray voltage in areas extending kilometers beyond individual IWT sites can contribute to electromagnetic injury and sensitivity to electromagnetic emissions.^[87]

Dr. Bray proposes that:

This cumulative effect of these various health-impacting factors combined with the prevalence of IWTs across the province suggests that significant steps at various levels and in various areas need to be taken to:

1. Widely acknowledge the potential risks that IWTs represent
2. Fully respond to the thousands of demonstrated complaints of adverse effects of IWTs across the province.^[87]

While symptoms related to EMF/RF exposure can pose significant diagnostic challenges, resources are available to assist physicians and health practitioners. For details, see diagnostic challenges and resources for moving forward.

Diagnosis of infrasound sensitivity and vibroacoustic disease

One participant described a combined diagnosis of “Electromagnetic Hypersensitivity/Infrasound Sensitivity.” A second participant described a diagnosis of “VAD from IWT Infrasound.” See also Diagnosis of VAD. Both participants described occurrences of vibration. *Each description is by a different participant.*

1. *The whole ground is vibrating. I had one...twice now it's happened where I've wakened-up during the night and the bed is vibrating. That is my understanding it is from the sub-transfer station*
2. *It's the uneasy feeling inside, it's the vibrating the whole body, is just vibration, like the sensations inside, my whole stomach are jittering it's like they're moving.*

Other participants described the effects related to infrasound and vibration. Additional examples are provided in Table 4: W/T infrasound and vibration: participants' descriptions of effects.

Table 4: Wind turbine infrasound and vibration: participants' descriptions of effects

▫ *The infrasound that it probably just pushed him over the edge and it affected his health.*

▫ *Our Ministry of Environment officer told us that all our symptoms are that of infrasound, but that there's nothing they can do because the Board of Health doesn't classify it as a health problem.*

▫ *I've learned there's no escaping or hiding from low-frequency sound....*

▫ *The noise got worse and worse. I had to understand that I was being affected by the infrasound*

▫ *Going up the chain, there's negative response. They won't even admit infrasound exists.*

▫ *Using our home as one of the homes that were studied. That was very supportive and helpful because we were able to pinpoint exactly what was happening with the southwest wind and able to plot and show on a graph exactly when we were experiencing infrasound and exactly how much. That was affirming because that was proving that we're not making this up. It was affirming.*

▫ *The government has decided not to study what could happen to people because of these turbines. They've decided not to regulate infrasound. They've decided, made all these decisions, so they won't ever learn. We're sitting ducks.*

▫ *Our home is cited [within 10 km] from the proposed turbines to be built. Being that close to a source of generation of infrasound it became a concern to us. That's why we really want to have our home tested in case there was another source of infrasound that we weren't aware of already in the home before the turbine was built and there was none. The signal was readily available from the neighbouring wind turbine project.*

▫ *It was vibration which was terrible. It felt like the ceiling was humming... you can't cover it up, it's something you feel...it invades you...it was frustrating...vibration was there almost all the time, very rarely was the house not vibrating and we were feeling it, the animals, our pets were feeling it. Our health just declined to the point where we hired a lawyer to get out and we just had no choice, we could not stay there.*

▫ *I woke up and you could feel my inside is vibrating. I was up looking for shoes, rubber shoes to stick under the bed and I said to [partner] that morning, “We are out here. That's it, we're done.”*

▫ *The vibrations and chest noise, unable to sleep, exhaustion and we had a lot of electrical pollution. You just felt very, very physically ill. Your whole body just was ill. I can't really explain what it felt like, but it was really terrible.*

▫ *The events were that I was experiencing vibrations not only in the home but in my body that were very disturbing. Obviously depriving me of sleep and leaving me very tired, lethargic, unenergetic.*

▫ *Sleep deprivation...I'd wake up, it just felt like my head was swimming and that was one of the initial things I think and it took me a long time to figure out that it started with turbines. Some might say that's vibration.*

Each example is by a different participant and excludes examples of those who were diagnose with VAD or exposure to electrical frequencies. [Inserted brackets] indicate where data have been omitted to maintain privacy.

Discussion

Initially, within the context of the US space program, chest wall vibration in response to infrasound and LFN exposure was documented in the 1960s.^[115,116]

In 1998, pathologist Castelo Branco observed that noise-exposed aeronautical workers reported “complaints of chest wall vibration” and that:

It is important to note that vibration at or above 16 Hz produces noise, and LFN induces vibration through the phenomena of resonance. Despite worldwide and independent publications indicating the existence of an extra-aural effect in occupational environments,

there are equally successive papers neutralizing and/or invalidating this clinical evidence.^[117]

Low-frequency sound is considered to range between 20 and 200 Hz. Sound below 20 Hz is called infrasound and if the level of infrasound is high enough, it is possible to feel body vibrations. It may be that a sound, i.e., “inaudible to some people, may be loud to others.”^[118] Infrasound is “clearly audible;” and the “popular concept that sound below 20 Hz is inaudible is not correct.”^[119]

A study conducted in the U.S.A. suggested that an adverse response to IWTs is an acceleration or vibration problem in the very low-frequency region. It was determined that:

The four investigating firms are of the opinion that enough evidence and hypotheses have been given herein to classify LFN and infrasound as a serious issue, possibly affecting the future of the industry.^[120]

Another study conducted in Australia found that nonacoustic findings of sensation disturbance occurred when IWTs were seeking to start up, during an increase or decrease in power, at maximum power (normally with wind above 15 m/s) and that:

The latter situation with excessive winds can occur for extensive periods at Cape Bridgewater with residents reporting that at times they have to leave the area to seek relief.^[121]

A 2019 review found that exposure to infrasound “directly causes adverse physiological health effects”^[122] and in 2015, magnetic resonance imaging found that the brain responded to infrasound at 8 Hz by activating areas usually associated with autonomic and emotional control.^[123]

While there are potential risks to being exposed to infrasound, Ontario’s IWT noise guidelines are based on A-weighting.^[124] However, regarding the use of dB(A), Cooper found that:

noise levels external to a dwelling did not correlate with internal noise levels or impacts that residents identified as coming from the wind farm.^[121]

Diagnosis of vibroacoustic disease

One participant described a diagnosis of VAD from IWT Infrasound with an additional diagnosis of cluster headache and refractory glaucoma.

...Symptoms didn't really start until about 6 months, till the second project came on...we did not connect [partner's] eye problems...headaches just got so bad that [partner] had to leave...Since the turbines began, everything's been deteriorated except for the 3 months when went away... we saw a specialist... We found out that infrasound as a source of inflammation. There are other things, but it is one source of inflammation and [partner] has been exposed to chronically.

VAD was identified among noise-exposed workers within the aeronautical industry and documented in 1998^[117] and 1999.^[125]

VAD is defined as a “whole-body pathology caused by excessive exposure to LFN.”^[126] Its onset is “insidious and frequently misdiagnosed.”^[125]

In 1999, Castelo Branco described the clinical stages (mild, moderate, and severe) of VAD, as identified in 140 aeronautical workers (after the application of selection criteria among a group of 306 workers), and as a function of the total number of years of occupational exposure. Signs and symptoms were included in the clinical stages if they were observed among 50% ($n = 70$) of the study group. After 5 years of occupational exposure to LFN, at least 70 of the 140 workers had developed bronchitis (independent of their smoking habits).^[125]

The clinical stages of VAD as defined for occupational exposure to LFN are: *Stage I* (mild) occurring at 1–5 years. Symptoms included “slight mood swings, slight gastrointestinal dysfunction, infections of the oropharynx, and bronchitis”. *Stage II* (moderate) occurring at 5–10 years with symptoms of “chest pain, definite mood swings, back pain, fatigue, fungal, viral and parasitic skin infections, gastritis, pain and dysuria, conjunctivitis, and allergies.” *Stage III* (severe) occurring at >10 years with symptoms of “psychiatric disturbances, hemorrhages of nasal, digestive and conjunctive mucosa, varicose veins and hemorrhoids, duodenal ulcers, spastic colitis, decreased visual acuity, headaches, severe osteoarticular pain, intense muscular pain, and neurological disturbances.”^[125] This clinical protocol for diagnosing VAD was reiterated at EuroNoise 2015.^[127]

In 2004, the first case of environmental VAD was documented in a family living near a Port Terminal.^[128] Subsequently, in 2007, the first documented case of VAD in neighbors living near IWTs was presented at the 2nd WT Noise Conference:

Wind Turbines in the proximity of residential areas produce acoustical environments that can lead to the development of VAD in nearby home-dwellers.^[129]

One of the more important factors associated with the onset of VAD is exposure time. Occupational exposures offer workers periods of respite, while residential contamination with LFN can oftentimes be continuous even throughout sleep-time. The presence of acoustic signatures generated by IWTs has already been shown to cause sleep disruption, while their absence permits peaceful sleep-time.^[130]

Castelo Branco and Alves-Pereira state the challenge with the recognition of VAD:

The bottom line is: VAD is not acknowledged as a pathological entity, and individuals who exhibit VAD clinical pictures are malingerers (if workers) or neurotic (if females and/or housewives). At best, they are considered “overly sensitive” individuals. Moreover, since LFN exposure is not considered a health hazard by the authorities, it is rarely evaluated. In addition, LFN-related studies are not “fashionable,” and thus grant money for this field is practically nonexistent. Given the data collected to date and the worldwide suffering of millions of LFN-exposed citizens, this status quo situation is unethical, unsustainable, and downright obscene.^[126]

Diagnosis of wind turbine syndrome

A participant in this study described a diagnosis of wind turbine syndrome (WTS) that was provided by the participant’s physician. Symptoms that characterize WTS 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 when awake or asleep.^[13]

The diagnosed participant described symptoms that were consistent with those of WTS such as heart palpitations, an inability to sleep, vibrations/chest sensations, headache, tinnitus, exhaustion, anger, and high anxiety.

Examples of descriptions by participants of symptoms that are consistent with those of WTS are provided in Table 5. Participants’ descriptions of symptoms.

Each example is provided by a different participant and excludes the participant diagnosed with WTS. [Inserted brackets] indicate where data have been omitted to maintain privacy.

Table 5. WTS: participants’ descriptions of similar symptomsx

-
- *The first was lack of sleep and that was difficult enough, but headaches started, major migraines where they would last for a day or two days or three days or four days with nausea and vomiting.*
 - *I was pretty sure whatever was causing the problem, started when [number of IWTs] turbines - I don’t know exactly how many kilometers south of us. I’m guessing about [distance] kilometers South. One stage started off, in fact, they were spinning around, but I thought they were freewheeling, and hadn’t really started [generating], and I was getting popping in my ears. It felt like champagne bubbles going off on my eardrum, it was painful....*
 - *I became so weak and ended up being hospitalized. I couldn’t sleep there [at home]. I couldn’t rest, I couldn’t function. I couldn’t work...lack of sleep... headaches...migraines...nausea and vomiting, dizzy, and vertigo, ear pain... pressure in the ear...cognitively impaired...couldn’t remember things.*
 - *I’ll wake up in the middle of the night with my head racing, pressure in my head. My memory has been terrible. My short-term memory, when it’s really bad, I have trouble making simple decisions, like what kind of cereal to buy, just simple things.*
 - *My memory was just terrible and my memory is better now [after vacating the home].*
 - *Unable to walk at times because I became so dizzy and vertigo, ear pain as though you were going up in an airplane, a kind of pressure in the ears, shakiness in my stomach, which at first I didn’t feel at my chest, but the more and more I lost weight, it became more apparent it was in my chest as well.*
 - *Dizziness...I’ve never had dizziness before...my sleep patterns are so disturbed... You cannot recover or regenerate when you have lack of sleep...I had so much head pressure and the tinnitus in my ears was so bad that I couldn’t find a place to rest...Racing heart and startled...agitated have to get out.*
 - *Terrible vertigo. Terrible. So many times I was stranded on the side of the road, I couldn’t drive, I was throwing up. As soon as I get into the wind area...it hits me. I don’t even have to be at home...I was pretty irritable, pretty miserable.*
 - *We become very agitated and irritable and our ears will pop and we’ll still get headaches and stress where your neck starts hurting and your jaw starts hurting and then you get a headache.*
 - *I found it very irritable and unbearable.*
 - *As I continue to be exposed, they [symptoms] continue to get worse. we need to get ourselves out of that toxic environment.*
 - *Ear pains, the headaches, ringing in your ears, popping in your ears... vibration...sleep deprivation...I’d wake up, it just felt like my head was swimming... it makes me certainly very angry and irate. I think my personality even changes when I have to put up with this. I’m very, like I said, angry, irritable.*
 - *Headaches still continues for us, we’re not well all of the time*
 - *It makes me certainly very angry.*
 - *I’d wake up with a panic feeling...My heart would be racing and I would be extremely alert, almost afraid, thinking that the response is similar to my house is on fire or some somebody is stealing my car.*
-

Discussion

Researcher Dr. Nina Pierpont, a physician with a specialty in pediatrics and a PhD in Behavioral Ecology published a peer-reviewed book and employed the term WTS to describe a range of symptoms that are severe enough to drive people from their homes when living in proximity to IWTs. Her case series included 10 affected families – 38 members ages <1–75, living 305 m–1.5 km from the IWTs. Detailed clinical interviews included descriptions of symptoms, sensations, and medical conditions of residents before and while living near operational IWTs and after leaving and/or intermittently leaving their homes.^[13]

Pierpont proposed that WTS is mediated by the vestibular system and disturbance of the “sensory input to eyes, inner ears, and stretch and pressure receptors in a variety of body locations” that feedback neurologically with the “sense of position and motion in space” being affected. Some evidence suggested that the amplitude (power or intensity) of the lower frequencies and vibration could stimulate the vestibular system - “opening the door” for the described WTS symptoms. Those with ear-related conditions such as motion sensitivity, or inner ear damage, i.e., pre-existing tinnitus, hearing loss, or industrial noise exposure, are at greatest risk of AHEs.^[13]

Although WTS has been debated,^[131-135] symptoms that are consistent with those of WTS have been reported by those from Ontario and internationally who live^[6-11,14,18-22,25,26] or work^[28-34] in proximity to IWTs. During testimony in the USA^[134] and under oath during an Ontario ERT,^[135] acoustician Leventhall stated that he was “happy to accept” the symptoms of WTS as they have been known to him for many years as the symptoms of “extreme psychological stress” from environmental noise, particularly LFN.

An expert panel convened by the former Canadian Wind Energy Association and American Wind Energy Association found that the symptoms of WTS were the “well-known stress effects of exposure to noise” experienced by a small proportion of the population. The panel noted that environmental noise control officers and other professionals were familiar with this stress effect.^[4]

Discussions have included the mechanism and risk factors for symptoms described as WTS^[13,132,133] and the effects of LFN associated with the vestibular system.^[133-136] It was reported that a French court recognized wind “turbine syndrome” and awarded more than €100,000 in compensation to the affected parties. The report noted that those affected by the IWTs had headaches, insomnia, heart irregularities, depression, dizziness, tinnitus, and nausea that disappeared after moving away from their home.^[137]

A 2015 Australian Senate Committee stated that regarding WTS:

The committee believes that these complainants deserve to be taken seriously. Those who have labeled “WTS” as a communicated disease or a psychogenic condition have been too quick to judge. In so doing, they have unnecessarily inflamed the debate on the issue. This has understandably caused those who suffer adverse symptoms even greater distress.^[138]

Descriptions of conversations held with participants’ health-care providers

Some participants described conversations that occurred during consultation with their health care providers. Examples are provided in Table 6.

Table 6. Descriptions of conversations held with participants’ health-care providers

- *The medical health office believes us and [name] says there’s nothing [name] can do about it.*
- *My eye doctor knows, he really understands [turbine-related effects].*
- *My doctor had been urging me for some time to go and I had been resisting going because I wanted to stay in my home.*
- *I was speaking with him [the physician] and he had told me he was concerned about the lesions. He said to me he truly believed that the infrasound exposure could have contributed to that. He suggested that I move away, get out of there before any more damage was done to my tissues*
- *I said - we have wind turbines. He [physician] goes “Really?” Then he goes “You better go home and do some research, and I’m going to do some”...it escalated from there.*
- *I told our family doctor. I disclosed to him what was happening with myself. He basically said, “Move.”*
- *My doctor understands. I’ve talked to [physician] about just being at the end of my rope and having to move [The doctor] said “And you don’t want to. That makes the decision harder.*
- *[The medical practitioner] has it down on record. Sadly, [the medical practitioner] said I’m not the only one that’s come.*
- *I’ve had all these tests...none of them pointed to any reason why I would have all this pressure in my head...She [specialist] said “Do you live near wind turbines?”...I said, “Yes we do.” [the specialist] said, “That could possibly be a problem.”*
- *I never experienced any anxiety, I even have a letter from my previous doctor that I had never been seen in that office for anxiety sleep disorders. It was something that was brought on by the turbines for sure.*
- *I have heart palpitations and I never had them until the wind turbines were here, and it’s kind of frightening...I went to a cardiologist...didn’t find anything wrong...I explained to the cardiologist about the wind turbines, and he was like, “Well you should just move.”*
- *My doctor had been urging and urging and urging, “You have to leave - you have to leave. [My doctor would ask] - Have you left yet?” Each time I’d come in for a visit or I’d have an emergency - I’d have to go [to emergency] sometimes for treatments. IVs and medications for the migraines, although I could not always get there. Sometimes pain was so severe I couldn’t actually make it to the hospital before it became so bad.*
- *I’ve spoken to my doctor at great length. He’s pretty proactive. I believe that he is genuinely concerned. That he believes me. I went through a series of tests and so on and so forth. I think we’ve done everything to eliminate any other factors.*
- *[Physician] is a family doctor so I knew that my [partner] was having sleep issues and vertigo...we discussed that the only new thing in our environment was turbines and that these were unusual symptoms for us...the physician] point blank said “Would you consider moving?”*
- *[My physician] said to me.[he] prescribes for me.treats my symptoms, the depression, and whatnot.*

Each example is provided by a different participant and includes those who were diagnosed by their physicians and physician specialists. [brackets] indicate where data have been omitted to maintain privacy

Discussion

An Ontario ERT Decision recorded a neighbor’s description of a “chain of causality” associated with AHEs and operating IWTs. The family physician had provided the Tribunal with a letter that described the symptoms being reported – including those of a 10-year-old child – and expressed the hope that before constructing more IWTs in the area, the Tribunal would conduct further investigation of their effects.^[139a]

Due to a rare benign tumor, a second witness had been advised to avoid stress, noise and wind. In addition, this witness operated a pony-ride business comprised of 29 horses, ponies, and donkeys and had concerns about the effects on her animals and the safety of the children visiting the property.^[139b]

The third neighbor testified about concerns associated with noise, light flicker (i.e., a stroboscopic effect), and infrasound associated with her son's existing condition of "severe sensory processing" issues that are mainly but not exclusively aural. The neighbor testified that those with this condition can be sensitive to noise, light, and touch - including vibration. If IWTs surrounded the home, the ability to control these issues would not be possible. In addition to a number of attachments, the witness provided a letter from her son's behavioral pediatrician that stated:

Wind turbines concern me concern me, given my strong knowledge of neurobiology. Due to well-documented disruption to the "normal" environment (vibration, noxious repetitive sound), this is potentially a danger to health.^[139c]

Based on the descriptions provided by participants and testimony provided during government judicial processes, some physicians have considered that the AHEs being reported by their patients either are or could be associated with living in proximity to WPPs/IWTs.

DISCUSSION AND CONCLUSIONS

It has been known for several decades that community and occupational noise has led to AHEs. In 1999, the WHO acknowledged some of the effects that have been described by this study's participants. Examples are the effects associated with the cardiovascular system, outcomes of sleep disruption and the after-effects regarding sleep quality, increased fatigue, depressed mood, effects on well-being, and a deterioration of cognitive performance for more complex tasks. It was acknowledged that sleep was a prerequisite for good physiological and mental functioning. Another finding was that LFN can disturb rest and sleep even at low sound power levels.^[140] Subsequently, in 2001 the World Health Organization (WHO) acknowledged that:

The recognition of the noise as a serious health hazard as opposed to a nuisance is a recent development and the health effects of the hazardous noise exposure are now considered to be an increasingly important public health problem.^[141]

Jarosińska *et al.* of the WHO acknowledged in 2018 that some neighbors are affected by IWT-related noise and observed reliance on wind energy in Europe has increased, resulting in "higher public annoyance in the EU." Requests to update environmental noise guidelines resulted in consideration of new noise sources and evidence relating to a range of health outcomes, including "quality of life, mental health, and wellbeing."^[142]

The WHO's 2018 noise guidelines commented that there are "serious issues with noise exposure assessment related to WTs" and that further work is needed to assess fully the:

...benefits and harms of exposure to environmental noise from WTs and to clarify whether the potential benefits associated with reducing exposure to environmental noise for individuals living in the vicinity of WTs outweigh the impact on the development of renewable energy policies in the WHO European Region.^[143]

Fredianelli *et al.* observed that with the increasing installation of IWTs, the attention of "citizens toward WT noise" has grown and that:

...the scientific community has promptly responded, increasing the studies and the social surveys in order to better understand the cause of disturbance and the indicators that relate to it.^[144]

Diagnostic challenges and resources for moving forward

Previously published papers describe the challenges of using a quantitative research methodology for this topic.^[37,145] For example, Krogh *et al.* note that regarding the Health Canada Wind Turbine Noise and Health study:

Correspondence from a Health Canada representative acknowledged that the study design did not have the necessary "statistical power to conduct an analysis of individual wind facilities (e.g., annoyance in site A vs. site B)."^[37]

Health Canada cautioned that regarding the Health Canada WT Noise and Health study design:

- Results will not provide a definitive answer on their own,
- Results may not be generalized to areas beyond the sample as the wind turbines locations in this study were not randomly selected from all possible sites operating in Canada,
- Results do not permit any conclusions about causality, and

- Results should be considered in the context of all published peer-reviewed literature on the subject.^[145]

While the diagnosis of some medical conditions can also be challenging,^[146] several diagnostic tools are available to assist physicians during the investigation of AHEs associated with living in proximity to IWTs. A case definition by McMurtry and Krogh provides an updated version of the criteria for the diagnosis of AHEs associated with IWT exposure. The authors comment that “rural physicians in particular must be aware of the possibility of people presenting to them with multisystem complaints that may be initially confusing.”^[147]

Castelo Branco *et al.* describe a clinical protocol for evaluating the pathology induced by exposure to LFN.^[127] Physician Bray provides preliminary clinical practice guidelines in the diagnosis and management of EHS^[148] and the Austrian Medical Association provides health practitioners with guidelines “for the diagnosis and treatment of EMF-related health problems and illnesses” and designates this condition as “EMF syndrome.”^[149] EUROPAEM EMF developed guidelines for the “differential diagnosis and potential treatment of EMF-related health problems.” The aim is to improve/restore individual health outcomes and propose prevention strategies.^[150]

The International Classification of Diseases-11 provides codes for special purposes such as vibration, noise, vertigo from infrasound, and non-ionizing radiation.^[151]

These methodological approaches for investigating and diagnosing the described symptoms may be helpful to physicians who are investigating their patients’ reports of AHEs associated with living near WPPs/IWTs.

CONCLUSIONS

Using the qualitative GT methodology, this manuscript explored the causal conditions of environmental interference and altered living conditions associated with living within 10 km of WPPs. Some physicians responded to their patients by taking into account that the AHEs being described either were or could be, associated with living in proximity to IWTs. In some cases, their physicians proposed or urged that the participants leave their homes. The use of the GT methodology and the resultant data analysis supported the theory that housing decisions were motivated by the presence of WPPs/IWTs within 10 km of family homes and occurrences of AHEs or its potential risk.

It is recommended that health care practitioners, members of the public, government authorities, policy makers, researchers, and social scientists with an interest in health policy and disease prevention acknowledges the occurrences of AHEs associated with living or working within 10 km of WWP/IWTs and seek immediate resolution for affected neighbors and workers.

Acknowledgments

This article is dedicated to those who participated in this study. We would like to acknowledge those participants who had the courage to describe their diagnoses of medical conditions and personal discussions with their physicians and health-care providers. Through the participants candid and insightful comments, this study has provided a significant contribution toward the understanding of the impacts of living within 10 km of an industrial WPP and the distress associated with vacating a beloved home or contemplating to do so. Without their participation, this research would not have taken place. Our research team is privileged to have been given the opportunity to present these findings. We also dedicate this manuscript to two of our authors who recently passed away. Mr. Richard James was a respected acoustician whose numerous contributions are valued nationally and internationally. On behalf of Appellants, he testified under oath during numerous judicial proceedings. He was a consummate professional and a beloved friend to many of his colleagues, authors, and others who were fortunate enough to know him personally. Mr. Stephen Ambrose had a long and successful career as a principal investigator in acoustics and held paramount the safety, health, and welfare of the public. He co-authored two ground-breaking peer-reviewed acoustic papers and for the next decade provided professional consulting to numerous communities on the effects of WT noise. Both are deeply missed. We thank the members of our team and our interviewers who volunteered their time and traveled considerable distances to conduct the interviews. Finally, we thank those who encouraged us to conduct this study and who provided the funding for the ethics review, the coding software, and costs associated with open access publishing that enabled the conduct of this study and its publication.

Ethics review

Chesapeake Research Review, LLC (“Chesapeake IRB”) *Note: Chesapeake Research Review, LLC (“Chesapeake IRB”) and Schulman Associates Institutional Review Board, Inc. (“Schulman IRB”) have merged to create Advarra, Inc. (“Advarra IRB”).*

Data availability statement

The data generated and/or analyzed during this study are included in this published article.

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Conflicts of interest

There are no conflicts of interest.

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