Final Report
Huron County Wind Turbine Study about Noise, Vibration and Light

December 2019

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Huron County Health Unit. (2019). Final report for Huron County wind turbine study about noise, vibration and light: December. Clinton, Ontario.

This report is available at www.huronhealthunit.ca/wind

Contents

Key Findings

- Exposure to industrial wind turbines is associated with annoyance. Over time, annoyance may lead to adverse health effects, however, the causal pathway from annoyance to adverse health effects is complex and not well understood
- Exposure to industrial wind turbines may be associated with sleep disturbance
- Participation rate and resulting sample size for this study was not sufficient for the intended analysis
- Results cannot be generalized beyond the participants in this study
- This study does not provide a meaningful contribution to the literature on the impact industrial wind turbines have on human health

Executive Summary

Electricity generated by wind turbines is a renewable energy source utilized in Ontario, however, there are questions as to whether living near wind turbines may cause adverse health effects. Huron County residents requested the Huron County Medical Officer of Health (MOH) to investigate whether the wind turbines in Huron County are a health hazard under the Health Protection and Promotion Act (HPPA, R.S.O. 1990). The Huron County MOH does not have the authority to regulate wind turbines because that authority was delegated to the Ministry of Environment and Climate Change (MOECC) (EPA, R.S.O. 1990), however, a MOH can choose to study the issue and report on it.

Prior research examining whether wind turbines are associated with adverse health effects has found they are associated with annoyance and may be associated with sleep disturbance and depression (Arra, Hazel, Barker, Ogbuneke, & Regalado, 2013; Merlin, Newton, Ellery, Milverton, & Fara, 2015; Schmidt & Klokker, 2014; Council of Canadian Academics, 2015; Onakpoya, O'Sullivan, Thompson, & Heneghan, 2015; Baliatsas, van Kamp, van Poll, & Yzermans, 2016; Freiberg, Schefter, Hegewald, & Seidler, 2019; Poulsen et al., 2019b). Seven systematic reviews documented consistent evidence of an association between wind turbine exposure and annoyance, however, the pathway from annoyance to adverse health effects is complex and not well understood (Arra et al., 2013; Merlin et al., 2015; Schmidt & Klokker, 2014; Council of Canadian Academics, 2015; Onakpoya et al., 2015; Baliatsas et al., 2016; Freiberg et al., 2019). Recent Danish research supports an association between long term wind turbine noise exposure and sleep disturbance and depression (Poulsen et al., 2019b) but not diabetes (Poulsen et al., 2018b), adverse birth outcomes (Poulsen et al., 2018c), and filling prescriptions for high blood pressure medication (Poulsen et al.,

2018a). Danish research on the association between wind turbine noise and myocardial infarctions and stroke suggest there are complexities to be explored with further research (Poulsen et al., 2019a; Poulsen et al; 2018d; Bräuner et al., 2018; Bräuner et al., 2019a).

The purpose of this study was to better understand the impact of wind turbines on Huron County residents. While doing so, we sought to address two knowledge gaps identified by the 2015 systematic review from the Council of Canadian Academics: lack of information on children and infants and the lack of a reporting system for the consistent collection of residents' experiences living near wind turbines. We sought to determine what percentage of study participants report they have been bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines. We also sought examine whether there are environmental conditions associated with more participants reporting being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines.

To do the analysis planned for this study, participation was needed from at least 1,000 of the estimated 30,000 Huron County residents eligible to participate. In total, 109 eligible Huron County residents (including five under 16 years) representing 72 unique households signed consent forms to participate in the study. This is less than one percent of those who were eligible to participate. As a result, we were unable to examine whether there are environmental conditions associated with more participants reporting being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines.

Analysis of study participants confirmed an association between wind turbine exposure and annoyance. Of participating households within one kilometre of at least one wind turbine, 58% had at least one person reporting they were bothered, disturbed or annoyed by noise or light from wind turbines. Selection bias is present due to the low participation rate and these findings cannot be applied to other residents in Huron County.

It is likely that Ontario public health units will continue to be asked to examine potential health hazards which the Ontario Ministry of Health does not have the legislative authority to regulate. Also, there will likely be more instances where a consistent data collection system is needed to better understand the experiences of those experiencing the potential health hazard. Further work is needed to examine how these issues can be addressed.

Background

One of the contested issues regarding wind turbines is whether they cause adverse effects on human health at the setback mandated by the Government of Ontario; 550 metres from a private dwelling (Ontario MOECP, 2008b). At this distance, sound should not exceed 40 dBA in a rural area when the wind speed is six metres per second or less (Ontario MOECP, 2008a). Until 2018, the body of literature addressing this issue mostly consisted of low level evidence, i.e. cross-sectional studies, case series, and case reports. Seven systematic reviews published from 2013 to 2019 came to similar conclusions; there is consistent evidence that wind turbines are associated with annoyance, limited evidence wind turbines exposure is associated with sleep disturbance, and insufficient evidence for other adverse health effects (Arra, Hazel, Barker, Ogbuneke, & Regalado, 2013; Merlin, Newton, Ellery, Milverton, & Fara, 2015; Schmidt & Klokker, 2014; Council of Canadian Academics, 2015; Onakpoya, O'Sullivan, Thompson, & Heneghan, 2015; Baliatsas, van Kamp, van Poll, & Yzermans, 2016; Freiberg, Schefter, Hegewald, & Seidler, 2019). The 2015 systematic review from the Canadian Council of Academics also concluded that there was sufficient evidence to rule out an association between wind turbine noise exposure and hearing loss in humans. Eight Danish longitudinal studies published in 2018 and 2019 provide stronger evidence on the association, or lack thereof, with sleep disturbance and other adverse health effects health (Bräuner et al., 2018; Bräuner et al., 2019a; Bräuner et al., 2019b; Poulsen et al., 2018a; Poulsen et al., 2018b; Poulsen et al., 2018c; Poulsen et al., 2019a; Poulsen et al., 2019b).

Strength of Conclusions in Systematic Reviews published before Sept 2019

All seven systematic reviews (Arra et al., 2013; Merlin et al., 2015; Schmidt & Klokker, 2014; Council of Canadian Academics, 2015; Onakpoya et al., 2015; Baliatsaset al., 2016; Freiberg et al., 2019) relied on a weak body of evidence that was mainly comprised of cross-sectional studies. Systematic review findings were accompanied by cautions that an association or lack of association between wind turbine exposure and human health might be due to problems with the quality of the studies reviewed. All authors noted that high quality evidence, including longitudinal cohort studies, was needed to determine whether wind turbines caused adverse health effects in humans.

Characteristics of Danish Cohort Studies

Two longitudinal cohorts, the Danish Nurse cohort and the nationwide Danish cohort, were the basis of eight longitudinal studies examining the impact of wind turbines on human health (Bräuner et al., 2018; Bräuner et al., 2019a; Bräuner et al., 2019b; Poulsen et al., 2018a; Poulsen et al., 2018b; Poulsen et al., 2018c; Poulsen et al., 2019a; Poulsen et al., 2019b). An additional case-

crossover study also used the nationwide Danish cohort but is not a longitudinal design (Poulsen et al., 2018d). The Danish Central Population Register, established in 1968, contributes to the cohort studies' strength (Poulsen et al., 2018a). All Danish citizens have a unique personal identification number allowing for accurate linkage between government databases. This allows researchers to establish an accurate historical record of a number of variables including household addresses, hospitals stays, emergency department visits and redemption of prescription medications (Poulsen et al., 2018a).

The Danish Nurse cohort includes nurses who were at least 44 years of age at time of recruitment in 1993 and 1999 (Bräuner et al., 2018; Bräuner et al., 2019a; Bräuner et al., 2019b). Nurses complete surveys on socioeconomic status, lifestyle behaviours, and self-reported health behaviours at recruitment and throughout the years they are in the cohort. This provides information on a number of variables that can then be linked to information in government databases using the Central Population Register.

The nationwide Danish cohort includes citizens of Denmark 25-85 years of age living at a pre-determined distance from at least one wind turbine for at least one year during the follow up period (Poulsen et al., 2018a; Poulsen et al., 2018b; Poulsen et al., 2018c; Poulsen et al., 2019a; Poulsen et al., 2019b). The follow up period spanned five years before the first wind turbine was built and ended in 2013. All health events of interest, such as a myocardial infarction, that occurred in that follow up period were tracked using the Central Population Register and included in the analysis. The group not exposed to wind turbine noise was defined as living within a radius of 20 to 40 wind turbine heights away from at least one wind turbine. The group exposed to wind turbine noise was defined as living within a radius of at least one wind turbine that was 20 times the height of the wind turbine or less. Wind turbine noise exposure within the exposed group was further defined by modeling the wind turbine noise expected to occur inside and outside of each household.

A limitation with all of the longitudinal cohort studies is the small number of cases (a case is someone who has the illness) in the highest wind turbine noise category (indoor or outdoor). Authors for all seven longitudinal cohort studies noted that their findings might be due to chance rather than a reflection of what is actually happening in the population. They cautioned that their findings should not be taken as definitive proof that an association does or does not exist between wind turbine noise exposure and human health (Bräuner et al., 2018; Bräuner et al., 2019a; Bräuner et al., 2019b; Poulsen et al., 2018a; Poulsen et al., 2018b; Poulsen et al., 2018c; Poulsen et al., 2019a; Poulsen et al., 2019b).

Findings from Danish Longitudinal Studies and Case-Crossover Study

Findings from the Danish longitudinal studies did not support an association between long term exposure to wind turbine noise and diabetes (Poulsen et al., 2018b), adverse birth outcomes (Poulsen et al., 2018c), and filling prescriptions for high blood pressure medication (Poulsen et al., 2018a). Due to the small number of cases in the high exposure groups, further research was recommended before ruling out a possible association (Bräuner et al., 2018; Bräuner et al., 2019a Poulsen et al., 2018b; Poulsen et al., 2018c; Poulsen et al., 2019a).

Research on the association between wind turbine noise and myocardial infarctions and stroke suggest there are complexities to be explored with further research. Research examining the incidence (new occurrences) of myocardial infarction and stroke using the nationwide Danish cohort (Poulsen et al., 2019a) and the Danish nurse cohort (Bräuner et al., 2018; Bräuner et al., 2019a) did not find an association. However, there were few cases in the high wind turbine exposure group for each study. Further, a case-crossover study using the Danish population found that indoor wind turbine noise may trigger a myocardial infarction or stroke (Poulsen et al, 2018d). Again, the authors caution there were few cases in the high wind turbine noise exposure group and the findings may be due to chance.

Research with the Danish Nurse cohort suggests there may be an association between long term exposure to wind turbine noise and atrial fibrillation (Bräuner et al., 2019b). The authors cautioned that further research was needed to confirm these findings as there were a small number of nurses with atrial fibrillation in the high wind turbine exposure group (Bräuner et al., 2019b).

An association between long term exposure to outdoor wind turbine noise and filling prescriptions for sleep medication and antidepressants among those 65 years and older was found suggesting wind turbine noise may be associated with sleep disturbance and depression (Poulsen et al., 2019b). The authors suggested that a lack of an association in the younger groups could be explained because older adults spend more time in the lighter stages of sleep and are therefore more susceptible to sleep disturbance. Poulsen et al. (2019b) also suggested that the association with antidepressant prescriptions could be the result of wind turbine noise induced sleep disturbance, spending more time at home experiencing annoyance or both. As with the other studies, Poulsen et al. (2019b) cautioned there were few individuals filling sleep and antidepressant prescriptions in the high wind turbines noise exposure group so more research is needed to confirm the findings.

Regulation of Wind Turbines in Ontario

Regulatory authority for wind turbines in Ontario was delegated to the Ontario Ministry of the Environment and Climate Change (MOECC) through the Environmental Protection Act (EPA) (EPA, R.S.O. 1990). Ontario public health units may choose to study whether an association exists between wind turbine exposure and human health but they cannot regulate them. To date, the MOECC has conducted acoustic monitoring at one household in Huron County to address wind turbine noise complaints. Testing was undertaken November 2015 but the equipment malfunctioned for most of the recordings. Further testing was done in February 2017 and the wind turbine noise levels were found to be non-compliant in a report released March 28, 2017. Documentation on the acoustic testing and subsequent reports has been given to the Huron County Health Unit by the home owner. As of December 2019, the non-compliant noise emissions at that household have not been resolved. Resolved is defined here as acoustic testing that demonstrates wind turbines are in compliance with regulations. The Huron County Health Unit is not aware of any other acoustic testing done at households in Huron County that have lodged complaints with the MOECC.

Knowledge Gaps in 2016

The Council of Canadian Academics report was the most recent systematic review specific to wind turbines available when this study was developed. The systematic review noted a number of knowledge gaps that needed to be addressed to determine whether exposure to wind turbine noise is a health hazard. The two gaps that this study focused on were the lack of information on children and infants and the lack of a reporting system for the consistent collection of residents' experiences living near wind turbines.

Purpose

The purpose of this study was to better understand the impact of wind turbines on Huron County residents. We sought to determine what percentage of study participants report they have been bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines. We also sought to examine whether there are environmental conditions associated with more participants reporting being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines.

The study purpose was intentionally restricted to annoyance and did not include looking for associations between wind turbine exposure and specific health conditions, such as myocardial infarctions. We knew at the outset that we would not have sufficient power (i.e. not enough sick

people) to find a significant association between a health condition and wind turbine exposure. We also knew that any assessment of an association between wind turbine exposure and health would not be considered credible if information was not collected on potential confounders (other explanations for why people are sick). Early consultations with Huron County residents indicated questions on confounders were likely to result in a boycott of the study. Therefore, the study purpose was restricted to an assessment of annoyance due to wind turbines.

Research Questions

There were three questions asked in this study:

1) What percentage of participating households have at least one person reporting being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines?
    a) Within 10km
    b) Within 5km
    c) Within 1km
2) What percentage of participants report being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines?
    a) At least once during the investigation
    b) At least once a season
    c) At least once a month
    d) At least once a week
3) What environmental conditions increase the likelihood that participating households will report being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines?

Methods

It was determined at the outset that it would not be possible to mask the intent of any data collection related to wind turbines in Huron County, so no attempt was made to blind or disguise the nature of the study. Data collection focused on self-reported annoyance attributed to wind turbines.

All Huron County residents living within 10 km of a wind turbine were invited to participate in the study. Approximately 30,000 Huron County residents were eligible to participate in the study. The study involved participants completing a one-time Registration Survey then documenting observations of noise, vibrations, sensations and light from wind turbines for at least one week every month. Recruitment was from October 26, 2017 to October 31, 2018. Data collection was from November 1, 2017 to November 30, 2018.

Table 1: Research questions and methods

Research question	Method
Determine percentage of participating households reporting being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines By distance from a wind turbine By frequency of complaints	The denominator is all participating households. The numerator is participating households with at least one person reporting being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines.
Determine percentage of participants reporting being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines By distance from a wind turbine By frequency of complaints	The denominator is all participating individuals. The numerator is participating individuals reporting being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines.
Determine whether there are environmental conditions that increase the likelihood that participating households will report being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines	Hierarchical regression analysis. The outcome variable is the degree of annoyance from noise, vibrations, sensations and light from wind turbines. The possible predictor variables include meteorological conditions, wind turbine operation variables, and where the house is located relative to the wind turbines.

Recruitment

In October 2017, the Huron County Wind Turbine Study about Noise, Vibration and Light launched. The Huron County Health Unit held an information meeting for the purpose of explaining the study process and answering questions from the public on Thursday, October 26, 2017 at the Huron County Health Unit in the Health and Library Complex, Clinton.

Media releases were sent to local media outlets announcing recruitment for the study October 26, 2017. Local radio stations, newspapers, and CTV News reported on this news release. Paid advertisements informing the public about the study also ran in all local weekly print

newspapers as well as the Focus biweekly print newsmagazine, during the first week of November 2017.

Another media release, sent out June 20, 2018, targeted seasonal Huron County residents. This release was also reported on by local and regional radio stations and newspapers.

Huron County residents living within five km of a wind turbine were mailed an information letter and consent form. In total, 4,516 households received an information letter and consent form. The mailing used Canada Post's neighbourhood mailing service to deliver information to households on Huron County mail routes that were within or mostly within five km of a wind turbine. The mail routes did not align perfectly with the area letters were to be mailed to. This meant some Huron County households that were within five km of a wind turbine did not receive a letter. If anyone who was missed by the neighbourhood mailing contacted the Huron County Health Unit, an information package was mailed to them. Anyone else who contacted the Huron County Health Unit asking for information on the study was mailed information unless they indicated they preferred to get it from a Huron County Library branch or front reception at the Huron County Health Unit Clinton office.

Residents living 10 km from a wind turbine were also invited to participate by reading the information letter on the Huron County Health Unit website, downloading and printing the consent form, and returning the completed consent form to the Huron County Health Unit by mail or in person. The Health Unit website maintained a prominent visual on its home page, linking to the study, for much of 2018.

Copies of the information letter, consent form, parent permission form, child assent form, Registration Survey and Observation Diary were also available at any branch of the Huron County Library as well as the Huron County Health Unit Clinton location. A copy of the map showing what areas of the county can participate in the study was available at all branches of the Huron County Library as well as in the front lobby of the Huron County Health Unit Clinton location.

Data Collection

Two data collection tools were developed for this study, the Registration Survey (Appendix A) and Observation Diary (Appendix B), with input from a group of Huron County residents. The Registration Survey utilized select questions from the *Community Noise and Health Study* conducted by Health Canada. Survey development focused on finding a balance between asking for information that would yield a meaningful analysis while avoiding questions that were likely to result in a boycott of the study by eligible residents. Question topics that were identified as likely to

result in a boycott included opinions about wind turbines, personal income, education, lifestyle behaviours (e.g. smoking and alcohol consumption), and chronic illnesses.

Results

Participation

When recruitment closed on October 31, 2018, 109 eligible Huron County residents (including five under 16 years) representing 72 unique households had signed consent forms to participate in the Huron County Wind Turbine Study about Noise, Vibration and Light. This is less than one percent of the estimated 30,000 who were eligible to participate. Further, only 70 of the 4,516 households that received a letter from the HCHU returned at least one consent form for a participation rate of 1.6%. Three additional consent forms were received after recruitment closed and are not included in the 109 total. Additional consent forms were excluded because they could not be mapped (n=2) or found to be outside the 10 kilometre inclusion area (n=2).

The registration survey was completed by older adults who (mostly) lived in single detached homes. Survey respondents' age range was 30-87 years and the average age was 61 years. Most respondents reported living in a fully or partially bricked single-detached home (see Table 1). The majority of respondents did not hold a wind turbine lease or receive money from a wind turbine company (see Table 1).

Table 1: Characteristics of registration survey respondents (47 total)

Characteristic	Number (per cent)
Age	
30-49 years	6 (13)
50-69 years	31 (66)
70-89 years	10 (21)
Sex	
Male	21 (45)
Female	26 (55)
Other	0 (0)
House exterior materials	
Fully bricked	13 (30)
Partially bricked	13 (30)
No brick	9 (20)
Other	9 (20)
Type of house	
Single-detached house	44 (94)
Apartment in a building that has fewer than five stories	3 (6)
Wind turbine leaseholder	
Yes	6 (13)
No	41 (87)
Receive money from a wind turbine company	
Yes	10 (21)
No	33 (70)
Do not know / Decline to answer	4 (9)
Distance from house to nearest wind turbine	
≤1km	28 (60)
>1km and ≤5km	18 (38)
>5km and ≤10km	1 (2)

Before this study began, we determined that a minimum of 1,000 participants would be needed to do the analysis for the third research question. The final sample size of 109 participants did not meet the minimum sample size set out for the third research question.

Personal communication was received from a few individuals indicating why they chose not to participate. These personal communications are not representative of the population that chose not to participate in the study.

- Not worth their time to participate because Huron County Health Unit unable to shut down or curtail wind turbines
- Sick of hearing about wind turbines / Just want to forget about wind turbines
- Not enough time / too busy / didn't get around to it
- Too stressful / too much work to be documenting what is happening in the observation diary
- Potential benefit does not justify the amount of work involved
- Did not believe it was ethical to do research on wind turbines and health unit should shut wind turbines down instead
- Health unit staff biased in favour of wind turbine companies
- Health unit staff biased in favour of anti-wind turbine groups

Percentage of households reporting annoyance

In total, at least one person from 36 unique households completed and submitted the Registration Survey.

Table 2: Households within one kilometre of a wind turbine with at least one participant reporting on annoyance (19 households total)

Have you ever been bothered, disturbed or annoyed by	Number (Per cent) reporting yes
Noise	11 (58)
Light	11 (58)
Vibration	8 (42)
Sensations	9 (47)

Table 3: Households within five kilometres of a wind turbine with at least one participant reporting on annoyance (35 households total)

Have you ever been bothered, disturbed or annoyed by	Number (Per cent) reporting yes
Noise	16 (46)
Light	17 (49)
Vibration	9 (26)
Sensations	12 (34)

Table 4: Households within 10 kilometres of a wind turbine with at least one participant reporting on annoyance (36 households total)

Have you ever been bothered, disturbed or annoyed by	Number (Per cent) reporting yes
Noise	16 (44)
Light	18 (50)
Vibration	9 (25)
Sensations	12 (33)

Percentage of participants reporting annoyance

In total, 47 participants completed and submitted the Registration Survey.

Table 5: Participants reporting if they were ever annoyed by wind turbines on the Registration Survey (47 participants total)

Have you ever been bothered, disturbed or annoyed by	Number (Per cent) reporting yes
Noise	21 (45)
Light	21 (45)
Vibration	15 (32)
Sensations	17 (36)

In total, 37 participants submitted at least one entry in the observation diary and 25 participants submitted at least seven entries in the observation diary.

Table 6: Participants reporting if they were every annoyed by wind turbines using the Observation Diary each season (47 participants total)

Moderately to extremely annoyed by noise, light, vibration or sensation at least once during	Number (per cent) annoyed more than slightly at least once	Total number of participants submitted at least one observation log
Winter	12 (44)	27
Spring	15 (56)	27
Summer	10 (56)	18
Fall	9 (53)	17

Discussion

Limited participation in this study means that the results cannot provide an accurate estimate of how many Huron County residents are bothered, disturbed or annoyed by wind turbines. This study does not address the knowledge gap for children and infants identified by the Canadian Council of Academics (2015). Further, no conclusions can be made regarding whether there are environmental conditions that increase the likelihood that participating households will report being bothered, disturbed or annoyed by noise, vibration, light and/or sensations from the wind turbines.

Selection Bias

Selection bias was present in this study. Household participation rate in the five kilometre study inclusion area was 1.5% and even lower for the 10 kilometre study inclusion area. Overall participation rate for Huron County residents living within 10 kilometres of a wind turbine is estimated to be less than one per cent. At this level of participation, selection bias is certain. Those who chose to participate in the study are different from those that did not. The results cannot be used to describe the experience of all Huron County residents living within 10 kilometres of a wind turbine.

Confounding

Measurement of potential confounders was problematic. Input from Huron County residents during data collection tool development indicated several questions on confounders were likely to be interpreted as an attempt to discredit those who were negatively impacted by wind turbines. The decision was made to proceed with a study design that focused on examining whether self-reported annoyance, rather than health, was influenced by environmental variables such as wind speed, humidity and cloud cover.

Reporting System

To answer the third research question, an Observation Diary was developed to document the experiences of Huron County residents living within 10 kilometres of at least one wind turbine. Only 25 participants submitted at least seven entries in the Observation Diary. Further, personal communication received from a few participants indicated the Observation Diary was too burdensome. This indicates we were unsuccessful in finding a way to consistently collect information on the experiences of those living near wind turbines.

Medical Officer of Health Regulatory Powers

A topic of discussion before and during this study was the regulatory powers held by the Ontario Ministry of Health for wind turbines. The Ontario Health Protection and Promotion Act (HPPA, R.S.O. 1990) appears to grant a Medical Officer of Health (MOH) the power to regulate anything that may be defined as a health hazard to Ontario residents through issuing a section 13 order. However, there are limits to that authority. In 2004, the Attorney General for Ontario requested a judicial review from the Ontario Superior Court of Justice on Pelletier v. Northwestern Health Unit because it was characterized as a test case to determine the scope of a MOH's authority. This means the Attorney General requested clarification from the Ontario Superior Court regarding the limits to a MOH's authority to issue a section 13 order. The Ontario Superior Court ruled that the HPPA provided an MOH the authority to issue case specific orders but not orders of general application. This means that a MOH cannot use a section 13 order to overrule the regulatory authority that was delegated to another agency by the Government of Ontario. For wind turbines, regulatory authority was delegated to the Ontario Ministry of the Environment and Climate Change through the Environmental Protection Act (EPA) (EPA, R.S.O. 1990).

Huron County residents have requested the Huron County Health Unit MOH investigate wind turbine exposure as a health hazard and issue a section 13 order to curtail or shut down wind turbines. Attempts to explain that this action was outside the scope of authority for the MOH were not well received. Throughout the design and implementation of this study there were questions as to whether it was an investigation under the HPPA or a research study. It is likely that confusion surrounding what the study could and could not do influenced participation amongst those that were and were not bothered, disturbed or annoyed by wind turbines.

Next Steps

It is likely that Ontario public health units will continue to be asked to examine potential health hazards which the Ontario Ministry of Health does not have the legislative authority to regulate. Also, there will likely be more instances where a consistent data collection system is needed to better understand the experiences of those experiencing the potential health hazard. Further work is needed to examine how these issues can be addressed.

References

Arra, I., Lynn, H., Barker, K., Ogbuneke, C., & Regalado, S. (2013). Systematic review 2013: Association between wind turbines and human distress. *Cureus, 6*(5), e183. doi: 10.7759/cureus.183

Baliatsas, C., van Kamp, I., van Poll, R., & Yzermans, J. (2016). Health effects from low-frequency noise and infrasound in the general population: Is it time to listen? A systematic review of observational studies. *Science of the total environment, 557-558*, 163-169. doi: 10.1016/j.scitotenv.2016.03.065

Bräuner, E. V., Jørgensen, J. T., Dunn-Henriksen, A. ., Backalarz, C., Laursen, J. E., Pedersen, T. H., Simonsen, M. K., & Andersen, Z. J. (2018). Long-term wind turbine noise exposure and incidence of myocardial infarction in the Danish nurse cohort. *Environment International, 121*, 794-802. doi: 10.1016/j.envint.2018.10.011

Bräuner, E. V., Jørgensen, J. T., Dunn-Henriksen, A. ., Backalarz, C., Laursen, J. E., Pedersen, T. H., Simonsen, M. K., & Andersen, Z. J. (2019a). Association between long-term wind turbine noise exposure and the risk of stroke: Data from the Danish Nurse Cohort. *Journal of the American Heart Association, 8*(14) e012143. doi: 10.1161/JAHA.119.013157

Bräuner, E. V., Jørgensen, J. T., Dunn-Henriksen, A. ., Backalarz, C., Laursen, J. E., Pedersen, T. H., Simonsen, M. K., & Andersen, Z. J. (2019b). Long-term wind turbine noise exposure and the risk of incident atrial fibrillation in the Danish Nurse cohort. *Environmental International, 130,* 104915. doi: 10.1016/j.envint.2019.104915

Council of Canadian Academies, 2015. Understanding the Evidence: Wind Turbine Noise. Ottawa (ON): The Expert Panel on Wind Turbine Noise and Human Health, Council of Canadian Academies. Retrieved from https://cca-reports.ca/reports/understanding-the-evidence-wind-turbine-noise/

Environmental Protection Act, R.S.O. 1990, c. E.19. Retrieved from https://www.ontario.ca/laws/statute/90e19?search=Environmental+Protection+Act%2C+R.S.O.+1990%2C+c.+E.19.

Freiberg, A., Schefter, C., Hegewald, J., & Seidler, A. (2019). The influence of wind turbine visibility on the health of local residents: a systematic review. *International Archives of Occupational and Environmental Health, 92,* 609-628. doi: 10.1007/s00420-019-01403-w

Health Protection and Promotion Act, R.S.O. 1990, c. H.7. Retrieved from https://www.ontario.ca/laws/statute/90h07?search=Health+Protection+and+Promotion+Act

Merlin, T., Newton, S., Ellery, B., Milverton, J., & Fara, C. (2015). Systematic review of the human health effects of wind farms. National Health and Medical Research Council, Canberra. Retrieved from https://www.nhmrc.gov.au/about-us/publications/expert-review-evidence-wind-farms-and-human-health#block-views-block-file-attachments-content-block-1

Onakpoya, I., O'Sullivan, J., Thompson, M., & Heneghan, C.J. (2015). The effect of wind turbine noise on sleep and quality of life: A systematic review and meta-analysis of observational studies. *Environmental International, 82,* 1-9. doi: 10.1016/j.envint.2015.04.014

Ontario. Ministry of the Environment, Conservation and Parks. Noise guidelines for wind farms. Toronto: Queen's Printer for Ontario; 2008a [revised 2016 May, cited 2019 October 28]. Retrieved from: https://www.ontario.ca/page/noise-guidelines-wind-farms#section-4.

Ontario. Ministry of the Environment, Conservation and Parks. Technical guide to renewable energy approvals Chapter 3: Required setback for wind turbines. Toronto: Queen's Printer for Ontario; 2008b [revised 2016 May, cited 2019 October 28]. Retrieved from: https://www.ontario.ca/document/technical-guide-renewable-energy-approvals/required-setback-wind-turbines.

Poulsen, A. H., Raaschou-Nielsen, O., Peña, A., Hahmann, A.N., Nordsborg, R.B., Ketzel, M., Brandt, J., & Sørensen, M. (2018a). Long-term exposure to wind turbine noise and redemption of antihypertensive medication: A nationwide cohort study. *Environment International, 121,* 207-215. doi: 10.1016/j.envint.2018.08.054

Poulsen, A. H., Raaschou-Nielsen, O., Peña, A., Hahmann, A.N., Nordsborg, R.B., Ketzel, M., Brandt, J.,& Sørensen, M. (2018b). Long-term exposure to wind turbine noise at night and risk for diabetes: A nationwide cohort study. *Environmental Research, 165,* 40-45. doi: 10.1016/j.envres.2018.03.040

Poulsen, A. H., Raaschou-Nielsen, O., Peña, A., Hahmann, A.N., Nordsborg, R.B., Ketzel, M., Brandt, J., & Sørensen, M. (2018c). Pregnancy exposure to wind turbine noise and adverse birth outcomes: A nationwide cohort study. *Environmental Research, 167,* 770-775. doi: 10.1016/jenvres.2018.09.011

Poulsen, A. H., Raaschou-Nielsen, O., Peña, A., Hahmann, A.N., Nordsborg, R.B., Ketzel, M., Brandt, J.,& Sørensen, M. (2018d). Short-term nighttime wind turbine noise and cardiovascular

events: A nationwide case-crossover study from Denmark. *Environmental International, 114*, 160-166. doi: 10.1016/j.envint.2018.02.030

Poulsen, A. H., Raaschou-Nielsen, O., Peña, A., Hahmann, A.N., Nordsborg, R.B., Ketzel, M., Brandt, J., & Sørensen, M. (2019a). Long-term exposure to wind turbine noise and risk for myocardial infarction and stroke: A nationwide cohort study. *Environmental Health Perspectives, 127*(3), 37004. doi: 10.1289/EHP3340

Poulsen, A. H., Raaschou-Nielsen, O., Peña, A., Hahmann, A.N., Nordsborg, R.B., Ketzel, M., Brandt, J., & Sørensen, M. (2019b). Impact of long-term exposure to wind turbine noise on redemption of sleep medication and antidepressants: A nationwide cohort study. *Environmental Health Perspectives, 127*(3), 37005. doi: 10.1289/EHP3909

Schmidt, J.H. & Klokker, M. (2014). Health effects related to wind turbine noise exposure: A systematic review. *PLoS ONE. 9*(12), e114183. doi: 10.1371/journal.pone.0114183