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Autism and the effect of introducing a new noise source into quiet rural communities: risk factor from industrial wind power generation

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Background and Objectives
Some individuals with Autism Spectrum Disorders (ASD) may react negatively to noise including low-frequency noise, infrasound, vibration and other environmental emissions. There are specific concerns in the Province of Ontario, Canada, related to the exposure of people with autism to the environmental noise and infrasound produced by an additional noise source, in this case from the introduction of industrial-scale wind turbines into quiet rural communities. The objective of this report is to explore the potential for effects of exposure to a new noise source on this specific and vulnerable population. There is a significant research gap regarding the impact of the introduction of industrial-scale power generation from wind into rural communities and on children with ASD. The additional noise and low-frequency sound produced by the wind turbines may add to the burden of environmental noise that the ASD population is already coping with, including exposures at home and at school. Front-line professionals such as educators and health care workers need to be aware of this possibility.

Keywords
noise, autism, low frequency noise, infrasound, hyper-reactivity, wind turbines, sleep disturbance, environmental noise, environmental health

Introduction

The Diagnostic and Statistical Manual of Mental Disorders published by the American Psychiatric Association (American Psychiatric Association, 2013) describes autism as a 'pervasive developmental disorder' and describes individuals with Autism Spectrum Disorders (ASD) as demonstrating a high sensitivity to changes in their environment. The exact physiological causes of autism are unknown, but researchers have recently observed subtle differences in certain areas of the brain in patients with ASD including mild brain enlargements, which appear to occur during early brain development (Minshew and Keller, 2010). These

changes affect the brain's limbic system, a complex set of brain structures that support a variety of functions.

Currently, approximately one in 160 persons is diagnosed as autistic (Kilee Patchell-Evans Autism Research Group). In Ontario, Canada, with a population of 13,505,900, there may be approximately 84,000 people affected in this province alone, of whom 14 % or 11,760 could be living in rural or small-town communities (Statistics Canada).

Noise

The words 'noise' and 'sound' are often used interchangeably, but this is incorrect: sound waves cause the ear drum to vibrate and are simply perceived, while 'noise' is perceived as sound that is unpleasant or annoying. The World Health Organization defines noise as 'unwanted sound' (Berglund, Lindvall and Schwela, 1999).

Noise can be sound that adds to or interferes with normal perception, such as the background of others' conversations in a crowd. Goines and Hagler (2007) suggest that unwanted noise is a form of environmental pollution: 'Noise pollution interferes with the ability to comprehend normal speech and may lead to a number of personal disabilities, handicaps, and behavioral changes.' Bronzaft (2002) notes that by defining noise as unwanted, uncontrollable, and unpredictable sound, researchers have produced a body of studies that suggest that noise can be hazardous to good health.

The World Health Organization (WHO) has noted the 'special vulnerability of children' to noise for two reasons: children lack the ability to identify dangerous levels of exposure, and their ability to control their environment is limited. Noting that the sources of noise are increasing in number in our environment, WHO is concerned about the effects from exposure to

noise, which can include direct effects such as ear and hearing damage, and indirect effects such as psychological and physiological effects (World Health Organization).

Others have noted concerns about children and exposure to noise, and also, the seriousness of the results of the exposure. Stansfeld and Matheson (2003) warned that '… there is a possible risk that exposure to an environmental stressor such as noise may have irreversible negative consequences for this group.'

The relationship between people with ASD and environmental stimuli such as noise

Hearing is a sensory and perceptual event. Once sound waves reach the ear drum, there is a complex process by which people process and interpret those sounds.

Hyper-acusis is defined as an unusual intolerance of ordinary environmental sounds (Stiegler and Davis, 2010). Between 1964 and 1994, the Autism Research Institute in San Diego, California collected histories on more than 17,000 children with autism; more than 40 percent contained parent reports of sound sensitivity (Rimland and Edelson, 1995, in Stiegler and Davis, 2010). This does not imply, however, that those with ASD possess extra-sensitive hearing ability. Rather, it may be that differences in reactions to sound in individuals with ASD are due to the abnormal neural connectivity in the brains of children with ASD (Shabha, 2006).

How this relationship may affect people with ASD

To illustrate the effect of the altered mechanism for processing sound, Shabha (2006) cites the case of 'Donna,' a young girl with ASD, and notes that 'although an individual may be able to see and hear perfectly well, their perception may be delayed and distorted; their sensory inputs are mixed; a color may trigger a taste or a smell; a sound may produce a picture.' Donna's

inability to select, sort and make meaning out of stimuli caused her to 'experience panic attacks in which her surroundings became a mess of confused color and noise.' The typical response to such over-stimulation ranges from avoidance behaviors such as covering the ears or eyes, to the compensating behaviors of unusual body movements or vocalizations, and also an apparent fixation on irrelevant but possibly comforting stimuli, and non-response to information that may be relevant to the task at hand.

Others propose that the neurophysiologic differences in ASD contribute to hyper-reactivity (Prizant and Meyer, 1993). This emotional response is known as phonophobia, an abnormally strong reaction of the autonomic and limbic system, without abnormally high activation of the auditory system by sound, resulting from enhanced connections between the auditory and limbic systems.

Potential effects of environmental noise for people with ASD

One result of environmental noise produced at night can be sleep disturbance (Babisch and Rokho, 2011). There is a growing body of research which indicates that children and adolescents with ASD already experience sleep problems at a higher rate than typically developing children (Malow, Marzec, McGrew et al., 2006; Cortesi, Gianotti, Ivanenko, et al., 2010). Several research teams conducted a study to corroborate parental reports with physiological evidence of poor sleep in children with ASD, and correlated this physical evidence with the reported incidence of affective or behaviour problems. Using information from scores on the Child Behavior Checklist, the researchers found that a significant number of the poor sleepers among those with ASD also had difficulties with attention, anxiety or depression, and aggression.

In a study of the effect of sleep disturbance on children, one group of researchers (Jan, Reiter, Martin et al., 2010) said that 'severe sleep disorders that last for years are common in children especially when they have neurodevelopmental disabilities. There is increasing evidence that chronic sleep loss can lead to neuronal and cognitive loss in children although this is generally unrecognized by the medical profession and the public.'

The introduction of a new noise source into the environment, such as that from industrial wind turbines, has resulted in complaints relating to sleep disruption. In an editorial in the *British Medical Journal*, Doctors Christopher Hanning and Alun Evans refer to findings showing that 'low-frequency noise is considerably more annoying than higher frequency noise…caus[ing] nausea, headaches, disturbed sleep and cognitive and psychological impairment' (Hanning and Evans, 2012). In a summary of English-language peer-reviewed literature related to audiology, (Punch, James, and Pabst, 2010) several authors created a concise yet comprehensive primer citing studies that identify common symptoms reported by those who live near turbines. These clinical studies have demonstrated an association between the vestibular system in the ear and its neural connections to brain nuclei involved with balance processing, sensory inflow, and fear and anxiety associations.

Of particular concern are the references to studies that identify sleep disturbance as the most prevalent symptom of vulnerability to low-frequency noise, such as is produced by industrial-scale wind turbines. Uninterrupted sleep is a key factor in the health of those with autism, and indeed in all persons (Hanning and Evans, 2012). The noise from industrial-scale wind turbines has been described as more annoying than transportation or industrial noises at comparable levels, measured in decibels (Pedersen and Nielsen, 1994). Punch et al. (2010) conclude in fact that 'there is increasingly clear evidence that audible and low-frequency

acoustic energy from these turbines is sufficiently intense to cause extreme annoyance and inability to sleep, or disturbed sleep.'

If a number of people with ASD are already dealing with internal anomalies in the neural connections and having problems sleeping, and if they are living, working or attending schools that are situated near wind turbines, it is possible that they will have an additional challenge in accomplishing routine activities.

Further research needed

In the articles reviewed for this paper, the suggestions for further research or review follow two themes. First, some authors call for a better understanding of the mechanisms by which people are affected by sound — not just loudness but also low-frequency vibration that can cause adverse health effects in those who may have slightly different mechanisms for processing this environmental element; in other words, those with ASD.

Second, there were concerns about the need for independent research into health effects on different population groups who may be living near sources of the noises present in the modern-day environment and, in this case, near turbines used for power generation from wind. While the wind power development lobby for a time completely denied the existence of low-frequency noise from the power facilities, the fact is there is sufficient research in the aviation and transportation industries not only to confirm the existence of infrasound but also to validate the concept that low-frequency sound and vibration can be damaging. Researchers on road traffic noise have commented that 'Infrasonic sound could travel long distances and penetrate openings in a dwelling occupied by humans and interrupt rest and sleep' (Ilgakojis, Jotautiene and Bazaras, 2005). They further made a connection between infrasound and wind turbines as a new

source of low frequency noise: 'The increased use of wind energy by windmills ... could increase the low frequency sound that could have a negative effect on the population' (Ilgakojis, Jotautiene, Merkevicius and Bazaras, 2005).

Salt and Hullar (2010) further concluded that, 'Based on our understanding of how low-frequency sound is processed in the ear, and on reports indicating that wind turbine noise causes greater annoyance than other sounds of similar level and affects the quality of life in sensitive individuals, there is an urgent need for more research directly addressing the physiologic consequences of long-term, low level infrasound exposures on humans.'

In their *British Medical Journal* editorial, Christopher Hanning and Alun Evans (2012) were quite specific when they identified the key players: 'When seeking to generate renewable energy through wind, governments must ensure that the public will not suffer harm from additional ambient noise.' They concluded that robust independent research into the health effects of existing wind farms is long overdue, as is an independent review of existing evidence and guidance on acceptable noise levels. Dr. Roy Jeffery, a Canadian family physician, notes further that with the proliferation of wind turbines, physicians will likely be presented with patients reporting health effects, and it will be important to identify the possibility of exposure to the noise and low-frequency noise as a common element (Jeffery, Krogh, and Horner, 2013).

The need for more research is confirmed by government sources. In Ontario, Canada, the panel members of the quasi-judicial tribunal hearing the public appeals of the approval of proposed wind power generation projects noted that, in their view, the evidence related to health effects stemming from the environmental noise and low-frequency noise produced by wind power generation machinery is currently at the 'hypothesis' stage. In *Erickson v. Director*,

Ontario Ministry of the Environment (2011), the panel ruled that 'the present situation is closer to the hypothesis generating phase of scientific research than it is to the point where conclusions can be made on causation' (*Erickson v. Director, Ontario Ministry of the Environment*, 2011). This legal opinion was repeated in a decision of the tribunal released in 2014 (*Bovaird v. Director, Ontario Ministry of the Environment,* 2014).

Conclusion

The World Health Organization advises it is important to 'understand, recognize and know' the effects of noise on health, particularly for vulnerable populations. It is critical therefore that, at a time when government policies are being developed regarding sources of renewable power generation, information is available on the health of vulnerable populations such as those with ASD who may be living near power plants which produce low-frequency sound and vibration. Such information will aid in the undertaking of studies to identify and measure noise levels in communities where wind turbines are planned or already situated, and also to help develop comprehensive siting guidelines for wind power projects to minimize the potentially adverse health effects of the noise and vibration they generate.

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