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Letter to the Editor: A critical analysis: Why "firm conclusions are not possible"☆, ☆☆

1. Background

Some people exposed to wind turbines (WT) experience negative health effects including sleep disturbance (Abbasi et al., 2015; Bakker et al., 2012; Inagaki and Nishi, 2015; Kageyama et al., 2016; Krogh et al., 2011; Onakpoya et al., 2015). Some exposed families have effectively abandoned their homes (Jeffery et al., 2014; The High Court, 2016), been billeted by wind energy developers or negotiated financial agreements with wind energy developers (Jeffery et al., 2014; Hansard, 2009).

Jalali et al. suggest self-reported sleep issues in the environs of industrial WTs may be associated with the indirect effects of visual and attitudinal cue and concern about property devaluation rather than distance to the nearest WTs or noise. These hypotheses are inconsistent with existing knowledge and appear to be founded on incomplete data.

Council of Canadian Academies, 2015 concluded that WT noise "... can cause annoyance". Annoyance is an acknowledged [redacted] effect (Berglund, 1999; Health Canada, 2005; Michaud et al., 2005; Møller and Pedersen, 2011; The Council of Canadian Academies, 2015). [redacted] Sleep interference is one of the stress symptoms associated with noise annoyance (Colby et al., 2009; HGC, 2010).

2. Acoustics

WT noise characteristics "... that are identified as plausible causes for reported health effects include amplitude modulation, audible low-frequency noise (LFN), infrasound, tonal noise, impulse noise and night-time noise." (Jeffery et al., 2014).

Jalali et al. does not present an analysis of these WT noise characteristics and their potential health impact. Instead, Jalali et al. presents selective noise measurements, stating "Associations between noise exposure and sleep parameters were not calculated, as only a small number of participants agreed to noise measurements in their bedrooms". (p. 404)

The relevance of the noise measurements presented in Jalali et al. is further diminished by methodological shortcomings. WT noise measurements and characteristics are affected by variables such as wind speed, direction and the power output of the WTs. Jalali et al. *Methods Part 2.2 Noise exposure assessments*, provide no indication the operational status of the WTs was considered. Apparent turbine power level is referenced as wind speed at 10 m height but critical information relating to kilowatt power output figures is not provided. Wind shear values are also not presented. Therefore, it is not known if the WTs were turned off, operating at full or partial power, ramping up and down, or idling during the taking of these noise measurements. To enhance the study design, Jalali et al. should have correlated their noise measurements with real time Supervisory Control and Data Acquisition data (SCADA, 2015) to determine the operational status of the WTs.

Study participants were asked about their sleep experiences of the past month. This timeline may be insufficient to capture chronic sleep disturbance due to variables such as wind speed, direction and WT power output.

Jalali et al.'s use of Leq did not account for indoor Lmax which could have assisted with assessing participant noise impacts. The World Health Organization indicates "LAmax are useful to predict short-term or instantaneous health effects." It notes that using the indicator LAmax inside a residence, biological effects such as "EEG awakening" and "changes in duration of various stages of sleep, in sleep structure and fragmentation of sleep" at a threshold of 35 dB as well as "motility, onset of motility" at a threshold of 32 dB occur (World Health Organization, 2009). The threshold of 30–32 dBA is consistent an Ontario field officer recommendation (Ministry of Environment, Memorandum, 2010). Recent testing in Vermont reported outdoor-indoor noise level reduction of 1–3 dBA, providing further support for stricter outdoor limits (Vermont, 2015).

Jalali et al. present averaged Leq (dBA) levels indoors, being time weighted to 1 h, which are skewed by intermittent peaks contrasted from lower background levels. Consideration of the acoustic time history and peak-to-background decibel ratios would have assisted with assessing time-localized impacts on sleep from noise peaks.

The Jalali et al. use of dBA filters out low-frequency noise and is unsuited as a stand-alone metric for low-frequency noise annoyance and sleep disturbance assessments (Kelley, 1987; DeGagne, 2012). Investigation of low-frequency noise using time history, dBC-dBA and spectral analysis could assist with the assessment of time-localized impacts on sleep from low-frequency noise spectra and amplitude modulations.

☆ Regarding: Jalali et al. (2016) The Impact of psychological factors on self-reported sleep disturbance among people living in the vicinity of wind turbines published in Environmental Research 148 (2016) 401–410.

☆☆ As published researchers on the topic of industrial wind turbines (WT) and adverse health effects, we read with interest the article by Jalali et al. This Letter presents critical analysis of some of Jalali et al. methodologies and findings.

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3. Study design and epidemiology

Jalali et al. disclose that the research is supported by the Ontario Research Chair in Renewable Energy Technologies and Health (Research Chair). In 2010, the Government of Ontario through the Ministry of Environment (MOE) created and funded the Research Chair (The Council of Ontario Universities, 2010).

The Government of Ontario is a proponent of wind energy development in Ontario (Green Energy Act, 2009). Government representatives have expressed the views some people do not like the look of WTs and/or WT concerns are "nimbyism" (The Canadian Press, 2009; Schliesmann, 2010) or argued that some people are made sick because WTs on the land reduce property values (Erickson v Ministry of Environment, 2011).

Jalali et al. conclude that "Results of the analysis show that participants reported poorer sleep quality if they had a negative attitude to WTs, concerns related to property devaluation, and if they could see turbines from their properties." This finding appears to bias in support of property value and visual hypotheses proposed by representatives of the Research Chair creator and funder, MOE.

Jalali et al. reports a sample size of 37 and a response rate of 30%. It is plausible that public awareness of MOE's views on WT health concerns and connection to the Research Chair may have contributed to a low participation rate by adversely affected individuals resulting in participation bias.

Jalali et al. elected to assess distance to nearest WT as a dichotomous, rather than a continuous variable. Dichotomization of continuous variables has been "rarely considered defensible" (MacCallum et al., 2002). This approach, coupled with the small sample size of 37, limits the ability to statistically assess the relationships between distance to WT and the three sleep outcomes. This is concerning given Jalali et al. Table 3 demonstrates differences in sleep quality between T1 and T2; with sleep quality deteriorating for both groups (< 1000 m and > 1000 m) across all three sleep quality outcomes (PSQI, ESS, ISI).

The small sample size likely contributed to large parameter standard deviations (as demonstrated in Table 3) and the inability for the authors to perform standard multivariate analysis. This makes it difficult to identify statistical significance at a P-value of 0.05 if differences exist (i.e. favouring the null). It is impossible to assess potential relationships (cofounding and interactions) among the various exposure variables (i.e. the relationship between attitude and distance to WT).

Jalali et al. is defined as a "prospective cohort … epidemiological study … undertaken to explore the possibility of sleep disturbance and the role of psychological factors in self-reported sleep disruption in people living within close proximity of WT in a pre- and post-study design." (p. 402)

Jalali et al. reported that sleep was disturbed by exposure to WTs noting this is consistent with other studies. Based on their analysis they suggest, poorer sleep quality occurred if study participants had a negative attitude to WTs.

The finding that sleep issues appear to be related to negative attitude is not consistent with other published research. Residents who initially welcomed WTs have also reported sleep or other health effects after exposure (Krogh, 2011; Shepherd et al., 2011; Nissenbaum et al., 2012). Attitudes to WTs may be positive pre-WT (Turkel, 2010) but change in a post-WT environment (State of Maine Superior Court, 2014).

Jalali et al. present data collected on the primary independent variable of discussion i.e., attitude, only at T2, after WT became operational. Consequently it is more correct to characterize this study for certain exposures of interest as a cross-sectional study, not as a prospective cohort. The absence of pre-WT attitude data, provides little support for the contention that attitude caused sleep disturbance. A prospective study should have captured attitude-related questions before WT exposure (T1).

Jalali et al. does not appear to evaluate whether sleep disturbance itself may be the cause of the subjective factors relating to negative attitude. The absence of pre-WT attitude measurements precludes whether sleep disturbance caused the negative attitude. Assumptions that attitudes at T2 were the same as attitudes at T1 could be misleading to readers.

4. Conclusion

Based on current knowledge, the sound from wind turbines at the levels experienced at typical distances in Ontario, is expected to result in a non-trivial percentage of persons being highly annoyed and contribute to stress related [redacted] impacts (HGC, 2010). Conversely, Jalali et al. appear to bias in support of hypotheses expressed by government authorities by suggesting sleep issues may be associated with indirect effects of visual and attitudinal cue and concern about property devaluation rather than distance to the nearest WTs or noise. Jalali et al. fails to present convincing data in support of their findings.

This letter proposes alternative acoustic and epidemiological methodologies with the intention of informing more meaningful investigation of WT [redacted] complaints. While our response critiques methodologies and hypothesis presented in Jalali et al. we do concur with its authors: "firm conclusions are not possible".

Declaration of interest

Aramini and Krogh and Rand and Krogh are co-authors of peer reviewed publications. We have no actual or potential conflict of interest including financial, personal or other relationships with other people or organizations within 3 years of beginning the submitted work that could inappropriately influence or be perceived to influence our work.

Submission declaration

We declare that each author contributed equally to this submission and confirm: "All of the authors have read and approved the Letter to the Editor and it has not been published previously nor is it being considered by any other peer-reviewed journal." If accepted, we would not seek to have it published elsewhere.

We declare this research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Dr. Jeffery Aramini is a qualified expert epidemiologist with knowledge of public health, statistics, and statistical analysis, has testified during several Ontario, Canada Environmental Review Tribunals and is published on the topic of IWT and health.

Dr. Jeffery Aramini (Scientific Advisor) and Carmen M. Krogh (Member of the Board) are associated with the Society for Wind Vigilance, a not-for-profit organization. Scientific Advisors and Members of the Board participate on a voluntary basis, as independent researchers, and receive no compensation for their participation with the Society. The Society's Objects are acknowledged in the following articles published in several medical journals.

Robert Y McMurtry and Carmen ME Krogh, Diagnostic criteria for adverse health effects in the environs of wind turbines. JRSM Open 2014 5:1-5 The online version of this article can be found at: DOI: 10.1177/2054270414554048
PMID: 25383200 [PubMed] PMCID: PMC4221978 http://www.ncbi.nlm.nih.gov/pubmed/?term=Diagnostic+criteria+for+adverse+health+effects+in+the+environs+of+wind+turbines

Roy D. Jeffery MD FCFP, Carmen Krogh, Brett Horner CMA, Adverse health effects of industrial wind turbines, Letter to editor, Can Fam Physician. 2013 Sep;59(9):921, 923-5 http://www.ncbi.nlm.nih.gov/pmc/articles/PMC3771715/ PMCID: PMC3771715

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