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Wind turbines and idiopathic symptoms: The confounding effect of concurrent environmental exposures

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ABSTRACT

Whether or not wind turbines pose a risk to human health is a matter of heated debate. Personal reactions to other environmental exposures occurring in the same settings as wind turbines may be responsible of the reported symptoms. However, these have not been accounted for in previous studies. We investigated whether there is an association between residential proximity to wind turbines and idiopathic symptoms, after controlling for personal reactions to other environmental co-exposures. We assessed wind turbine exposures in 454 residences as the distance to the closest wind turbine (D_w) and number of wind turbines <1000 m (N_{w1000}). Information on symptoms, demographics and personal reactions to exposures was obtained by a blind questionnaire. We identified confounders using confounders' selection criteria and used adjusted logistic regression models to estimate associations. When controlling only for socio-demographic characteristics, $\log_{10}D_w$ was associated with "unnatural fatigue" ($OR_{adj} = 0.38$, 95%CI = 0.15–1.00) and "difficulty concentrating" ($OR_{adj} = 0.26$, 95%CI = 0.08–0.83) and N_{w1000} was associated with "unnatural fatigue" ($OR_{adj} = 1.35$, 95%CI = 1.07–1.70) and "headache" ($OR_{adj} = 1.26$, 95%CI = 1.00–1.58). After controlling for personal reactions to noise from sources different from wind turbines and agricultural odor exposure, we did not observe a significant relationship between residential proximity to wind turbines and symptoms and the parameter estimates were attenuated toward zero. Wind turbines-health associations can be confounded by personal reactions to other environmental co-exposures. Isolated associations reported in the literature may be due to confounding bias.

1. Introduction

Wind energy is the fastest-growing source of electricity in the world. It is considered a good alternative to fossil fuel-generated electricity and for that reason it has become a preferred option of renewable energy for many planners and governments. In Denmark, the world leader in total wind capacity per capita, wind power provided a record of 39.1% of Denmark's electricity consumption in 2014. The global benefits of wind energy in terms of reduced emissions of air pollutants are often emphasized, while local considerations receive relatively less attention. However, in recent decades, there has been a growing public interest on how features of modern life may pose threats to personal health, and wind energy is not an exception. Concerns have been raised about the potential health effects of living close to wind turbines and as a result, epidemiological studies have been carried out to elucidate the health implications of wind industry.

However, whether or not there is a relationship between residential proximity to wind turbines and health is still a matter of debate. Population studies have not found consistent evidence indicating that exposure to wind turbines audible and inaudible noise has a direct effect on human physiological health (Pedersen et al., 2009; Van den Berg et al., 2008; Knopper et al., 2014). However, literature has also developed to suggest that there is a connection between wind turbines and health (Havas and Colling, 2011; Salt and Kaltenbach, 2011; Hanning and Evans, 2012a; Bakker et al., 2012; Kuwano et al., 2014), Symptoms reported by people who live in close proximity to wind turbines have been idiopathic symptoms, such as sleep disturbance, fatigue, nausea, dizziness, headache, and lack of concentration, as well as annoyance (Chapman et al., 2013; Shepherd et al., 2011; McCallum et al., 2014; Kuwano et al., 2014; Pawlaczyk-Łuszczyńska et al., 2014). Pedersen (2011) reviewed the results of three cross-sectional studies (Pedersen and Persson-Waye, 2004, 2007; Pedersen et al., 2009), and found that annoyance was consistently directly associated with A-weighted sound pressure levels, but no other variable measuring health or well-being (e.g. headache, tiredness, sleep disturbance) was consistently related to sound pressure levels throughout the three studies.

One of the main methodological limitations of current studies on wind turbines and health associations is the poor control for potential confounders. Adjustment for confounding variables is a key step to obtain an unbiased estimate of the relationship between exposure and

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outcome in observational studies. Basic demographical features (such as age and gender) have been adjusted for in the analyses (Pedersen, 2011), but other possibly confounding factors have not been consistently controlled. Exposure to other environmental stressors occurring in the same settings as wind turbines may act as confounders and play an important role in physical symptom reporting. On-shore wind turbines are mainly placed in rural settings, and typical land use of rural areas are farming activities, which can be a source of offensive odors (Blanes-Vidal et al., 2009). Previous studies have demonstrated the relationship between agricultural odor annoyance and symptoms (Blanes-Vidal et al., 2014; Blanes-Vidal, 2015). In addition, due to the rural context with low background noise and the specific type of transport (e.g. heavy truck loads, agricultural tractors), people in rural areas can experience significant exposure to road noise. Road noise annoyance has also been related with non-specific symptoms (Héritier et al., 2014). Despite these indications that negative reactions to odor and non-wind turbine noise may be important confounders, to date no study on the association between wind turbines and health has controlled for these other environmental factors.

In this study, we explored the associations between residential proximity to wind turbines and idiopathic symptoms, and investigated whether these relationships can be confounded by personal reactions to other environmental exposures occurring in the same settings as wind turbines.

2. Materials and methods

2.1. Data collection on demographics, potential confounders and symptoms

A cross-sectional, population-based study was conducted in six 12 km × 12 km non-urban regions distributed throughout Denmark (Blanes-Vidal et al., 2014). A total of 1120 households within the six study areas were randomly selected and a structured questionnaire was mailed from October 2011 to February 2012. The sample selection bias was minimized by approaching the residents randomly, irrespective of whether they lived in close proximity to wind turbines or not. The questionnaire was based on a standard questionnaire on indoor climate (Brauer et al., 2000), which includes items concerning symptoms, perceived environment and personal characteristics. Some supplementary questions were included, and the final questionnaire was the same as the one used in previous studies (Blanes-Vidal et al., 2012, 2014). Adults (>18 years old) living at the household (1 adult/household) were requested to fill and return the anonymous questionnaire. Research was conducted in accordance with principles of the Declaration of Helsinki and approved by the Danish Data Protection Agency (Datatilsynet).

To minimize self-selection bias, the intent of the study was fully masked by: (1) introducing the study as a study on living conditions in rural areas, (2) including questions about different environmental factors (i.e. odor, noise, dust and smoke) and symptoms that are in principle not related with wind turbines exposures (e.g. running nose), (3) mentioning multiple potential sources of annoyance different from wind turbines (i.e. traffic, factories, farms, fertilizer spreading) and (4) not mentioning the word "wind" and any of its forms (e.g. "wind turbine", "wind power", "wind energy", "wind tower") at any time in the survey.

The first part of the structured questionnaire included general socio-demographic and lifestyle data and an open-ended question whereby participants listed, according to their own experience, the main advantages and disadvantages of living in the countryside. The second part referred to environmental stressors, i.e. annoyance, health risk perception and behavioural interference experienced during the years 2010 and 2011 due to environmental odor, noise, dust and smoke. Questions regarding annoyance included: degree of perceived annoyance (estimated using the 5-point verbal annoyance scale, i.e. "0 = not annoyed", "1 = slightly annoyed", "2 = moderately annoyed", "3 = very annoyed" and "4 = extremely annoyed") and origin (i.e., traffic, factory, farm, fertilizer spreading, unknown, or others). The specific questions (translated from Danish) were: "Have you, within the past two years, been annoyed by noise, odor, particulates or smoke in your home (inside or near)?" and "What was their origin?". Concerns about the adverse health impacts of these four environmental stressors at their residences were evaluated using a verbal scale (0 = not concerned; 1 = slightly concerned; 2 = very concerned). The specific question (translated from Danish) was: "Are you worried that some of the following conditions in your home can damage your health?". Finally, residents were asked whether the existence of each of these environmental stressors at their properties prevented them from properly ventilating their homes or from performing outdoor activities that they wished to (0 = no behavioural interference; 1 = behavioural interference). The specific question was "Are there circumstances that prevent you from airing enough out in the home or performing outdoor activities (e.g. BBQ) which you would like to?". The responses were: "Yes, outdoor noise", "Yes, outdoor odor", "Yes, outdoor dust", "Yes, outdoor smoke", "Yes, other factors (open response)" and "No".

The third part of the questionnaire referred to physical symptoms and health. Eleven symptoms were included: Five idiopathic symptoms that have been reported by residents who live in close proximity to wind turbines (i.e. dizziness, difficulty concentrating, headache, unnatural fatigue and nausea) and six irritation/respiratory symptoms that have been related to exposure to air pollutants (i.e. "itching, dryness or irritation of eyes", "itching, dryness or irritation of the nose", "runny nose", "cough", "chest wheezing or whistling" and "difficulty breathing"). Unnatural fatigue ("unaturlig træthed" in Danish) is the fatigue that has no apparent cause, which could also be translated into English as "abnormal fatigue" or "unexplained fatigue". The six irritation/respiratory symptoms were "dummy symptoms", since association between proximity to wind turbines and these symptoms is unlikely. Residents were asked to estimate the frequency of symptoms within the last two years on a 0–4 scale: 0 = Never/Very rarely; 1 = Several times per year; 2 = Several times per month; 3 = Several times per week; 4 = Daily. Self-reported information on physician-diagnosed medical conditions was categorized into: 1) acute respiratory conditions, 2) chronic respiratory conditions, and 3) other chronic diseases.

2.2. Wind turbine exposures

Information on the wind turbines was obtained from the Danish register of wind turbines, a national database that contains information on location, size and output for each Danish power producing wind turbine (Danish Energy Authority, 2010). In this study we considered wind turbines that were operative 12 months or more, during 2 years before the population survey was mailed. Overall there were 5122 active on- and offshore wind turbines in Denmark. Of these, about 4717 were onshore and about 405 were offshore. A total of 219 on-shore wind turbines were sited in the studied rural regions. In these regions farm-related activities are the predominant land use. Other typical uses include residential land use (i.e. scattered residential dwellings and clustered non-farm settlements) and industrial land use (mainly agricultural-related local industries); intermixed with major and local roads.

In our study we used residential proximity to the source as a surrogate of exposure to wind turbines. Residential proximity has also been used is previous studies investigating potential wind turbines-health associations (Nissenbaum et al., 2012). Each home address and each wind turbine was geo-coded, and separate exposure estimates were developed on the basis of the distance from each house to the closest wind turbine (D_w), the number of wind turbines within 1000 m around participants' home (N_{w1000}), and the number of wind turbines within 500 m (N_{w500}).