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Long-term exposure to wind turbine noise at night and risk for diabetes: A nationwide cohort study

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Highlights

- We investigated a cohort of 365,986 Danes living close to wind turbines (WT).
- We identified 25,148 cases of diabetes during the period 1996–2002.
- Long-term exposure to WT noise was not associated with increased risk of diabetes.
- Similar results were seen for indoor night-time noise and across a range of strata.
- Results do not support an association between wind turbine noise and diabetes.

Abstract

Focus on renewable energy sources and reduced unit costs has led to increased number of wind turbines (WTs). WT noise (WTN) is reported to be highly annoying at levels from 30 to 35 dB and up, whereas for traffic noise people report to be highly annoyed from 40 to 45 dB and up. This has raised concerns as to whether WTN may increase risk for major diseases, as exposure to traffic noise has consistently been associated with increased risk of cardiovascular disease and diabetes. We identified all Danish dwellings within a radius of 20 WT heights and 25% of all dwellings within 20–40 WT heights from a WT. Using detailed data on WT type and hourly wind data at each WT position and height, we estimated hourly outdoor and low frequency indoor WTN for all dwellings, aggregated as nighttime 1- and 5-year running means. Using nationwide registries, we identified a study population of 614,731 persons living in these dwellings in the period from 1996 to 2012, of whom 25,148 developed diabetes. Data were analysed using Poisson regression with adjustment for individual and area-levels covariates. We found no associations between long-term exposure to WTN during night and diabetes risk, with incidence rate ratios (IRRs) of 0.90 (95% confidence intervals (CI): 0.79–1.02) and 0.92 (95% CI: 0.68–1.24) for 5-year mean nighttime outdoor WTN of 36–42 and ≥ 42 dB, respectively, compared to < 24 dB. For 5-year mean nighttime indoor low frequency WTN of 10–15 and ≥ 15 dB we found IRRs of 0.90 (0.78–1.04) and 0.74 (95% CI: 0.41–1.34), respectively, when compared to and < 5 dB. The lack of association was consistent across strata of sex, distance to major road, validity of noise estimate and WT height. The present study does not support an association between nighttime WTN and higher risk of diabetes. However, there were only few cases in the highest exposure groups and findings need reproduction.

Introduction

Focus on renewable energy sources has increased globally during the last decades, which together with reduced costs has led to an increased number of wind turbines (WTs). WT noise (WTN) has consistently been associated with annoyance among people living by. Schmidt and Klokker (2014), Michaud et al. (2016a), Janssen et al. (2011), Michaud et al. (2016b). Also, reviews and meta-analyses have found WTN to be associated with self-reported disturbance of sleep, (Schmidt and Klokker, 2014, Onakpoya et al., 2015) although recent studies using objective measures of sleep have failed to find an association (Michaud et al., 2016; Jalali et al., 2016). This has raised concern as to whether WTN may increase risk for major diseases.

Recent studies have found exposure to road traffic and aircraft noise to be significantly associated with higher risk of diabetes, (Sorensen et al., 2013, Eze et al., 2017a, Clark et al., 2017) whereas no association was found for railway noise (Roswall et al., 2018). In support of this, traffic noise has been associated with major risk factors for diabetes, including fasting blood glucose, (Cai et al., 2017) glycosylated hemoglobin, (Eze et al., 2017b) obesity (Eriksson et al., 2014, Pyko et al., 2015, Pyko et al., 2017, Christensen et al., 2016) and physical inactivity (Roswall et al., 2017; Foraster et al., 2016). The believed pathophysiologic pathways behind noise as a metabolic risk factor are activation of a general stress response and disturbance of sleep, which may lead to reduced insulin secretion and sensitivity, reduced glucose tolerance and altered levels of appetite-regulating hormones (Spiegel et al., 2004; Taheri et al., 2004; Mazziotti et al., 2011; McHill and Wright, 2017). Also, reduced sleep quality and quantity have both consistently been shown to increase risk of diabetes (Cappuccio et al., 2010).

Findings on traffic noise and diabetes are not readily applicable to WTN. Levels of WTN are generally much lower than noise from traffic in urban settings. However, WTN has been associated with a higher proportion of annoyed residents than traffic noise at comparable sound levels (Janssen et al., 2011). While people start reporting WTN to be highly annoying at levels from 30 to 35 dB and up, traffic noise is generally not reported as highly annoying at levels below 40–45 dB (Michaud et al., 2016). A potential explanation is that WTN depends on wind speed and direction making it less predictable than traffic noise, where the latter e.g. often abates at night. Also, amplitude modulation may give WTN a rhythmic quality different from e.g. road traffic noise. It has therefore been suggested that the characteristics of WTN relevant for annoyance may be better captured by metrics focusing on amplitude modulation or low frequency (LF) noise, rather than the full spectrum A-weighted noise as typically used in studies of traffic noise (Jeffery et al., 2014). A review from 2016 on LF noise (from various sources) indicated that LF noise was associated with annoyance and potentially sleep disturbance, although it was added that research in this area was scarce and with methodological short-comings (Baliatsas et al., 2016). Lastly, WTs are often placed in rural areas, where the auditory impact of WTs may be more pronounced as compared to more densely populated areas, due to less background noise from traffic, industry and others.

Two studies have investigated associations between WTN and self-reported diabetes: (Michaud et al., 2016a, Pedersen, 2011) A Canadian study of 1238 participants living within 12 km of a WT, among whom 113 reported to have diabetes, found no associations between estimated A-weighted residential WTN and prevalent diabetes (Michaud et al., 2016a). In the second study, results from two Swedish and one Dutch study population(s) were presented. In one of the Swedish study populations (N = 744), A-weighted residential WTN was associated with an odds ratio (OR) for prevalent diabetes of 1.13 (95% confidence intervals (CI) 1.00–1.27) in analyses adjusted for age and sex. However, no association was seen for the other two study populations (N = 1011, ORs of 0.96 and 1.00) (Pedersen, 2011). Both of these studies were cross-sectional, which prevent conclusions on causality and chronological order of events, and with risk of selection and recall bias. No prospective studies have investigated associations between WTN and diabetes.

We aimed to prospectively investigate associations between long-term residential exposure to WTN and risk for diabetes in a nationwide register based study, combining data on WTN, meteorology, WT position and type, residential addresses, development of disease and socioeconomic indicators over the period 1996–2012.

Section snippets

Study base and estimation of noise

The study was based on the entire Danish population, where all citizens since 1968 can be tracked in and across all Danish health and administrative registers by means of a personal identification number (PIN) maintained by the Central Population Register (Schmidt et al., 2014).

We identified all WTs (7860) in operation in Denmark any time between 1980 and 2012 from the administrative Master Data Register of Wind Turbines maintained by the Danish Energy Agency. It is mandatory for all WT owners …

Results

We identified 735,384 adults (age 25–84 years) living ≥ one year in the inclusion dwellings. We excluded persons who had emigrated (n = 40,190; 5.5%) or been recorded as disappeared (n = 1475; 0.2%) prior to entry, who had unknown address for eight or more consecutive days in the five years prior to entry (n = 57,668; 7.8%), who lived in hospitals or institutions at study start of follow-up (n = 1599; 0.2%) or who had diabetes before start of follow-up (n = 19.721; 2.7%). The final study …

Discussion and conclusion

We did not find long-term nighttime exposure to outdoor or indoor LF WTN to be associated with increased risk of diabetes in a large prospective study based on the full Danish population ever exposed to WTN. The lack of association between WTN and diabetes was consistent across various strata, including sex, distance to a major road, validity of the noise estimate and total height of the nearest WT.

A major strength of the present study is the prospective nationwide design with information on …

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Source of funding

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Diabetes Care (2010)

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2022, Renewable and Sustainable Energy Reviews

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A sustainable way forward for wind power: Assessing turbines' environmental impacts using a holistic GIS analysis
2020, Applied Energy

> *Citation Excerpt :*

…Nocturnal turbine noise emissions can definitely affect neighboring residents' sleep quality [9,10,55]. In the literature there is no certain confirmation of adverse health impacts from WT noise, aside from sleep disturbances which are attributed to annoyance [10,56,57,58,59]. Studies show that annoyance statements are frequently influenced by the planning process and public participation [18]….

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Monitoring annoyance and stress effects of wind turbines on nearby residents: A comparison of U.S. and European samples

2019, Environment International

Citation Excerpt :

…Additionally, most WT also have lighting in the form of aircraft obstruction markings. These emissions have impacts on people living nearby (e.g., Michaud et al., 2016a, 2016b, 2016c; Pedersen et al., 2009; Poulsen et al., 2018a, 2018b; Pohl et al., 1999, 2012, 2018; Rudolph et al., 2017). To analyze and monitor WT impacts, reliable and valid indicators are required.…

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