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ORIGINAL ARTICLE

Influence of distances between places of residence and wind farms on the quality of life in nearby areas

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Abstract

Background: The quality of life has three main characteristics: it always refers to the living conditions of an individual; it is measured both with subjective and objective indicators; and it is a multidimensional concept.

Aim of the study: To assess how the quality of life is affected by the close proximity of wind farms.

Material and methods. The study group consisted of 1,277 Polish adults (703 women and 574 men), living in places located near wind farms. The mean age was 45.5 ± 16.10. Some 33.2% of participants lived more than 1,500 m from wind farms; 17% – below 700 m. The research tool consisted of the Norwegian version of the SF-36 General Health Questionnaire, the Visual Analogue Scale (VAS) for health assessment, and original questions.

Results: Regardless of the distance between a place of residence and a wind farm, the highest quality of life was noted within the physical functioning subscale (mean 76±27.97), and the lowest within the general health (mean 55.3±24.06). Within all scales, the quality of life was assessed highest by residents of areas located closest to wind farms, and the lowest by those living more than 1,500 m from wind farms.

Conclusions: Close proximity of wind farms does not result in the worsening of the quality of life. Similar research should be conducted before any intended investment, and at least 6 months after construction of a wind farm.

Key words

quality of life, SF-36 scale, wind farm, VAS

INTRODUCTION

Provided that the present rate of electricity consumption remains unchanged, the world coal reserves should be enough for 200 years, natural gas for 60 years and petroleum for 40 years, as predicted by the World Energy Council [1]. This situation is caused by the growth of the world population and, consequently, higher electricity consumption. Implementation of new technologies capable of generating electricity guarantees that more energy will be acquired from renewable resources, such as the wind. As a member country of EU, Poland declared that by the year 2020, 20% of energy will be produced from renewable sources. The production of electricity from wind involves new technologies and changes to the living environment. The fear of new technologies often results in local protest. According to Lazarus, stress is caused by external stimulants, and various types of threat are its essence. He defines stress as a certain type of reaction between individuals and their environment, the reaction which they consider as overstraining or exceeding their coping abilities, and threatening their interests [2]. Whether the relationship between an individual and his/her environment takes on the nature of stress, depends on a cognitive assessment. If people spread myths and stereotypes about the negative effects of wind turbines on their health and functioning in everyday life, then they will perceive new investments as a risk. This may create a chain of factors contributing to a subjective feeling that the quality of life (QoL) is getting worse [3].

Quality of life depends on many factors, such as financial situation, satisfaction with work, family life, and changes in the local environment. It was assumed in this study that this aspect of human life is particularly important [4, 5]. Quality of life is a broad term. According to Fahey et al. it has three main characteristics: it always refers to the living conditions of an individual; it is measured both with subjective and objective indicators, and it is a multidimensional concept [5, 6, 7, 8, 9]. Methods of health assessment in residents living near new investments include quality-of-life research. In accordance with the recommendations of the Health Impact Assessment (HIA), plans for such research should be incorporated into investment projects for the wind power industry. Identification and description of the type and extent of possible effects (both positive and negative) on health, is a typical stage of assessment by the HIA [10, 11, 12].

Aim of the study. To recognize the effects of wind farms on the quality of life in nearby areas. A determinant taken into consideration was the distance between a house and a wind farm, and the accepted limits were: below 700 m, from 700-1,000 m, from 1,000-1500 m, more than 1,500 m distant. To date, Polish law has not clearly defined the lower distance limit between wind farms and dwelling houses; nevertheless, it is good practice to keep a distance of at least 700 m.

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METHODS

Subjects. The study was performed in the year 2010 on a group of 1,277 adults from areas situated near wind farms. The study group members were randomly chosen using a two-stage sampling technique. The participants for the study came from the places with the biggest number of wind farms in the area of northern Poland (34), the Mazurian, Greater Poland and Lower Silesian Provinces (12), Podlaskie Province (11) and Sub-Carpathian Province (9) [13]. The research protocol was approved by the Bioethics Commission of the Pomeranian Medical University in Szczecin [KB-0012/83/10]. All participants gave their conscious consent for the study.

Measurement of health-related quality of life. The research tool consisted of the Norwegian version of the SF-36 General Health Questionnaire, the Visual Analogue Scale (VAS) for health assessment, and original questions about approximate distance between a house and a wind farm, age, gender, education, and professional activity. Permission was obtained obtained from Quality Metric Inc., for using the authorized SF-36 Polish Version.

The SF-36 (Short Form-36) Questionnaire consists of 36 questions divided into 8 subscales: physical functioning (PF), role functioning-physical (RP), bodily pain (BP), general health (GH), vitality (V), social functioning (SF), role-functioning emotional (RE), mental health (MH), and one additional question concerning health change [14, 15, 16]. The score on the Likert scale for each of these areas varies from 0-100, with 0 denoting the worst and 100 the best possible state of health. Conducting research using the SF-36 is not time-consuming, and its repeatability, usefulness, and the ability to reveal changes in the quality of life was demonstrated [17].

Statistical analysis. Statistical analysis was performed using Statistica 5.0. The accepted significance level was $p<0.05$. Mainly mean scores and standard deviation were presented. The Kruskal Wallis test was used to analyse the relationship between two variables. The reliability of the quality of life assessment according to particular scales was measured with Cronbach's alpha coefficient. The hypothesis about the influence of the distance between a place of residence and a wind farm on the quality of life was verified using the analysis of variance (ANOVA). Each quality of life area was analysed separately. The statistically significant results in the analysis of variance were analysed *post hoc* with the Tukey test for unequal group sizes in order to check how the quality of life assessment differed between the groups of respondents, depending on the distance between a place of residence and a wind farm.

RESULTS

Participants' profiles. The mean age of the 1,277 respondents (703 women and 574 men) was 45.54±16.1 years (18-94 years). Education: higher – 139 (10.9%), secondary – 397 (31%), vocational – 400 (31.3%) and primary – 332 (26%). Professional status: employed – 551 (43.2%), old age pensioners – 268 (21%), unemployed – 239 (19%), those working on a farm only – 108 (8.5%), students – 107 (8.4%).

424 (33.2%) respondents lived at a distance of more than 1,500 m from wind farms, 221 (17.3%) from 1,000-1,500 m, 279 (21.9%) from 700-1,000 m, and 220 (17.2%) below 700 m. About 85 (6.7%) respondents knew nothing about the plans for building a wind farm in their neighbourhood.

Quality of life of people living near wind farms. The respondents assessed their health through answering questions included in SF-36 and VAS. They were asked to mark the point corresponding with their well-being on the level from 0-100, where 0 denoted the worst possible state of health, and 100 – excellent health. Next, it was checked whether there was a correlation between such health assessments, SF-36 general health (GH) score and answers to the following questions in SF-36:

- Q 1 in SF-36: Generally, do you think that your health is: excellent, very good, good, average, bad.
- Q 2 in SF-36: How would you assess your health now compared to your health three months ago: much better than three months ago, slightly better than three months ago, rather the same, slightly worse than three months ago, much worse than three months ago. This question had not been previously analysed because it is not included in any scale, and thus it is suggested that it should be analysed separately.

Health assessments according to VAS correlated significantly with SF-36 general health (GH) scores and answers to questions 1 and 2 from this questionnaire (all $p < 0.05$).

The correlation between health assessment according to VAS, the GH subscale and the first question (Q 1) in SF-36, suggests that the higher scores in VAS corresponded with the higher scores in the GH subscale and answers to the first question (Q 1) in SF-36.

People living near wind farms rated their quality of life highest within the physical functioning (PF) subscale (Tab. 1).

Table 1. The quality of the respondents' lives in the SF-36 eight subscales

	N	Mean	CI-95%	CI+95%	Range min.-max.	SD
PF	1277	**76.05**	74.51	77.58	0-100	**27.97**
RP	1276	59.83	57.67	61.98	0-100	39.29
BP	1277	63.66	61.89	65.43	0-100	32.22
GH	1277	55.28	53.96	56.61	0-100	24.06
V	1277	58.23	56.90	59.55	0-100	24.14
SF	1277	58.74	56.75	60.74	0-100	36.30
RE	1276	62.73	60.51	64.94	0-100	40.36
MH	1276	60.13	58.87	61.40	0-100	23.05

PF – physical functioning; RP – role-physical; BP – bodily pain; GH – general health; V – vitality; SF – social functioning; RE – role-functioning emotional; MH – mental health.

The physical functioning scores of particular respondents differed from the average value by about ±27.97. The average general health (GH) score was the lowest of all analysed subscales (Fig. 1).

The reliability analysis of the quality of life assessment within particular subscales is illustrated in Table 2.

The obtained results suggest a high internal consistency of the 5 scales: PF, RP, BP and RE (a from 0.82-0.94, depending on the scale), and slightly lower consistency of the other scales, but in no case was a is lower than 0.70. Cronbach's

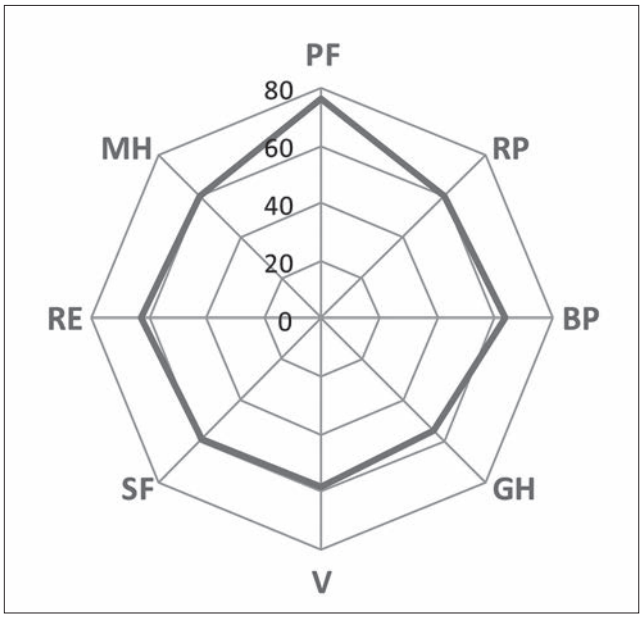

Figure 1. The quality of life in the neighbourhood of wind farms.
PF – physical functioning, RP – role-physical, BP – bodily pain, GH – general health, V – vitality, SF – social functioning, RE – role-functioning emotional, MH – mental health

Table 2. The reliability analysis of the SF-36 internal consistency

Subscale	Cronbach's alpha coefficient				
	X	SD	Cronbach's alpha coefficient	Standardized alpha	N
PF	768.411	278.446	**0.949**	0.950	1218
RP	240.880	156.690	0.870	0.870	1261
BP	127.347	64.461	**0.936**	0.939	1276
GH	276.239	120.377	0.766	0.770	1259
V	232.775	96.473	0.718	0.719	1247
SF	-	-	-	-	-
RE	188.569	120.771	0.861	0.861	1265
MH	300.689	115.536	0.774	0.768	1249

PF – physical functioning, RP – role-physical, BP – bodily pain, GH – general health, V – vitality, SF – social functioning, RE – role-functioning emotional, MH – mental health

alpha coefficient was not calculated for the SF questionnaire, which resulted from the fact that this is a one-question scale.

Correlation between QoL assessment and the distance from a place of residence to a wind farm. The quality of life scores were rated within each subscale depending on the distance between a house and a wind farm. The subscales with the lowest scores (1-4) obtained by at least 20% of the respondents were taken into consideration (Tab. 3). The scores lower or equal to 4 were most common within the general health (GH), both among women and men, irrespective of distances between their houses and wind turbines, and least common within the role functioning-emotional (RE).

Each quality of life area was evaluated separately using the analysis of variance (ANOVA). Analysis of the ANOVA for QoL assessment, with reference to the distance between a house and a wind farm, proved statistically significant differences in the QoL scores within the RP, MH and V subscales ($p<0.05$) (Tab. 4).

Table 3. The ranks of the quality of life self-assessment scores within particular subscales with reference to the distance between a place of living and a wind farm

Sub-scale	Number of people No %				
	Distance 1	Distance 2	Distance 3	Distance 4	Distance 5
PF	57 (25.91)	60 (21.51)	44 (19.91)	61 (14.39)	11 (12.94)
RP	75 (34.09)	122 (43.73)	88 (39.82)	182 (42.92)	44 (51.76)
BP	90 (40.91)	108 (38.71)	80 (36.20)	183 (43.16)	33 (38.82)
GH	**162 (73.64)**	**207 (74.19)**	**157 (71.04)**	**274 (64.62)**	**60 (70.59)**
V	138 (62.73)	168 (60.22)	138 (62.44)	256 (60.38)	49 (57.65)
SF	59 (26.82)	77 (27.60)	85 (38.46)	234 (55.19)	29 (34.12)
RE	70 (31.82)	107 (38.35)	82 (37.10)	149 (35.14)	47 (55.29)
MH	129 (58.64)	152 (54.48)	130 (58.82)	253 (59.67)	48 (56.47)

The distance between a house and a wind farm or the intended place of construction: *Distance 1: below 700 m, *Distance 2: 700-1000 m, *Distance 3: 1000-1500 m, *Distance 4: more than 1500 m, *Distance 5: knows nothing about the plans of wind farm construction

Table 4. The analysis of variance (ANOVA) for the quality of life scores within PF (physical functioning), MH (mental health) and V (vitality) subscales depending on distances between houses and wind farms

	SS	Df	MS	F	p
RP (role-physical)					
Absolute term	3366989	1	3366989	2216.793	0.0001
Distance	20889	4	5222	3.438	0.0083
Error	1857560	1223	1519		
MH (mental health)					
Absolute term	3488069	1	3488069	6801.397	0.0001
Distance	30079	4	7520	14.663	0.0001
Error	627211	1223	513		
V (vitality)					
Absolute term	3253875	1	3253875	5684.188	0.0001
Distance	12094	4	3023	5.282	0.0003
Error	700670	1224	572		

SS – sums of squares for the analysed effects and errors; df – degrees of intragroup freedom (concerning error) and intergroup freedom (concerning effect); MS – mean square effect and error; F – F-test for comparing variances; p – F-statistics probability value

Using the Tukey test for unequal group sizes, a *post-hoc* analysis was then performed to check which groups of respondents differed in the QoL scores within the RP, MH and V subscales, depending on distances from wind farms. The results of the Tukey test did not confirm significant differences in the QoL scores within the role functioning-physical (RP) subscale, depending on the distance from a wind farm (all $p>0.05$) for $\alpha = 0.05$. On the other hand, with $p=0.065$, people living more than 1,500 m from a wind farm assessed their QoL within the RP subscale significantly lower than those living the closest to a wind farm (up to 700 m). Analysis of the MH subscale gave similar results for the respondents living less than 700 m, and those living from 700-1000 m from a wind farm. There were no differences when $p=0.05$, but some differences were noted for $p=0.062$.

The Tukey test proved that people living more than 1,500 m from a wind farm assessed their vitality (V) significantly lower than those living in the closest distance from a wind farm ($p<0.05$). Within the mental health (MH) subscale,

the respondents living in the closest distance from a wind farm assessed their QoL significantly higher, compared to those living from 1,000-1,500 m or more from a wind farm (in both cases $p<0.05$).

It was found that the distance between a place of residence and a wind farm had an effect on the QoL score within the social functioning (SF) and the role functioning-emotional (RE) ($p<0.05$). Results of the multiple comparison test showed that people living within the distance of 1,000-1,500 m or more from a wind farm assessed their QoL significantly lower in SF than those living closer, and those who did not know about the plans for the construction of a wind farm (all $p<0.05$). Statistically significant differences in the QoL scores within other subscales ($p>0.05$) were not found between other groups of respondents with reference to the distance between a place of residence and a wind farm.

Influence of socio-demographic and health factors on quality of life. Regression analysis was also performed to estimate the parameters of a model describing the QoL perception, with reference to socio-demographic and health variables within particular subscales. The highest per cent of the respondents who learned, worked, or had farms, obtained the lowest scores within the GH, V and MH subscales. Statistically significant variables had only limited influence on how the respondents perceived their QoL. Therefore, it may be assumed that there are other factors having more profound effects on the analysed phenomenon.

DISCUSSION

This study presents pioneering research. So far, there have been few reports on the QoL and health self-assessment of people living near wind turbines [18]. Quality of life can be measured in many ways. Generally, objective and subjective indicators can be singled out; objective indicators include the living conditions of communities (e.g. degree of environmental pollution, new investments) and the living conditions of particular people (material, health, social factors), assessed according to commonly-accepted criteria: good-bad, desirable-undesirable, positive-negative.

In a subjective approach, which served as a basis for the presented research project, QoL is evaluated by means of subjective measures and individual criteria. It includes QoL assessments within SF-36 eight subscales. In the presented research, an attempt was made to analyse a possibly broad spectrum of factors contributing to the subjective QoL [17]. The aim was not only to show them with reference to socio-demographic differences, but rather to go deeply into their relationship with a place of residence near a wind farm as an objective indicator of living conditions. An answer was needed to the question whether the place of residence situated near a wind farm has an influence on how people perceive QoL. The obtained results show that people living in the closest neighbourhood of wind farms assessed their QoL higher than those living in more distant areas. A high quality of life and satisfaction with life are important criteria for psychosocial health [17, 19]. This may indicate the influence of other contributors, which were not taken into consideration during the analysis, namely, economic factors. While repeating this research, respondents should be asked about the possibility of employment in the wind energetics industry and the opportunity of proceeds from renting their land for wind farm construction.

CONCLUSIONS

The obtained data meet the criterion of reliability and make a good basis for further analysis and formulation of the conclusions about the influence of wind farms on human health. In the study group of 1,277 respondents, there were significant differences in average subjective scores within particular QoL subscales, which probably corresponded with the distribution of the importance degree ascribed to particular subscales by the respondents. It was observed that, regardless of the distance between a place of residence and a wind farm, the quality of life received the highest scores within the physical functioning (PF), and the lowest within the general health (GH). Therefore, it can be stated that a place of residence near wind turbines does not lower the quality of life.

Quality of life was best assessed within all subscales by the respondents living the closest to wind farms, while the worst by those living farther than 1,500 m from a wind farm, and those who did not know about the plans of for the construction of a wind farm in their neighbourhood. QoL was best assessed within the mental health subscale by the respondents living in the closest to a wind farm, and the lowest by those living farther than 1,500 m. Similar results were obtained within the general health (HP), social functioning (SF), and role-functioning emotional (RE) subscales. Residents of places located at a considerably distance from wind farms should be analysed with particular care in order to find out what factors, different from those taken into consideration in the study, affect the quality of their lives.

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