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Neurodegenerative disease and magnetic field exposure in UK electricity supply workers

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Neurodegenerative disease risks and magnetic field exposure in UK electricity supply workers.

Introduction 390 words
Methods 140 words
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Abstract

Objective- To investigate whether risks of Alzheimer's, motor neuron or Parkinson's disease are related to occupational exposure to magnetic fields.

Methods- The mortality experienced by a cohort of 73 051 employees of the former Central Electricity Generating Board of England and Wales was investigated for the period 1973-2010. All employees were hired in the period 1952-82, were employed for at least six months, and had some employment after 1st January, 1973. Detailed calculations had been performed by others to enable an assessment to be made of exposures to magnetic fields. Poisson regression was used to calculate relative risks (rate ratios) of developing any of the three diseases under investigation for categories of lifetime, distant (lagged) and recent (lugged) exposure.

Results- No statistically significant trends were shown for risks of any of these diseases to increase with estimates of lifetime, recent or distant exposure to magnetic fields.

Conclusions- There is no convincing evidence that UK electricity generation and transmission workers have suffered elevated risks from neurodegenerative diseases as a consequence of exposure to magnetic fields.

KEYWORDS: Alzheimer's disease, motor neuron disease, Parkinson's disease, electricity supply industry, cohort mortality study

Introduction

There have been many studies into exposure to extremely low-frequency electric and magnetic fields (ELF-EMF) and risks of neurodegenerative disease (NDD) and two meta-analyses are available for Alzheimers' disease (AD)[1-2]. Garcia and colleagues reported an increased risk of AD from ELF-EMF exposure based on pooled risk estimates from nine case-control studies (OR 2.03, 95% CI 1.38 to 3.00) and five cohort studies (RR 1.62, 95% CI 1.16 to 2.27)[1]. They also found considerable heterogeneity between study results and an indication of publication bias in the case-control studies. Various definitions of 'exposure' were used in the different studies and it was not possible to select a single 'main result' from each study in a standardised manner (these are limitations for all the meta-analyses under discussion). A more recent meta-analysis is also available [2]. Increased risks were shown for 36 risk estimates from thirteen case-control studies (RR1.29, 95% CI 1.11 to 1.50), and 15 risk estimates from six cohort studies (RR 1.39, 95% CI 1.10 to 1.75). In this meta-analysis, a study could contribute more than a single risk estimate.

Two meta-analyses are also available for motor neuron disease (MND) or its principal subtype amyotrophic lateral sclerosis (ALS). Zhou and colleagues reported significant increases in risk of ALS due to ELF-EMF exposure based on nine case-control studies (RR 1.39, 95% CI 1.05 to 1.84), but no significant increase in eight cohort studies (RR 1.16, 95% CI 0.80 to 1.69)[3]. Similar findings are shown in the meta-analysis from Vergera and colleagues [2]. There was a significant increased risk for MND/ALS based on 27 risk estimates from twelve case-control studies (RR 1.38, 95% CI 1.13 to 1.68),

but no significant increased risk from 23 risk estimates from nine cohort studies (RR 1.14, 95% CI 0.92 to 1.42).

If the above meta-analyses are taken at face value it would not be possible to exclude a possible role for ELF-EMF exposure on risks of NDD, but convincing evidence requires cohort studies that show statistically significant positive trends of disease risk with quantitative exposure estimates (there is no requirement for such dose-response effects to be monotonic). This paper seeks to obtain important new information on the topic of occupational magnetic field exposure and risks of mortality from NDD by examining data from an on-going, pseudonymised epidemiological study of UK electric utility workers. An earlier report considered follow-up to the end of 2004 [4]; a further six years of mortality data are now available.

Methods

The materials and methods have been summarised in an earlier companion paper on brain tumour risks [5]. The analysis reported here is based on the same cohort of 73 051 study subjects (62 825 men, 10 226 women) first employed in the period 1952-82 for whom a work history was available. The current paper, however, only considers death certificate data as there are no national registers for NDD and follow-up is censored at age 95 years (rather than 85 years in the earlier analysis [5]) because an important percentage of death certificates mentioning NDD occur after the age of 85 years. The survey was established with the approval of the Central Ethical Committee of the British Medical Association, and the author is currently accredited by the Health and Social Care Information Centre as the "Approved Researcher" of this cohort study.

Results

Relative risks (rate ratios) for AD (any mention on the death certificate: 170 cases in total) are shown in Table 1 for four categories of estimated cumulative occupational exposure to magnetic fields relative to the corresponding rates in the lowest (baseline) category of exposure (model 1). Corresponding relative risks are also shown for a simultaneous analysis of distant (lagged) and recent (lugged) exposures (model 2). Rate ratios in the left hand side of the Table were adjusted for age and sex. Rate ratios in the right hand side of the Table were additionally adjusted for calendar period, and socio-economic status (three categories: managers, scientists and engineers; administrative and clerical workers; industrial and construction workers). To be concrete, the Table summarises four separate analyses. None of the individual point estimates of risk are significantly different from unity and there is no suggestion that risks increase with exposure. Findings were little different with or without adjustment for calendar period and socio-economic status.

Findings for MND (86 cases) are shown in Table 2. There are no significant trends between disease risks and exposure but the point estimate of risk for the second exposure category is significantly elevated both for lifetime exposure and for exposures received more than ten years ago. Point estimates of risk for lifetime and distant exposures were greater than unity for all four higher exposure categories. Findings were little different with or without adjustment for calendar period and socio-economic status.

Findings for Parkinson's disease (PD)(278 cases) are shown in Table 3. There are no statistically significant positive trends of disease risk with exposure, but point estimates of risk are significantly raised for the third exposure category, both for lifetime exposures and for exposures received more than ten years ago. Point estimates of risk for lifetime and distant exposures were greater than or equal to unity for all four higher exposure categories. Findings were little different with or without adjustment for calendar period and socio-economic status.

The analyses summarised in Tables 1-3 were then repeated for the sub-cohort of those 48 768 employees first employed in power stations; these analyses were carried out because the exposure assessments for power station workers are more detailed than for other groups of workers. Relative risks (rate ratios) for AD (125 cases) are shown in Table 4. None of the individual point estimates of risk are significantly different from unity and there is no suggestion that risks increase with increasing exposure. Findings were little different with or without adjustment for calendar period and socio-economic status.

Findings for MND (68 cases) are shown in Table 5. There are no significant trends between disease risks and exposure but the point estimate of risk for the second exposure category is significantly elevated for lifetime exposure and approaches statistical significance for exposures received more than ten years ago. Point estimates of risk for lifetime and distant exposures were greater than unity for all four higher exposure categories. Findings were little different with or without adjustment for calendar period and socio-economic status.

Findings for PD (205 cases) are shown in Table 6. There are no statistically significant positive trends of disease risk with exposure, but point estimates of risk are significantly raised for the third exposure category, both for lifetime exposures and for exposures received more than ten years ago. Point estimates of risk for lifetime and distant exposures were greater than unity for three of the four higher exposure categories. Findings were little different with or without adjustment for calendar period and socio-economic status.

Discussion

This large cohort of UK electricity generation and transmission workers has found no significant positive trends between estimated exposures to magnetic fields and the risks of three neurodegenerative diseases (AD, MND and PD). This was the case for lifetime occupational exposures, distant (lagged) and recent (lugged) exposures. The findings are consistent with the hypotheses that both distant and recent magnetic field exposures are not causally related to MND or PD, and that distant magnetic field exposures are not causally related to AD. The study is uninformative about recent magnetic fields exposures and AD because most death certificates mentioning AD occur many years after retirement age (range 60-94 y). These summaries are not dependent on the selection of covariates in the analysis or on the selection of sub-cohorts for analysis (all employees or power station workers only).

The analysis has many strengths including the large size of the cohort, long period of

follow-up, large number of NDD cases available for analysis, and detailed exposure assessments that used the physics of exposure to magnetic fields as a starting point [6]. However, there are limitations to be attached to the work. It was necessary to assume that for those workers hired before 1973, job and place of work in the 1950s and 1960s were the same as those pursued in the early 1970s, and it was also assumed that working patterns (time spent by different groups of workers in different parts of power stations) are the same in different power stations. These assumptions will have introduced errors into the exposure assessments. We remain confident, however, that the exposure assessments have value particularly if we accept the relative rankings of the five exposure categories and do not attach overwhelming importance to the their absolute values. It must be the case, however, that the current exposure estimates fall short of an ideal survey that would include measured individual exposures over time. In addition, exposures were considered in relation to the date of death rather than the date of diagnosis, and there will have been diagnoses of NDD that do not appear on the death certificates. It is not possible on the basis of death certificate data to separate ALS from other types of MND.

This analysis was designed to carry out a minimum of multiple testing; there was one set of cut-off points for each of the three exposure metrics, and the principal test was a single test for trend across all exposure categories; there is, of course, no requirement for trends to be monotonic (risks in each exposure category greater than or equal to the risk in the preceding exposure category). One could only be confident of finding a monotonic trend in an infinitely large study with all relevant variables known with complete accuracy. These analyses do not consider the possible role of threshold effects (no effects at lower exposures) or saturation effects (same effects at moderate and

higher exposures) and it is possible that, in the course of time, physiological considerations might lead to very different exposures metrics being investigated. There were some positive findings for motor neuron disease and for Parkinson's disease, including significant findings for motor neuron disease at exposures of 2.5-4.9 μT year and for Parkinson's disease at exposures of 5.0-9.9 μT year; confident interpretation of these isolated findings is not possible, but emphasis on these findings would involve making unattractive post-hoc arguments. It would also be possible to combine the exposure categories to achieve either more positive or more negative results but the resulting p-values would be meaningless.

In conclusion, the current UK study does not provide convincing evidence that magnetic field exposures are a risk factor for NDD. .

data queries.

Conflicts of Interest

The author's University salary was defrayed, in part, by the research award from the Sponsor.

Key Messages

1. This large UK study has not found convincing evidence to support the hypothesis that exposure to magnetic fields is a risk factor for neurodegenerative diseases.

2. The findings are consistent with the hypotheses that both distant (in time) and lifetime magnetic field exposures are not causally related to neurodegenerative diseases.

3. Most deaths with Alzheimer's disease occurred well after retirement age and the study is not informative for the topic of recent exposures and Alzheimer's disease.

REFERENCES

1. Garcia AM, Sisternas A, Hoyos SP. Occupational exposure to extremely low frequency electric and magnetic field and Alzheimer disease: a meta-analysis. *Internal Journal of Epidemiology* 2008;**37**:329-340.

2. Vergara X, Kheifets L, Greenland S *et al*. Occupational exposure to extremely low-frequency magnetic fields and neurodegenerative disease: a meta-analysis. *Journal of Occ Env Med* 2013;**55**:135-146.

3. Zhou H, Chen G, Chen C *et al*. Association between extremely low-frequency electromagnetic field occupations and amyotrophic lateral sclerosis: a meta-analysis. *PLoS ONE* 2012;**7(11)**: e48354. doi:10.1371/journal.pone.0048354.

4. Sorahan T, Kheifets L. Mortality from Alzheimer's, motor neuron and Parkinson's disease in relation to magnetic field exposure: findings from the study of UK electricity generation and transmission workers, 1973-2004. *Occup Environ Med* 2007;64:820-826.

5. Sorahan T. Magnetic field exposures and brain tumour risks in electricity workers. *Occup Med* 2014. Doi:10.1093/occmed/kqu003.

6. Renew DC, Cook RF, Ball MC. A procedure for assessing occupational exposure to power frequency magnetic fields for electricity generation and transmission workers. *J Rad Prot* 2003;**23**:279-303.

Table 1. Relative risks of Alzheimer's disease[a] by levels of estimated cumulative magnetic field exposure (four separate analyses), total cohort under study (73 051 workers first employed in period 1952-82), 1973-2010.

Exposure to magnetic fields (μT year)[b]	N	RR[c]	(95 % CI)	RR[d]	(95% CI)
Model 1. Occupational cumulative lifetime exposure to magnetic field.					
0-	89	1.0		1.0	
2.5-	21	1.25	(0.77 to 2.02)	1.22	(0.75 to 2.00)
5.0-	23	0.83	(0.52 to 1.33)	0.81	(0.50 to 1.31)
10.0-	30	1.27	(0.82 to 1.95)	1.22	(0.78 to 1.90)
≥20.0	7	0.78	(0.36 to 1.71)	0.73	(0.33 to 1.61)
RR per 10 μT year[e]		0.98	(0.82 to 1.16)	0.96	(0.80 to 1.15)
Model 2. Occupational exposure to magnetic fields received more than ten years ago (lagged exposure)					
0-	89	1.0		1.0	
2.5-	21	1.25	(0.77 to 2.03)	1.20	(0.73 to 1.98)
5.0-	23	0.84	(0.52 to 1.37)	0.79	(0.48 to 1.30)
10.0-	30	1.30	(0.82 to 2.05)	1.19	(0.74 to 1.90)
≥20.0	7	0.81	(0.37 to 1.81)	0.72	(0.32 to 1.61)
RR per 10 μT year[f]		0.99	(0.83 to 1.18)	0.96	(0.80 to 1.15)
Occupational exposure to magnetic fields received less than ten years ago (lugged exposure)					
Zero	145	1.0			
0.01-	24	0.98	(0.61 to 1.58)	1.12	(0.69 to 1.82)
0.5-	0				
2.0-	1				
≥5.0	0				
RR per 10 μT year[g]		-[h]			

RR rate ratio or relative risk
a. any part of death certificate coded to ICD-9 331.0 or ICD-10 G30.
b. one year refers to a working year, approx. 250 8-hour shifts.
c. analysed simultaneously with sex and attained age (5 year age groups)
d. analysed simultaneously with sex, attained age, calendar period (5 year periods), and socio-economic status (three categories: managers, scientists and engineers; clerical and administrative workers; industrial and construction workers).
e. five exposure categories scored by the mean value in each category, namely 0.47, 3.71, 7.26, 13.97, 38.60 μT year.
f. five exposure categories scored by the mean value in each category, namely 0.45, 3.69, 7.24, 13.82, 38.27 μT year.
g. five exposure categories scored by the mean value in each category, namely zero, 0.19, 1.11, 3.31, 12.01 μT year.
h. Maximum likelihood estimate was not available

Table 2. Relative risks of motor neuron disease[a] by levels of estimated cumulative magnetic field exposure (four separate analyses), total cohort under study (73 051 workers first employed in period 1952-82), 1973-2010.

Exposure to magnetic fields (μT year)[b]	N	RR[c]	(95 % CI)	RR[d]	(95% CI)
Model 1.Occupational cumulative lifetime exposure to magnetic field.					
0-	37	1.0		1.0	
2.5-	16	2.22	(1.23 to 4.03)	2.23	(1.21 to 4.09)
5.0-	16	1.40	(0.77 to 2.55)	1.41	(0.76 to 2.61)
10.0-	11	1.11	(0.56 to 2.20)	1.11	(0.55 to 2.23)
≥20.0	6	1.32	(0.55 to 3.16)	1.30	(0.54 to 3.14)
RR per 10 μT year[e]		1.04	(0.84 to 1.28)	1.03	(0.83 to 1.27)
Model 2.Occupational exposure to magnetic fields received more than ten years ago (lagged exposure)					
0-	42	1.0		1.0	
2.5-	15	1.94	(1.05 to 3.57)	1.92	(1.03 to 3.58)
5.0-	12	1.05	(0.53 to 2.05)	1.04	(0.52 to 2.08)
10.0-	11	1.19	(0.59 to 2.41)	1.18	(0.57 to 2.45)
≥20.0	6	1.55	(0.63 to 3.79)	1.48	(0.58 to 3.73)
RR per 10 μT year[f]		1.11	(0.89 to 1.38)	1.10	(0.87 to 1.37)
Occupational exposure to magnetic fields received less than ten years ago (lugged exposure)					
Zero	57	1.0		1.0	
0.01-	15	1.10	(0.60 to 2.01)	1.11	(0.59 to 2.08)
0.5-	7	1.20	(0.53 to 2.72)	1.19	(0.47 to 2.96)
2.0-	5	1.00	(0.38 to 2.61)	0.99	(0.34 to 2.87)
≥5.0	2	0.49	(0.11 to 2.09)	0.50	(0.11 to 2.32)
RR per 10 μT year[g]		0.61	(0.21 to 1.79)	0.58	(0.18 to 1.86)

RR rate ratio or relative risk
a. any part of death certificate coded to ICD-8 348, ICD-9 335.2 or ICD-10 G12.2.
b. one year refers to a working year, approx. 250 8-hour shifts.
c. analysed simultaneously with sex and attained age (5 year age groups)
d. analysed simultaneously with sex, attained age, calendar period (5 year periods), and socio-economic status (three categories: managers, scientists and engineers; clerical and administrative workers; industrial and construction workers).
e. five exposure categories scored by the mean value in each category, namely 0.47, 3.71, 7.26, 13.97, 38.60 μT year.
f. five exposure categories scored by the mean value in each category, namely 0.45, 3.69, 7.24, 13.82, 38.27 μT year.
g. five exposure categories scored by the mean value in each category, namely zero, 0.19, 1.11, 3.31, 12.01 μT year.

Table 3. Relative risks of Parkinson's disease[a] by levels of estimated cumulative magnetic field exposure (four separate analyses), total cohort under study (73 051 workers first employed in period 1952-82), 1973-2010.

Exposure to magnetic fields (µT year)[b]	N	RR[c]	(95 % CI)	RR[d]	(95% CI)
Model 1. Occupational cumulative lifetime exposure to magnetic field.					
0-	123	1.0		1.0	
2.5-	27	1.02	(0.67 to 1.55)	1.04	(0.67 to 1.59)
5.0-	70	1.54	(1.14 to 2.08)	1.57	(1.15 to 2.15)
10.0-	42	1.06	(0.74 to 1.51)	1.09	(0.75 to 1.57)
≥20.0	16	1.05	(0.62 to 1.77)	1.10	(0.64 to 1.87)
RR per 10 µT year[e]		1.02	(0.90 to 1.15)	1.03	(0.90 to 1.16)
Model 2. Occupational exposure to magnetic fields received more than ten years ago (lagged exposure)					
0-	124	1.0		1.0	
2.5-	29	1.08	(0.72 to 1.63)	1.12	(0.74 to 1.70)
5.0-	69	1.52	(1.11 to 2.07)	1.60	(1.16 to 2.22)
10.0-	41	1.04	(0.72 to 1.52)	1.12	(0.76 to 1.65)
≥20.0	15	1.00	(0.58 to 1.75)	1.11	(0.63 to 1.96)
RR per 10 µT year[f]		1.02	(0.90 to 1.15)	1.03	(0.90 to 1.17)
Occupational exposure to magnetic fields received less than ten years ago (lugged exposure)					
Zero	223	1.0		1.0	
0.01-	44	1.08	(0.76 to 1.53)	1.01	(0.71 to 1.44)
0.5-	4	0.69	(0.25 to 1.91)	0.49	(0.17 to 1.42)
2.0-	5	1.33	(0.52 to 3.39)	0.99	(0.37 to 2.66)
≥5.0	2	0.84	(0.20 to 3.57)	0.64	(0.14 to 2.80)
RR per 10 µT year[g]		1.00	(0.34 to 2.94)	0.76	(0.23 to 2.49)

RR   rate ratio or relative risk
a.   any part of death certificate coded to ICD-8 342, ICD-9 332 or ICD-10 G20.
b.   one year refers to a working year, approx. 250 8-hour shifts.
c.   analysed simultaneously with sex and attained age (5 year age groups)
d.   analysed simultaneously with sex, attained age, calendar period (5 year periods), and socio-economic status (three categories: managers, scientists and engineers; clerical and administrative workers; industrial and construction workers).
e.   five exposure categories scored by the mean value in each category, namely 0.47, 3.71, 7.26, 13.97, 38.60 µT year.
f.   five exposure categories scored by the mean value in each category, namely 0.45, 3.69, 7.24, 13.82, 38.27 µT year.
g.   five exposure categories scored by the mean value in each category, namely zero, 0.19, 1.11, 3.31, 12.01 µT year.

Table 4. Relative risks of Alzheimer's disease[a] by levels of estimated cumulative magnetic field exposure (four separate analyses), 48 768 employees first hired in power stations in period 1952-82, 1973-2010.

Exposure to magnetic fields (µT year)[b]	N	RR[c]	(95 % CI)	RR[d]	(95% CI)
Model 1. Occupational cumulative lifetime exposure to magnetic field.					
0-	47	1.0		1.0	
2.5-	21	1.20	(0.71 to 2.01)	1.23	(0.73 to 2.06)
5.0-	23	0.82	(0.49 to 1.37)	0.83	(0.50 to 1.39)
10.0-	27	1.21	(0.74 to 1.98)	1.23	(0.75 to 2.01)
≥20.0	7	0.86	(0.38 to 1.93)	0.84	(0.38 to 1.89)
RR per 10 µT year[e]		0.98	(0.81 to 1.19)	0.98	(0.81 to 1.19)
Model 2. Occupational exposure to magnetic fields received more than ten years ago (lagged exposure)					
0-	47	1.0		1.0	
2.5-	21	1.22	(0.72 to 2.05)	1.22	(0.72 to 2.06)
5.0-	23	0.85	(0.50 to 1.43)	0.83	(0.49 to 1.40)
10.0-	27	1.28	(0.77 to 2.15)	1.22	(0.72 to 2.06)
≥20.0	7	0.93	(0.41 to 2.13)	0.85	(0.37 to 1.96)
RR per 10 µT year[f]		1.00	(0.82 to 1.21)	0.99	(0.81 to 1.20)
Occupational exposure to magnetic fields received less than ten years ago (lugged exposure)					
Zero	101	1.0		1.0	
0.01-	24	0.90	(0.55 to 1.46)	1.04	(0.63 to 1.70)
0.5-	0				
2.0-	0				
≥5.0	0				
RR per 10 µT year[g]		-[h]			

RR   rate ratio or relative risk

a. any part of death certificate coded to ICD-9 331.0 or ICD-10 G30
b. one year refers to a working year, approx. 250 8-hour shifts.
c. analysed simultaneously with sex and attained age (5 year age groups)
d. analysed simultaneously with sex, attained age, calendar period (5 year periods), and socio-economic status (three categories: managers, scientists and engineers; clerical and administrative workers; industrial and construction workers).
e. five exposure categories scored by the mean value in each category, namely 0.76, 3.72, 7.27, 13.92, 38.50 µT year.
f. five exposure categories scored by the mean value in each category, namely 0.71, 3.70, 7.25, 13.75, 37.82 µT year.
g. five exposure categories scored by the mean value in each category, namely zero, 0.19, 1.11, 3.29, 12.26 µT year.
h. Maximum likelihood estimate was not available

Table 5. Relative risks of motor neuron disease[a] by levels of estimated cumulative magnetic field exposure (four separate analyses), 48 768 employees first hired in power stations in period 1952-82, 1973-2010.

Exposure to magnetic fields (µT year)[b]	N	RR[c]	(95 % CI)	RR[d]	(95% CI)
Model 1. Occupational cumulative lifetime exposure to magnetic field.					
0-	19	1.0		1.0	
2.5-	16	2.25	(1.15 to 4.39)	2.26	(1.16 to 4.42)
5.0-	16	1.39	(0.71 to 2.72)	1.40	(0.71 to 2.74)
10.0-	11	1.18	(0.55 to 2.49)	1.17	(0.55 to 2.49)
≥20.0	6	1.48	(0.59 to 3.73)	1.42	(0.56 to 3.60)
RR per 10 µT year[e]		1.04	(0.82 to 1.30)	1.03	(0.81 to 1.29)
Model 2. Occupational exposure to magnetic fields received more than ten years ago (lagged exposure)					
0-	24	1.0		1.0	
2.5-	15	1.92	(0.99 to 3.69)	1.89	(0.98 to 3.67)
5.0-	12	1.05	(0.51 to 2.13)	1.03	(0.50 to 2.14)
10.0-	11	1.31	(0.62 to 2.77)	1.29	(0.59 to 2.78)
≥20.0	6	1.84	(0.73 to 4.67)	1.73	(0.65 to 4.57)
RR per 10 µT year[f]		1.13	(0.89 to 1.42)	1.11	(0.87 to 1.41)
Occupational exposure to magnetic fields received less than ten years ago (lugged exposure)					
Zero	40	1.0		1.0	
0.01-	14	0.88	(0.47 to 1.66)	0.89	(0.46 to 1.74)
0.5-	7	1.02	(0.44 to 2.36)	1.01	(0.37 to 2.71)
2.0-	5	0.84	(0.32 to 2.23)	0.84	(0.27 to 2.66)
≥5.0	2	0.42	(0.10 to 1.81)	0.45	(0.09 to 2.19)
RR per 10 µT year[g]		0.53	(0.18 to 1.62)	0.56	(0.17 to 1.85)

RR   rate ratio or relative risk
a.   any part of death certificate coded to ICD-8 348, ICD-9 335.2 or ICD-10 G12.2.
b.   one year refers to a working year, approx. 250 8-hour shifts.
c.   analysed simultaneously with sex and attained age (5 year age groups)
d.   analysed simultaneously with sex, attained age, calendar period (5 year periods), and socio-economic status (three categories: managers, scientists and engineers; clerical and administrative workers; industrial and construction workers).
e.   five exposure categories scored by the mean value in each category, namely 0.76, 3.72, 7.27, 13.92, 38.50 µT year.
f.   five exposure categories scored by the mean value in each category, namely 0.71, 3.70, 7.25, 13.75, 37.82 µT year.
g.   five exposure categories scored by the mean value in each category, namely zero, 0.19, 1.11, 3.29, 12.26 µT year.

Table 6. Relative risks of Parkinson's disease[a] by levels of estimated cumulative magnetic field exposure (four separate analyses), 48 768 employees first hired in power stations in period 1952-82, 1973-2010.

Exposure to magnetic fields (µT year)[b]	N	RR[c]	(95 % CI)	RR[d]	(95% CI)
Model 1. Occupational cumulative lifetime exposure to magnetic field.					
0-	61	1.0		1.0	
2.5-	26	1.01	(0.64 to 1.61)	0.99	(0.63 to 1.58)
5.0-	68	1.55	(1.09 to 2.20)	1.53	(1.07 to 2.18)
10.0-	38	1.07	(0.71 to 1.61)	1.06	(0.70 to 1.60)
≥20.0	12	0.93	(0.50 to 1.74)	0.95	(0.51 to 1.78)
RR per 10 µT year[e]		0.98	(0.85 to 1.13)	0.98	(0.85 to 1.14)
Model 2. Occupational exposure to magnetic fields received more than ten years ago (lagged exposure)					
0-	62	1.0		1.0	
2.5-	28	1.08	(0.69 to 1.69)	1.09	(0.69 to 1.71)
5.0-	67	1.53	(1.07 to 2.19)	1.57	(1.09 to 2.26)
10.0-	37	1.05	(0.68 to 1.61)	1.10	(0.71 to 1.70)
≥20.0	11	0.87	(0.45 to 1.68)	0.96	(0.49 to 1.87)
RR per 10 µT year[f]		0.97	(0.84 to 1.13)	0.99	(0.85 to 1.15)
Occupational exposure to magnetic fields received less than ten years ago (lugged exposure)					
Zero	151	1.0		1.0	
0.01-	43	1.10	(0.77 to 1.58)	1.02	(0.70 to 1.47)
0.5-	4	0.73	(0.26 to 2.06)	0.49	(0.16 to 1.47)
2.0-	5	1.45	(0.56 to 3.77)	0.97	(0.34 to 2.79)
≥5.0	2	0.96	(0.22 to 4.16)	0.66	(0.14 to 3.04)
RR per 10 µT year[g]		1.10	(0.37 to 3.23)	0.81	(0.24 to 2.72)

RR rate ratio or relative risk
a. any part of death certificate coded to ICD-8 342, ICD-9 332 or ICD-10 G20.
b. one year refers to a working year, approx. 250 8-hour shifts.
c. analysed simultaneously with sex and attained age (5 year age groups)
d. analysed simultaneously with sex, attained age, calendar period (5 year periods), and socio-economic status (three categories: managers, scientists and engineers; clerical and administrative workers; industrial and construction workers).
e. five exposure categories scored by the mean value in each category, namely 0.76, 3.72, 7.27, 13.92, 38.50 µT year.
f. five exposure categories scored by the mean value in each category, namely 0.71, 3.70, 7.25, 13.75, 37.82 µT year.
g. five exposure categories scored by the mean value in each category, namely zero, 0.19, 1.11, 3.29, 12.26 µT year.