DRAFT - WORK IN PROGRESS – Version 1 – 29/6/06

Adverse health effects associated with exposure to ELF electric and magnetic fields – assembly of scientific evidence and discussion of possible public health impact

Volume 3 - Tables

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Notes: In all tables, unless otherwise stated, the confidence intervals quoted are at the 95 % confidence level. RR = Risk Ratio; OR = Odds Ratio; CC = Case Control study; CHD = Quoted in the California Health Department Report; LMP = Last menstrual period; PEMF = Pulsed Electromagnetic Field; RR = Risk Ratio; OR = Odds Ratio; MHOR = Mantel - Haenszel odds ratio; PMR = Proportionate Mortality Rate; PIR = Supervisors, power installers and repairers; TI = Telephone installers and repairers; EEF = Electrical equipment repairers; PPO = Power plant operators; EE = Electrical engineers; ET = Electrical technicians; E = Electricians; BC = Breast cancer; SMR = Standardised Mortality Ratio.

The blank spaces indicate we have not yet been able to get hold of the papers; these will be filled in in future versions.

6.1 Childhood Leukaemia

To be included in a later version of the report.

6.2 Adult leukaemia

6.2.1 Direct epidemiological evidence from the California Report

No	Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	OR, RR etc	Notes
1	Savitz & Loomis, 1995	Cohort mortality study: No workers: 138905. No deaths: 20733 including 164 leukaemia (AML 49, CLL 34). All male, from US electric company employees, 1950 - 1986	Duration/level of exposure by job title (>6 months). Measured (TWA) per job category (2,842 measurements) to compile exposure matrix	5 groupings, arithmetic means 0.12, 0.21, 0.39, 0.62, 1.27 μT. Lineman 0.65 μT; Electrician 1.11 μT; Power plant 0.79 μT	Presumably present in some job areas but not studied	Duration of work RR: 5 - 20yr = 1.31 (0.87 - 1.97) 54 cases; > 20yr = 1.00 (0.60 - 1.65) 28 cases. Electrician: 5 - 20yr = 135 (0.62 - 2.94) 7 cases; > 20yr = 2.50 (1.08 - 5.76) 6 cases. Total exposure RR/ μT – yr = 1.01 (0.94 - 1.08); AML = 1.04 (0.93 - 1.18); CLL = 0.96 (0.78 - 1.09)	All RRs are different
2	Floderus, 1993	CC: cases: 250, controls: 1121. Cases taken from Cancer Register, controls taken from 1980 Census. Aged 20 - 64 in 1980. All male from mid - Sweden	Arithmetic mean Median Standard deviation Time > 0.20 μT Split into 4 quartiles, OR 95% CI found referenced to lowest quartile (Except for median: lowest 2 quartiles)	MF exposure at work EMDEX meter carried on waist. Measured 1 day 'snapshot' of job held longest in 10 years	Not considered	Mean ≥ 0.29 μT, 270 controls, All 1.6 (1.1 - 2.4) 61 cases; CLL 3.0 (1.6 - 5.8) 33 cases; Median ≥ 0.17 μT, 255 controls, All 1.3 (0.9 - 1.9) 59 cases; CLL 1.7 (1.1 - 2.7) 17 cases; SD ≥ 0.71 μT, 259 cont; All 1.4 (0.9 - 2.0) 47 cases; CLL 2.2 (1.2 - 3.8) 18 cases; Time ≥ 0.2 μT ≥ 29% 256 cont ; All 1.5 (1.0 - 2.2) 62 cases; CLL 2.4 (1.3 - 4.3) 24 cases	CHD quoted odds ratio is different to that quoted on paper

3	Floderus, 1992						Get paper
4	Floderus *et al.,* 1994	CC				All leukaemia: engine drivers 1.6 (0.7 - 3.6) n = 6, railway workers 1.2 (0.7 - 1.9) n = 17, railway industry 1.2 (0.8 - 1.6) n = 33	Get paper
5	Törnqvist *et al.,* 1991	Cohort study: Sweden Incidences of cancer 1961 - 1979 compared with data on 1960 census. Males aged 20 - 64 working in electrically related occupation. 133687 men worked in selected occupations, 1905660 men in reference population. 334 cases of leukaemia in selected occupations: 20% AML, 15% CML, 2% ALL, 32% CLL, 31% unspecified	Job title in 1960 census. No information on length of time in occupation. Some measures taken,: median field strength & % of time at field strength > 0.35 µT. Occupations highest median MF: power station operators, linesmen, engine drivers & conductors	Limited information on intensity & duration of MF exposure	Not measured	Electrical engineers & technicians: All leukaemia = 1.3 (1.0 - 1.7), CLL = 1.7 (1.1 - 2.5). Telegraph/ telephone technicians: All leukaemia = 2.1 (1.1 - 3.6), CLL = 1.5 (0.3 - 5.8). Machine technicians: All leukaemia = 2.6 (1.0 - 5.8), AML = 2.6 (0.0 - 14.6), CLL = 4.8 (1.0 - 14.6). Linesmen: All leukaemia = 1.3 (0.8 - 1.9), CLL = 2.0 (1.0 - 3.5). Electric power linesmen: CLL = 2.8 (1.1 - 5.7). Radio/ TV assembly & repair: AML = 2.1 (0.0 - 11.7). Welders & flame cutters: AML = 1.2 (05 - 2.2). Miners: All leukaemia = 1.4 (0.9 - 1.9), AML = 2.2 (1.0 - 4.1). Miners (iron ore): All leukaemia = 1.5 (0.7 - 2.8), AML = 5.7 (2.1 - 12.4), CLL = 0.8 (0.1 - 2.9)	OR in CHD not in paper. No increased risk found for all electrical occupations taken together. Increased risk found in some occupations (see previous column). Occupations with increased risk are not the same as occupations with highest median MF measurements

6	Linet *et al.,* 1988						Get paper
7	Tornqvist *et al.,* 1986	Cohort Mortality Study: 10 cases leukaemia, from power linesmen. 16 cases leukaemia from power station operators, from 3358 power linesmen, 6703 power station workers, Swedish born men aged 20 – 64 according to Swedish 1960 census, cases taken from Cancer environment agency	Standardised Morbidity ration (SMR) used to assess risk with 90% confidence intervals	Levels & duration of EMFs not known. EMF exposure classed by job type	EFs may be present – not investigated	For power linesmen SMR = 1.3 (0.7 - 2.1); For power station operators: SMR = 1.0 (0.6 - 1.5)	Disagrees with CHD (which groups several papers together) unclear if CHD calculates 95% CI instead of published 90% CI. Both groups exposed to chemicals, so may be confounding
8	London *et al.,* 1994	Registry based CC: 121 leukaemia cases in electrical workers	Task weighted estimate on sample jobs. Measurements of current workers, estimates historical job	Grouped as % day exposed to > 0.25 μT & 0.25 μT		1.31 (1.1 - 1.6) all leukaemia (121); 1.2 (1.0 - 1.6) AML (41); 1.3 (1.0 - 1.8) CLL (28); 1.3 (0.8 - 2.1) CML (25)	AML not put in CHD all others correct. Non - exposed group included machinist & machine operators
9	Wright *et al.,* 1982	Proportional incidence ratio 35 cases (22 AML & 23 AL)	Occupational	Occupational	Occupational	For all electrical jobs significant $p < 0.05$ for AML & ALL	

10	Theriault *et al.,* 1994 France: Electricite de France - Gas de France (1978 - 1989) (EDF) Canada: Ontario Hydro (1973 - 1988) (OH) Canada: Hydro - Quebec (1970 - 1988) (HQ)	CC: 3 cohorts of electric utility workers 4,151 cases occurred case:control ratio, 1:4. Cases among 170,000 men Cases among 31,543 men Cases among 21,749 men	Occupational exposure to MFs of 50 - 60Hz. Cumulative exposure calculated using job exposure matrices (JEM) & measurements of MF exposure levels of occupation Estimates also made of past exposure based on knowledge of current loading, work practises, & usage	Exposure groups < median (3.1 μT - years), ≥ median & ≥ 90th percentile (15.7 μT - years)	EF & corona ion exposure depending on occupation (i.e definite exposure for transmission & distribution workers)	For ≥median: OR (95% CI), number cases: number controls. All Leukaemia (AL): 1.54 (0.90 - 2.63), 140:546 CLL: 1.48 (0.50 - 4.40), 41:156; AML: 3.15 (1.20 - 8.27), 108:415 AL: 1.39 (0.61 - 3.08), 71:279; CLL: 4.79 (0.45 - 70.57), 13:51; AML: 1.70 (0.49 - 5.54), 29:114 AL: 3.14 (1.12 - 9.74), 45:172; CLL: 2.14 (0.39 - 11.64), 18:65; AML: 37.36 (3.51 to > 100), < median 18:0 ≥median 30:12 AL: 0.29 (0.04 - 1.75), 24:95; CLL: 0.25 (0.02 - 2.56), 10:40	CHD correct. All cancers as a whole, for each cohort & overall show no correlation between exposure & risk, all OR's close to 1. No clear dose - response trends with increasing exposure. No consistency among the 3 cohorts OH shows non - statistically significant increasing trend for CLL with increasing exposure, whereas HQ does not

11	Tynes *et al.,* 1994a	Nested CC: ratio 1-3 to 5. Cohort size: 13030 male railway workers in 1958, follow up 1958 – 1990, 52 cases, 258 controls	Job description, cumulative exposure, time spent at railway line, both EF & MFs	16.67 Hz MF measured 1m above tracks, & estimated from tonnage on railway lines; Max 88 μT, min 0.88 μT, yearly average 19.7 μT Grouped: low (<310 μT - yr) high (310 - 3600 μT - yr) 50/50 split also v. high (1900 - 3600 μT - yr) 10/90 split	Max spot measurements: 0.8 kV/m, min: 0.02 kV/m, yearly average 0.34 kV/m. Grouped low (< 5 kV/m - yr), high (5 – 30 kV/m - yr), v. high (21 – 30 kV/m – yr)	Ever exposed: never exposed OR = 0.72 (0.37 - 1.40). Groupings: MF no significant results. Low OR = 0.97 (0.43 - 2.19), 20 cases, 84 controls. High OR = 0.56 (0.23 - 1.34), 11 cases, 83 controls. EF no positive result for any category	CHD OR = 1.0 (0.6 - 1.6)
12	Tynes *et al.,* 1994b	Cohort study of 5088, 11 cases leukaemia. Employed for at least 1 year between 1 Jan 1920 & 31 Dec 1985, all male workers in hydroelectric power stations in Norway	Occupational	Cumulative exposure to MFs (μT years) electric fields (max voltage by years employed). Workers between minimum 0.1 μT & 200 μT. Typical values between 1 & 10 μT	Electric fields categorised in four levels. Also estimated cumulative exposure (V years)	Incidence leukaemia amongst all workers SIR = 90 (45 - 160) Cumulative exposure < 5 μT years (2 observed) SIR = 95; 5 - 35 μT years (4 observed) SIR = 74; > 35 μT years (5 observed) SIR = 104	CHD quotes leukaemia risk for all workers
13	Ciccone *et al.,* 1993						Get paper

14	Guénel *et al.,* 1993	Cohort of 2.8 million Danes aged 20 - 64 in 1970. Followed for 17 years (1970 - 87). 282 male cases of leukaemia, 119 acute. 94 female cases leukaemia, 47 acute	Industry & occupation information collected in 1970 census	Only ELF EMF considered (50Hz). Threshold for MF assumed to be 0.3 μT	Not considered	Male: Intermittent exposure obs = 282, exp = 300.12 obs/exp = 0.94 (0.84 - 1.06) Continuous exposure obs = 39, exp = 23.80 obs/exp = 1.64 (1.20 - 2.24) Female: Intermittent exposure obs = 94, exp = 102.13 obs/exp = 0.92 (0.75 - 1.13). Continuous exposure obs = 2, exp = 3.35 obs/exp = 0.56 (0.07 - 2.03)	Significant increased risk found for males with continuous exposure. No increased risk found for females
15	Matanoski *et al.,* 1993	CC study of link between telephone linework & occurrence of leukaemia in a retired population of American Telephone & Telegraphy Company workers who died between 1975 & 1980	Exposure defined by job title & lifetime exposure score based on personal monitoring	Grouped into below & above median exposure for the population. Latent periods of 10 & 15 years	Abstract doesn't define what 'exposure' is. Also would expect exposure to corona ions.	OR = 2.5 (0.7 - 8.6) for >median exposure. Peak exposure scores>median, OR = 2.4 (0.7 - 9.0) & 6.6 (95% CI 0.7 - 58) for latent periods of 10 & 15 years respectively. Higher risk for peak exposure than for constant exposure. Risk associated with exposure 10 or more years before death. For peak exposure scores, increasing risk with increasing exposure, p for trend = 0.05	Only found abstract, CHD OR = 2.5 (0.7 - 8.6). Numbers in study small

16	Sahl *et al.,* 1993	3 nested CC: of 36221 workers	Occupational study with sample EMFs measured in comparable jobs	Sample workers used EMDEX II for a day, 776 days of measurement	Not considered	1.09 (0.51 - 2.29) on 17 cases	CHD OR = 0.9 (0.7 - 1.2)
17	Tynes *et al.,* 1992	Cohort: 37945, including 3806 cancers (107 leukaemias). Norwegian workers aged 20 - 70. Group I 1960 census, follow up 1960 – 1985. Group II both 1960 & 1970 census, follow up 1970 - 1985 (for a minimum 10 yr occupational exposure)	Occupational, 5 categories: Weak MF, intermediate MF, weak MF + EF, heavy MF + EF, radiofrequency. Specified for train drivers (16.67 Hz, 11 kV) & tram drivers (600 Vdc)	Not quantified, grouped as left	Included as part of exposure categories, not measured directly	Overall SIR 1.08 (0.89 - 1.31); Group II SIR 1.41 (1.10 - 1.76) 74 cases; Significant for radio/TV repairmen (RF) SIR 3.18 (1.03 - 7.43) 5 cases, & powerline workers (heavy MF/EF) SIR 1.90 (1.01 - 3.24) 13 cases; RF increased risk SIR 2.85 (1.30 - 5.41) 9 cases; heavy MF/EF increased risk SIR 1.79 (1.09 - 2.76) 20 cases; ALL 1.45 (0.18 - 5.24) 2 cases; AML 1.56 (1.06 - 2.26) 29 cases; CLL 1.26 (0.77 - 1.94) 20 cases; CML 1.97 (1.10 - 3.26) 15 cases	CHD overall the same SIR but different for ALL/AML/CLL/CML

18	Richardson, 1992	French CC: 185 cases of acute leukaemia over 30 years old; matched with 513 controls hospitalised for other conditions.	Occupational histories assessed in detail by questionnaire. Job exposure matrix used by an industrial hygienist who coded the exposure into "low" (< 5% of working time), "medium" (5 - 50%) & "high" (> 50%). A weighted length of exposure was defined on the level & total length of exposure	No measurements were taken. No information given	No information given	Significant excess among cases found for electronic engineers 3 cases, 0 controls (p = 0.027) RR estimates: Electric & magnetic fields – all types of exposure: 14 cases, 23 controls: OR = 1.7 (0.9 - 3.5); Arc welding - all types of exposure: 8 cases, 18 controls: OR = 1.2 (0.5 - 3.0); Arc welding – high or medium exposure: 4 cases, 9 controls: OR = 1.3 (0.4 - 4.2); Exposures other than arc welding - all types of exposure: 7 cases, 5 controls: OR = 3.9 (1.2 - 12.5); Other than arc welding – high or medium exposure: 7 cases, 3 controls: OR = 2.9 (0.6 - 14.4)	CHD correct
19	Bastuji - Garin, 1990	CC: 185 cases, 513 controls	Occupational study	By occupation	Probably, but not considered	No association with arc welders All other electrical workers 4.04 (1.26 - 12.88) – figure in CHD Association with benzene & weed killers with these taken into account EMF exposure 3.2 (1.2 - 5.3) 7 cases with 5 controls, all 7 cases AML	Complete work history

20	Loomis, 1991	Mortality study: 53 electrical worker cases, 598 controls	Occupational study	By occupation	Probably, but not considered	OR = 0.9 (0.7 - 1.2) for electric installers & electricians	Figures don't appear in CHD report. Very little about EMFs
21	Loomis & Savitz, 1990	Mortality case - control study based on all male deaths in 1985/6 in 16 states of the US. 3400 deaths from all leukaemias. Each case matched with 10 controls that died from other causes in same year. In "exposed" group; 76 cases of all leukaemia's 752 controls	Occupational data on death certificates			Electrical vs other occupations (all leukaemias) OR = 1.0 (0.8 - 1.2). Cell type: AML = 1.1 (0.7 - 1.7), ALL = 1.5 (0.7 - 3.4), CLL = 0.6 (0.3 - 1 - 1), CNL = 1.1 (0.8 - 1.7). Electrical & electronic engineers & technicians. (19 cases vs 140 controls, OR = 1.3 (1.0 - 1.7)) & manufacturing (26 cases, 172 controls, OR = 1.5 (1.0 - 2.2).	CHD correct.
22	Robinson *et al.,* 1991	Deaths identified from industrial mortality data among white men in electrical occupations in 14 US states, 1979 - 1985 183 cases recorded	Occupational code from death certificates	11 occupations looked at with potential exposure to electric & magnetic fields	Not considered	PMR all Leukaemia = 119 (102 - 137) (183 cases), AML = 114 (85 - 150) (51 cases)	CHD correct

23	Simonato *et al.,* 1991	Mortality study for stainless steel, mild steel & shipyard welders. Cohort size: 11,092. 6 cases of leukaemia death. From 9 European countries, sub cohort of 7510 welders from Nordic countries. 11 cases leukaemia, all male	Standard mortality rates & standard incidence rates found. EMFs not measured or estimated	Level of EMFs not extimated. Assumed that welders may be exposed to EMFs	Possible EFs but not measured	SMR for full cohort = 63 (23 - 138). SIR for Nordic countries (sub cohort) = 126 (63 - 225)	CHD quotes sub - cohort result but details of whole cohort. Study size too small for leukaemia. Little consideration of EMFs Primarily a lung cancer paper. Possible 'healthy worker effect' confounding results
24	Spinelli, 1991	Cohort study: cases of cancer, 1970 - 1985; & deaths from cancer, 1950 - 1985; among 4,213 male workers with 5+ years working in an aluminium reduction plant in British Columbia, Canada: 7 deaths, 3 incidences	Committee determined whether there was EMF exposure for each job identified from employee records		EMF exposure considered	Cancer Mortality: SMR = 1.75 (90% CI 0.82 - 3.30) (7 cases, 3.99 expected). Cancer Incidence: SIR = 0.76 (90% CI 0.21 - 1.96) (3 cases, 3.96 expected)	Paper mainly about exposure to coal - tar pitch volatiles
25	Flodin, 1990	Case - referent study based on cases of AML diagnosed between 1977 & 1985 from hospitals in 4 countries 86 cases, 172 referents, aged 20 – 70	Questionnaire about different exposures, occupational & leisure	Occupational codes for electrical work	Not considered	RR = 2.1 (0.7 - 5.9) (8 cases, 8 referents)	

26	Flodin *et al.,* 1986	Case referral study 59 cases 354 referals	Estimated from occupation	Exposure category estimated from occupation	Estimated from occupation	Exposure category, cases non - exposed, OR: I, 6, 246,1.0; II, 6,67,3.64 III, 2, 27, 3.04; II +III, 8, 14, 3.8 (1.5 - 9.5)	Also looked at background gamma, (not radon!), solvent (styrene), poultry contact, psychotherapeutic drugs & X - ray treatment
27	Gallagher *et al.,* 1990	Proportional mortality rate	Estimated from occupation	Estimated from occupation	Estimated from occupation	OR = 1.1 (0.8 - 1.5) for all leukaemias	CHD ignores categories with zero deaths
28	Garland, 1990	CC: 102 cases, white men aged 17 - 34 in the US navy. Compared with SEER program population & Navy population	Occupational	Electricians mate estimated to have larger exposure to magnetic fields than most naval occupations. Largely 60 Hz. All naval personnel not shown to have larger EMF exposure than general population	Electricians mate may have larger than average exposure to EFs	All naval personnel: SIR = 0.9 (0.8 - 1.1), electricians mate (7 cases). SIR = 2.4 (1.0 - 5.0), compared to general population. SIR = 2.5 (1.0 - 5.1), compared with Naval occupations	CHD statistic is not found in paper. CHD quotes increase in risk for all naval occupations, but there is no obvious increase in EMFs for all naval occupations
29	Juutilainen *et al.,* 1990						Get paper
30	Juutilainen, 1988						Get paper
31	Gubéran *et al.,* 1989	Cohort study of male painters & electricians living in Geneva, 1970 – 1984: 1916 painters 1948 electricians, incidences compared: expected Geneva rates	Occupation as classified in 1970 census	No information given	No information given	2 cases of leukaemia, 1.6 cases expected: SIR = 1.25 (0.22 - 3.93)	95% CI given in CHD are wrong

32	Pearce *et al.,* 1989	CC	Occupational study	Occupational study	Occupational study	All leukaemias 1.62 (1.04 – 2.52); CLL 3.36 (1.27 - 8.89) 4 cases under 65; AML 1.21 (0.38 - 3.85) 3 cases under 65	High OR for TV repair men 7.86 (2.2 - 28.09)
33	Pearce *et al.,* 1986	New Zealand Cancer Registry CC study of 546 male leukaemia patients, 1979 - 1983 aged 20+, 2184 controls, 4 per case, agricultural workers.	Occupational code from registry.	No information given	No information given	ORs (95% CI) for the agricultural category: All Leukaemia: 1.24 (0.95 - 1.61), AML: 1.24 (0.80 - 1.91), ALL: 1.28 (0.55 - 2.97), CLL: 1.09 (0.70 - 1.69), CML: 1.14 (0.58 - 2.22); Electrical (agricultural) workers: All leukaemia: OR = 1.72 (0.92 - 3.20) (15 cases,33 controls)	ORs given in CHD not found in paper
34	Pearce *et al.,* 1985	CC: 546 cases 2184 controls	Occupational study	Occupational study	Occupational study	OR = 1.7 (0.97 - 2.97) Driven by electronic equipment assemblers: 4 cases 8.17 (1.49 - 44.74); radio/TV repairmen: 7 cases 4.75 (1.59 - 14.23)	None of the figures correspond to CHD report but in same box as two previous Pearce *et al.,* papers
35	Cartwright, 1988	CC: 13 cases & 11 controls for electrical workers	Occupational study	Occupational study	Occupational study	2.4 (0.95 - 6.0) for electrical workers	Very little is mentioned of EMFs

36	Milham, 1988	Proportionate mortality ratio study, 2,485 deaths, from 67,829 amateur radio operators (232,499 person years), all male from California & Washington state From Jan 1 1979 to Dec 31 1984	Standardised mortality ratio calculated. 95% confidence intervals found.	Person years of exposure used. MF exposure not measured but radio operators estimated as high exposure	EFs not considered.	All leukaemia, n = 36 SMR = 124 (87 - 172), ALL, n = 3, SMR = 120 (26 - 381), CLL, n = 6, SMR = 109 (40 – 238), AML, n = 15, SMR = 176 (103 – 285), CML, n = 3, SMR = 86 (17 – 250)	Only 1 significant result, but this could be due to low numbers
37	Milham, 1985	Cohort study of Amateur radio operators 24 cases, 126 controls				PMR 191 $p < 0.01$	Some link with employment in electrical occupations Figures don't correspond to CHD report but in same box as Milham 1988
38	Preston - Martin & Peters, 1988	CC study: living cases of CML from the Los Angeles County Cancer Registry, 1979 - 1985 130 cases, aged 20 - 69 130 matched controls; 22 cases & 4 controls had worked as welders	Welders, or employed in one of 11 specific job titles from questionnaire data	Length of employment & job title & description.	Probably but not considered	OR adjusted for all other variables = 25.4 (95% CI 2.78 - 232.54)	CHD correct

39	Tola *et al.,* 1988	Occupational cohort study. Cases: 987 cancer incidences 19 cases of leukaemia. Controls: 12 693 workers. Data from personnel registers of 5 shipyards & 4 machine shops. Diagnosis from 195 till 31 Dec 1981, from South - south-western Finland	Attempted to find standard incidence ratios (SIR) & 95% confidence limits for leukaemia based on expected number of cases. Workers split into occupational subgroups, but nor by EMF exposure	Welding electrodes present for welders. Remnant magnetic fields in shipyard machinists did not differ to that of controls 2 decades lower than a shipyard welder, one lower than a fulltime grinder No other attempt top characterise field. No attempt was made to characterise or measure EMFs	EF not considered	SIR for leukaemia insignificantly raised for shipyard workers (not machine shops) 19 cases: SIR = 114 (69 - 179)	Number of cases too small & EMFs not characterised. Agrees with CHD finding CHD also quotes SIR for welders, but number of cases = 2, so not relevant. Confounding from asbestos & smoking cannot be ruled out. Incidence of cancers could be due to carcinogens such as welding fumes
40	Olsen, 1987						Get paper

41	Stern *et al.,* 1986	CC study of 53 leukaemia deaths & 212 controls within a cohort of 24,545 on - shore workers employed at the Portsmouth Navel Shipyard, 1952 - 1977	Occupational exposure to ionizing radiation & organic solvents, work history	Occupation, no consideration to EMF exposure level	Not considered	Jobs ever held in which 3 or more cases were employed: electrician: OR = 3.00 (95% CI 1.29 - 6.98) (11 exposed cases), welder: OR = 2.50 (95% CI 0.91 - 6.90) (7 exposed cases). Shops ever held in which 3 or more cases were employed: electrician: OR = 2.57 (95% CI 1.11 - 5.96) (10 exposed cases), welder: OR = 2.25 (95% CI 0.92 - 5.53) (7 exposed cases). Exposure category: electrician: OR = 3.39 (95% CI 1.40 - 8.18) welder: OR = 3.19 (95% CI 1.09 - 9.37). Continuous exposure variables: electrician (average exposure for all controls, 6.46 yrs): OR = 1.67 (95% CI 1.01 - 2.78), welder (average exposure for all controls, 13.16 yrs): OR = 2.86 (95% CI 1.02 - 8.04)	Study looking at exposure to ionizing radiation & organic solvent, not EMFS Gives ORs for electricians & welders, but value quoted in CHD does not match any given in paper
42	Blair, 1985	Nationwide cohort 107563 deaths 15 leukaemia deaths in electricians & electrical engineers	Usual occupation from questionnaires	Occupational study	Occupational study	OR = 0.9 (0.5 - 1.5)	Not sure how CHD get 95% CI. Averaged electricians & electrical engineers to get CHD results

43	Calle & Savitz, 1985	Mortality study, state of Wisconsin, white men aged 20 or older. 10 electrical occupations from 1963 to 1978	PMRs calculated for 10 electrical occupations	Level & type of exposure not measured. Occupational 'electrical' occupations mentioned	EFs may be present	For All leukaemia, 81 cases (78.3 exp), PMR = 103, for Acute leukaemia, 41 cases (36.2 exp), PMR = 113	Small numbers, short study, CHD correct
44	Gilman, 1985	CC: risk in occupational exposure to EMF of 40 leukaemia decedents & 160 controls 19000 males coal miners entered into 4 NIOSH cohorts; 6,066 death certificates reviewed, prior to 1985	Number of years of underground mining employment at time of cohort creation	Length of employment divided at less than 25 years & 25 years & over used as a surrogate for exposure to EMF	EMF as a whole considered	ORs for ≥25 years of underground mining: All Leukaemia: OR = 2.53 ($p<0.05$) (32 cases for 25+ group, 8 cases for <25), AML: OR = 3.80 (14 cases), ALL: OR = 0.63 (2 cases), CLL: OR = 6.33 ($p<0.05$) (11 cases)	CHD correct, CI for all leukaemia not in paper
45	Milham, 1985b	Occupational mortality study on 486000 deaths of Washington State white males aged over 20, 1950 - 1982	Occupational code from mortality data	Occupations with presumed exposure to electrical or magnetic fields.	Occupations with presumed EF exposure included in study	AL PMR 162 (67 deaths, 41 expected). Other lymphomas PMR 164 (51 deaths, 31 expected)	
46	Milham, 1982	Mortality study of 468,000 deaths of Washington State white males aged over 20, 1950 - 1979	Occupational code from mortality data	Occupations with presumed exposure to electrical or magnetic fields	Occupations with presumed EF exposure included in study	All leukaemia: PMR = 137 ($P < 0.01$) (observed cases = 136, expected cases = 99.2); acute leukaemia: PMR = 163 ($P < 0.01$) (observed cases = 60, expected cases = 36.7)	CHD quotes PMRs as observed/expected, paper quotes observed/expected x100, some values misquoted.

47	Olin *et al.,* 1985	Cohort with control group, No participants: 1243 (108 deaths), No controls: 659 (80 deaths) Male electrical engineering graduates from Sweden RIT technical college 1930 - 1959 (controls architecture grads from same period), exposure period 1930 - 1979	Occupational, unspecified	Unspecified	Unspecified	SMR electrical engineer: 0.9 (0.1 - 3.2) 2 cases	CHD different SMRs CHD quotes 1,245 participants, incorrect
48	Morton, 1984	All incidences of leukaemia occurring during a 15 year period in the Portland - Vancouver area were classified by occupation. 1678 cases of adult leukaemia	Occupation category			Electricians: (all leukaemias) 4 cases, annual rates = 10.1 All men: 975 cases, annual rates = 11.4	No excess risk found in occupations with obvious high EMF exposure. Figures given in CHD not in paper
49	Coleman *et al.,* 1983	113 cases of EMF exposed patients	Proportional registration ratio	Occupational study	Occupational study	OR = 1.17 $p < 0.05$ (1.0 - 1.4) all leukaemia, 1.2 AML (33 cases), 1.5 ALL (12 cases), 1.3 CLL (33 cases), 0.9 CML (16 cases)	CHD say 6 cases but actually 16

50	Howe, 1983	Mortality study of 10% sample of Canadian Labour Force. 415201 males. 204 leukaemia & aleukaemia deaths. Entered cohort between 1965 & 1969	Standard mortality rate & 95% CIs found. Occupation codes form census. EMFs not measured or estimated	Job titles given but no indication of MF exposure	Job titles given but no indication of EF exposure	Occupation division with significantly increased risk, n = number deaths; transport & communication, n = 28 SMR = 1.68, $0.001 \geq p \geq 0.01$. Occupations with significantly increased risk: cooks, n = 6, SMR = 3.24 $0.01 \geq p \geq 0.05$; metalwork machine operators, n = 7, SMR = 2.47 $0.01 \geq p \geq 0.05$; truck drivers, n = 13, SMR = 1.69, $0.01 \geq p \geq 0.05$; motor vehicle manufacturers n = 6, SMR = 2.82, $0.01 \geq p \geq 0.05$	CHD quotes insignificant result from industry division, occupation division gives a significant result Mining also gives insignificant increase in risk No mention of EMFs in CHD
51	McDowall, 1983	Leukaemia mortality in electrical occupations: Engl& & Wales 1970 – 1972, males aged 17 - 74. 537 deaths of AML, 1074 controls of non - leukaemia related death	Job occupation from 1970 census	Level of exposure not considered	Other sources of exposure not considered.	PMR (& no of cases) for all electrical occupations: All leukaemia: 98 (85), ALL: 104 (11), AML: 104 (31)	Values quoted are rounded & quoted as decimals Confidence interval quoted for all leukaemia not found in paper
52	McDowall, 1983	Leukaemia mortality in electrical occupations: Engl& & Wales 1970 – 1972, males aged 17 – 74. 537 deaths of AML, 1074 controls of non - leukaemia related death	Job occupation from 1970 census	Level of exposure not considered	Other sources of exposure not considered	RR of AML (95% CI) (no cases): All electrical occupations: 2.1 (1.36 - 3.6) (30), No significant RR's when split into occupations	CHD mistyped: AML CI in ALL column

53	Polednak, 1981	Cohort study of mortality & cause of death of 1,059 white male welders employed between 1943 – 1973 in Tennessee, USA. 1 death from adult leukaemia, 173 deaths from all causes	Welders who were identified using work histories specifying job titles			Observed no of deaths = 1, expected no of deaths = 1.56. SMR not given in paper as no of deaths < 5	Figures given in CHD not in paper. SMR calculated from paper = 0.6
54	Severson *et al.,* 1988	CC: from western Washington State, diagnosed 1981 – 1984. 114 cases of AML, 133 controls	Wire - codes within 42.7 m of residences where subjects had lived in past 15 years	Single measurements of 60 Hz MF inside & outside of residence, taken with appliances switched off (low power) & then again switched back on (high power). RMS calculated from 3 measurements taken at 90^0		OR for Exposure levels (μT) From wire - codes: (longest lived at residence): 0.051 – 0.199 = 0.69 (0.37 - 1.32); ≥ 0.200 = 0.75 (0.31 - 1.80); (residence closest to diagnosis): 0.051 – 0.199 = 0.80 (0.47 - 1.36); ≥ 0.200 = 0.97 (0.47 - 1.98). From weighted measurements: (low power): 0.051 – 0.199 = 1.17 (0.54 - 2.54); ≥ 0.200 = 1.03 (0.33 - 3.20); (high power): 0.051 – 0.199 = 0.91 (0.42 - 1.96), ≥ 0.200 = 1.25 (0.35 - 4.48)	OR given in CHD not in paper. No risk estimates greater than 1.0 statistically significant. No dose - response relation observed
55	Wertheimer & Leeper, 1982						Get paper

6.2.2 Other relevant epidemiological evidence

Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
Alfredsson *et al.,* 1996	Cohort study of male engine drivers & conductors employed by Swedish State railways 1976 - 90. Cancer incidence rates in 7,466 drivers & 2,272 conductors compared against general Swedish population. 14 cases of leukaemia 10 cases of lymphocytic 4 cases of myeloid	Working on electrical trains: low frequency (15 2/3 Hz)	Measured: mean exposure of modern railway engines was 10 μT (range 1 - 54 μT) & higher (20 μT) in older engines. In wagons, mean exposure was approx 7 μT	Not considered	Drivers: Myeloid leukaemia 4 cases, RR = 1.3 (0.4 - 3.3); Lymphocytic leukaemia 8 cases, RR = 2.3 (1.0 - 4.5) Conductors: Myeloid leukaemia 0 cases; Lymphocytic leukaemia 2 cases, RR = 2.3 (0.3 - 8.2)	Significant increased risk observed for lymphocytic leukaemia for drivers & conductors combined
Baris *et al.*, 1996	CC: mortality of 21744 electrical utility workers in Quebec 1970 - 1988, exposed to 60Hz MFs, EFs & pulsed EMFs. 1582 deaths	Exposure classified using JEMs & measurements on 466 workers. SMRs calculated relative to Quebec men, RRs in exposed groups relative to background groups estimated using Poisson regression	Grouped into below & greater than background (0.16 μT for MFs, 5.76 V/m for EFs & 23.70 ppm for pulsed EMFs).	Included	All generation (power plant workers), SMR = 1.38 (95% CI 0.17 - 4.99), (significant at $p<0.5$ two - sided). Linemen, SMR = 0.56 (95% CI 0.01 - 3.14). Substation workers: SMR = 2.16 (95% CI 0.45 - 6.33). No cases among electricians. MFs: SMR = 0.94 (0.30 - 2.19) for ≤BG; SMR = 1.21 (0.44 - 2.64)>BG; RR = 1.41 (0.42 - 4.66). EFs: SMR = 1.16 (0.43 - 2.53) for ≤BG; SMR = 0.98 (0.32 - 2.28) for >BG; RR = 0.92 (0.28 - 3.02). Pulsed EMFs: SMR = 1.20 (0.55 - 2.28) for ≤BG; SMR = 0.71 (0.09 - 2.58) for >BG; RR = 0.67 (0.14 - 3.18)	

Guénel *et al.,* 1996	Nested CC, within cohort of 170,000 male employees of EDF (France) between 1978 and1989. 72 cases of leukaemia, each case matched with 4 controls	Specifically looked at 50 Hz electric fields. Measurements of electric fields were taken to calculate Job Exposure Matrix (JEM). Measurements taken at different workplaces & at different times of year to take account of regional/seasonal variations. Cumulative exposures were calculated (JEM x no of years in job)	Not looked at in this paper (published previously	Both arithmetic (TWA) & geometric mean values used to summarise electric field exposure of a worker	OR (V/m - years arithmetic mean) <253 = 1.00; 253 – 329 = 0.96 (0.45 - 2.03); 330 - 401 = 0.71 (0.27 - 1.92); ≥ 402 = 0.37 (0.11 - 1.28)	
Miller *et al.,* 1996	Nested CC: 1484 cancer cases, 2179 matched controls taken from a cohort of 31, 543 Ontario Hydro male employees. Employees & pensioners followed from 1970 – 1988. 50 cases of all leukaemia, 19 cases of CLL, 13 cases of AML, 8 cases of CML, 10 cases of other	Job exposure matrix created from direct measurements on current workforce with the same job title as subjects	Job title compared against JEM	Job title compared against JEM	OR for EF 172 - 344 V/m – years, all leukaemia = 2.07 (0.59 - 7.22); ≥345 V/m – years, all leukaemia = 4.45 (1.01 - 19.7); OR for MF: 3.2 - 7 μT - years, all leukaemia = 1.67 (0.58 - 4.76); ≥7.1 μT - years, all leukaemia = 1.56 (0.47 - 5.14)	

Feychting *et al.*, 1997	325 leukaemia cases from cohort of 400000		Residual exposure with distance from powerline & MF calculated Occupation from census data & measurements from previous study applied		Occupational exposure ≥ 0.2 μT: 1.7 (1.1 - 2.7); Residential exposure ≥ 0.2 μT: 1.3 (0.8 - 2.2); Both ≥ 0.2 μT: 3.7 (1.5 - 9.4)	Not included in leukaemia in CHD report but in brain, but found positive association
Wertheimer & Leeper, 1987	CC: 1179 cancer cases, death addresses matched with non - cancer deaths in Colorado. Occupational cases - male only. Residential cases – both sexes. Leukaemias taken as a whole	Powerline configurations used as index of residential 60 Hz MF exposure. Occupational exposure also looked at	Occupations classified as "exposed" or "unexposed"	Not included in paper	Occupational exposure: obs/exp = 116 (171 cases males), (X^2 test ≤ 0.10). Residential powerline exposure: C - ratio = 100 (46 cases, both sexes)	

Floderus *et al.,* 1999	Cohort: 1596959 males, 806278 females. All Swedish aged 20-64 years between 1971-1984	Occupations classed as High, medium or low dependent on job description. Job types analysed for MF by personnel dosimetry in a few cases, extended data to cover all cases	MF levels (μT): High ≥ 0.116; Med 0.084 - 0.115; Low < 0.084	Possible, but neither measured or estimated	Males, medium exp: All Ls = 1.0 (0.9-1.1) n = 579, AML = 1.1 (0.9-1.3) n = 184, CML = 1.1 (0.8-1.4) n = 120, ALL = 1.8 (1.0-3.0) n = 36, CLL = 0.9 (0.7-1.0) n = 239; high exp: All Ls = 1.1(1.0-1.2) n = 648, AML = 1.1(0.9-1.4) n = 144, CML = 1.1(0.8-1.4) n = 116, ALL = 1.5 (0.9-2.7) n = 32, CLL = 1.1(0.9-1.2) n = 648; Females, medium exp: All Ls = 1.0(0.8-1.3) n = 173, AML = 1.0(0.7-1.3) n = 71, CML = 0.7(0.4-1.0) n = 35, ALL = 1.3(0.6-2.8) n = 12, CLL = 1.6(1.0-2.3) n = 55; high exp : All Ls = 1.1 (1.0-0.4) n = 263, AML = 1.1 (0.8-1.5) n = 107, CML = 0.8 (0.6-1.2) n = 57, ALL = 1.1 (0.5-2.4) n = 12, CLL = 1.7 (1.2-2.4) n = 87	Not in CHD for brain tumours (only in for breast cancers)
Feychting & Ahlbom, 1994	Nested CC: 223 cases CNS tumour, 1091 controls. Controls matched 2 per case (including 325 Leukaemia cases) matched for age, sex & parish. Population of 382,501 people living near 220 or 400 kV powerlines in Sweden. All occupations, aged 16+, 50% male	Average exposure within house calculated for year of diagnosis, plus 1, 5 & 10 years before date of diagnosis. Also measure cumulative measurements (μT years), and distance from lines	People exposed to residential MFs. Field calculated by computer program taking into account position of lines	Not considered . Corona ions may have been present	Calculated field closest to diagnosis, ≤ 0.09 μT: Field ≥ 0.2 μT, 76 controls: All L: 1.0 (0.7 - 1.7) n = 26, AML: 1.7 (0.8 - 3.5) n = 9, CML: 1.7 (0.7 - 3.8) n = 7, CLL: 0.7 (0.3 - 1.4) n = 7; Cumulative exposure (μT years) 15 years before diagnosis, ≤ 0.99 μT yrs: ≥ 2.0 μT years: All L: 1.5 (1.0 - 2.4) n = 29, AML: 2.3 (1.0 - 4.6) n = 9, CML: 2.1 (0.9 - 4.7) n = 7, CLL: 1.3 (0.6 - 2.6) n = 10	On CHD for CNS tumours, not leukaemia. Many different results – see paper for more details. Number of cases small

6.3 Adult brain cancer

6.3.1 Direct epidemiological evidence from the California Report

No	Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
1	Pearce *et al.,* 1989	CC: 12 cases 476 controls	Occupational study	Estimated from occupation	Estimated from occupation	(0.56 - 1.82), electrical workers	431 workers in total but only 12 in electrical workers
2	McLaughlin *et al.,* 1987	Cohort study of Swedish males diagnosed with cancer 1961 – 79. Cases of intercranial gliomas in various occupations compared with rates in general Swedish population SIR calculations regionally adjusted. 3394 cases, 82% malignant	Occupation as classified in 1960 census	No information given	No information given	Electricians & electronic workers (75 cases), SIR = 0.9. "other" electronics (86 cases), SIR = 1.2. SIR individual occupations (cases): electricians = 0.8 (42), powerline workers = 1.0 (13), telecommunication workers = 1.1 (13)	Figures given for risk estimate in CHD do not appear in paper. No 95% CI given in paper
3	Lin *et al.,* 1985	CC & mortality study of 951 adult white male Maryland residents who died of brain tumours (Glioma & Astrocytoma) between 1969 & 1982, matched by age & date of death	Occupational – level of possible exposure to EM fields based on job title & industry entry, time in job not considered as information unavailable	EMF exposure grouped into 4 categories: A, definite; B, probable; C, possible & D, none	Yes, as study looking at EMFs	Glioma & Astrocytoma: A (27 cases, 14 controls): OR = 2.15 (95% CI 1.10 - 4.06) B (21 cases, 12 controls): OR = 1.95 (95% CI 0.94 - 3.91) C (128 cases, 99 controls): OR = 1.44 (95% CI 1.06 - 1.95) D (323 cases, 360 controls): OR = 1. Non - specified brain tumours: no ORs significantly different from 1	CHD quotes OR = 1.62 (1.12 - 2.34), not found in paper

4	Vagero *et al.,* 1985	Retrospective cohort study 2918 workers in telecommunication industry in Sweden		No EMFs considered	No EMFs considered	CNS tumours SMR 5 obs 5.1 expected 1.0 (95% CI 0.3 - 2.3)	
5	Tornqvist *et al.,* 1986	Cohort Mortality Study: 13 cases nervous system cancer, from power linesmen. 17 cases nervous system cancer from power station operators. From 3358 power linesmen, 6703 power station workers. Swedish born men aged 20 – 64 According to Swedish 1960 census. Cases taken from Cancer environment agency	Standardised Morbidity ration (SMR) used to assess risk with 90% confidence intervals. EMFs not measured	Levels & duration of EMFs not known. EMF exposure classed by job type	EFs may be present – not investigated	For power linesmen: SMR = 1.5 (0.9 - 2.4). For power station operators: SMR = 1.0 (0.6 - 1.5)	CHD slightly different, unclear if CHD calculates 95% CI instead of published 90% CI. Both groups exposed to chemicals which may be confounding.
6	Gubéran *et al.,* 1989	Cohort study of male painters & electricians living in Geneva, 1970 – 1984. 1916 painters 1948 electricians, incidences compared with expected Geneva rates	Occupation as classified in 1970 census	No information given	No information given	2 cases of brain cancer, 1.7 cases expected, SIR = 1.18 (0.21 - 3.70)	CHD has wrong risk measure & wrong 95% CI
7	Speers *et al.,* 1988	Mortality CC: Total 202 cases of white males – gliomas, 69 - 78	Occupational study	Estimated from occupation	Estimated from occupation	OR = 3.94 (1.52 - 10.20) those exposed to EMFs, OR = 2.26 (1.18 - 4.32) in transportation, communication & utilities industries	Age adjusted CHD report takes all exposed EMFs figure

8	Thomas *et al.,* 1987	Mortality CC study, 435 cases, 386 controls. Taken from death certificates of men who died between Jan 1 1979 & Dec 31 1981. Controls matched per case by age at death, year of death & area of usual residence. All white males aged 30 & over From New Jersey, Louisiana & Philadelphia	PMRs found for different estimated exposure to MW/RF radiation. Split into whether exposed to radiation in their job, further divided into electrical / electronics jobs or not electrical / electronics jobs	Measure of EMF exposure not recorded. Occupations were either classed as exposed to MW/RF freqs or not. Jobs also classified by census codes. Duration of exposure assessed	EFs not considered.	Ever exposed to MW/RF rad, 66 cases, 44 controls: RR = 1.6 (1.0, 2.4). Ever exposed to MW/RF rad, electrical or electronics job 44 cases, 19 controls: RR = 2.3 (1.3 4.2). Exposed to MW/RF rad but not in electrical or electronic job, 25 cases 25 controls: RR = 1.0 (0.5, 1.9)	CHD correct. Paper also shows trends for cumulative exposure over time, but significance intervals not quoted.
9	Milham, 1985b	Occupational mortality study 486,000 deaths 5 cancers studied lung, brain, pancreas, kidney & leukaemia	Occupational study	Occupational	Intuitive from occupation	PMR = 123 (101 brain cancers observed ,81 expected)	CHD OR = 1.23 (1.01 - 1.49) unclear as to origin of CI. Cofounders such as fumes could account for excess
10	Coggon *et al.,* 1986	2942 cancers diagnosed, 75 - 80	Occupational study	No EMFs mentioned but electrical workers were looked at	No EMFs mentioned but electrical workers were looked at	R.R 2.0 (7 cases) for electrical workers	CI (0.95 - 4.20) in CHD report does not appear in paper

11	Theriault *et al.,* 1994	CC: 3 cohorts of electric utility workers, Quebec 4151 cases occurred cases = 108, controls = 415, case/control ratio, 1:4.	Occupational exposure to MF. of 50 – 60 Hz. Cumulative exposure calculated using JEM & measurements. Estimates made of past exposure	Exposure groups < median (3.1 µT - years), ≥ median & ≥ 90th percentile (15.7 µT - years)	EF & corona ion exposure depending on occupation i.e. for transmission & distribution workers)	OR = 1.54 (0.85 - 2.81) for ≥ median.	CHD correct
12	Savitz & Loomis, 1995	Cohort mortality study. No workers: 138905 No deaths: 20733 including brain cancer 144. All male, from US electric company employees, 1950 - 1986	Duration/level of exposure by job title (>6 months). Measured (TWA) per job category (2842 measurements) to compile exposure 'matrix'	5 groupings, arithmetic means 0.12, 0.21, 0.39, 0.62, 1.27 µT. Lineman 0.65 µT, electrician 1.11 µT, power plant 0.79 µT	Presumably present in some job areas but not studied	Duration of work RR: 5 - 20yr 1.87 (1.20 - 2.92) 56 cases; >20yr 1.45 (0.83 - 2.53) 27 cases; lineman 5 - 20yr 1.58 (0.89 - 2.80) 15 cases; electrician 5 - 20yr 1.64 (0.89 - 3.03) 12 cases; Total exposure RR: Consistent increase with inclusion of 2 - 10yr latency period: 0 - 0.2 µT - yr 1.17 (0.66 - 2.??) 22 cases; 0.2 - 0.4 µT - yr 1.39 (0.75 - 2.??) 26 cases; 0.4 - 0.7 µT - yr 1.46 (0.76 - 2.??) 22 cases; >0.7 µT - yr 2.56 (1.35 - 4.??); Overall RR per µT - yr 1.94 (1.34 - 2.??); 10 - 20yr latency period RR 1.35 (1.01 - 1.7?); > 20yr latency period RR 1.06 (0.97 – 1.??)	CHD quotes 151 cases. CHD quotes incorrect exposure period (to 1988 - this included the latency period - exposure dates 1950 - 1986). All RRs are different to CHD. RR difficult to read due to photocopy, hence lots of unknown figures (x.??). Overall mortality 1.13 (1.09 - 1.18) 4555 deaths & cancer 1.19 (1.09 - 1.29) 1162 cancers RR slightly elevated

13	Ryan *et al.,* 1992	CC: 170 cases (110 glioma, 60 meningioma), 417 controls. Cases chosen from new diagnoses from S Australia Central Cancer Registry & Australian Brain Tumour Registry. Controls frequency matched for age, sex &s postal code 2:1 ratio. Occupations varied, Aged between 25 & 74, 48% male	Jobs categorised into rough groups: worked in electrical / electronic industry, work with radiation, work with high currents, use of electric blankets, use of electrically heated water beds	Occupational exposure. No measure of field strength or frequency. Exposure status determined by exposure experience up to 2 years before time of diagnosis	EFs not considered	No significant results, positive trends RR & 95% CI found. Glioma, exposed to radiation: RR = 1.30 (0.63 - 2.69), high currents: RR = 0.93 (0.39 - 2.24); Meningioma, exposed to radiation: RR = 1.58 (0.45 – 5.55), high currents: RR = 1.70 (0.32 – 9.15). Significant result occurred for women who work with CRTs: RR = 4.1 (1.28 - 13.24)	CHD quoted first result in table
14	Magnani *et al.,* 1987	CC: using death certificates 642 cases of brain cancer	Occupational study	By occupation	Probably as electrical workers	RR = 1.3 (0.7 - 2.5)	
15	Loomis & Savitz, 1990	Case - control study based on all male deaths in 1985/6 in 16 states of the US. 2173 deaths from brain cancer (76 of which had electrical occupations). Each case matched with 10 controls who died from other causes in same year	Occupational data on death certificates			OR for association of brain cancer with employment in electrical vs other; 1.4 (1.1 - 1.7)	CHD correct. Positive association between electrical occupations & mortality from brain cancer found
16	Preston - Martin, 1989						Get paper

17	Tynes *et al.,* 1992	Cohort: 37945 including 3806 cancers (119 brain cancer), Norwegian workers aged 20 – 70. Group I 1960 census, follow up 1960 – 1985; Group II both 1960 & 1970 census, follow up 1970 - 1985 (for a min 10yr occupational exposure)	Occupational, 5 categories: weak MF, intermediate MF, heavy MF, Weak MF + EF, Radiofrequency. Specified for train drivers (16.67 Hz, 11 kV) & tram drivers (600 Vdc)	Not quantified, grouped as left	Included as part of exposure categories, not measured directly	Overall SIR 1.09 (0.90 - 1.41); Group II SIR 1.14 (0.90 - 1.42); Significant for railway track walkers (weak MF/EF) 2.20 (1.10 - 4.18), 9 cases; heavy MF/EF increased risk but not sig., 1.37 (0.81 - 2.17), 18 cases	CHD gives same SIR but different 95% CI (0.91 - 1.30). CHD specifies SIR for engine drivers 0.67 (0.2 - 1.6)
18	Sahl *et al.,* 1993	3 nested CC: of 36221 workers	Occupational study with sample EMFs measured in comparable jobs	Sample workers used EMDEX II for a day 776 days of measurement	Not considered	Rate ratio 1.09 (0.44 - 2.69) based on 12 cases	
19	Spinellli, 1991	Cohort study: cases of cancer, 1970 - 1985; & deaths from cancer, 1950 - 1985; among 4,213 male workers with 5+ years working in an aluminium reduction plant in British Columbia, Canada ; 7 deaths, 3 incidences	Committee determined whether there was EMF exposure for each job identified from employee records		EMF exposure considered	Cancer Mortality: SMR = 2.17 (90% CI 1.18 - 3.68) ($p<0.015$) (10 cases, 4.61 expected); Cancer Incidence: SIR = 1.94 (90% CI 0.97 - 13.50) (8 cases, 4.12 expected)	Paper mainly about exposure to coal - tar pitch volatiles
20	Gallagher *et al.,* 1991	PMR study: 320423 deaths, 65 deaths from EMF exposed occupations. All male, over 20 from British Columbia, from 1950 to 1984	Number of deaths used to calculate proportional mortality ratio. No EMF measures or metrics	Jobs classed as exposed to EMFs	EF may be present but were not measured	PMR = 121 (93 – 154)	CHD correct

21	Olin *et al.,* 1985	Cohort with control group. No participants: 1243 (108 deaths). No controls: 659 (80 deaths). Male electrical engineering graduates from Sweden RIT technical college 1930 - 1959 (controls architecture grads from same period), exposure period 1930 - 1979	Occupational, unspecified	Unspecified	Not considered	SMR electrical engineering (EE) 1.0 (0.1 - 3.7) 2 cases, architects (A) 2.0 (0.2 - 7.2) 2 cases	CHD different SMRs, CHD quotes 1254 participants but this does not include 11 lost to follow - up as mentioned in paper
22	Törnqvist *et al.,* 1991	Cohort study: Sweden Incidences of cancer 1961 - 1979 compared with data on 1960 census. Males aged 20 - 64 working in electrically related occupation. 133687 men worked in selected occupations. 1905660 men in reference population. 250 cases of brain tumours in selected occupations. 4% glioma, 64% glioblastoma, 22% meningiomas	Job title in 1960 census. Some measurements: median field strength & % of time at field strength < 0.35 μT. All of the median measurements taken in the groups showing increased SMR for brain tumours were < 0.35 μT with the exception of one welder who had a median MF strength measurement of 0.48 μT	Limited information on intensity & duration of MF exposure.	Not measured	Increased SMR found for; assemblers & repairmen in the radio/tv industry: (SMR for all brain = 2.9 (1.2 - 5.9)), welders in the iron/steel industry: (SMR for all brain = 3.2 (1.0 - 7.4), glioma = 4.8 (0.1 - 26.5), glioblastoma = 2.0 (0.2 - 7.3)) and electrical engineers & technicians in the machine industry: (SMR for all brain = 2.2 (0.7 - 5.1), glioblastoma = 2.1 (0.4 - 6.1))	OR in CHD not in paper. No increased risk found for all electrical occupations. Increased risk found for certain occupations (see previous column) but only based on small number of cases. Occupations with increased risk are not the same as occupations with highest median MF measurements

23	Juutilainen *et al.,* 1990	Cohort study, cases: 942. Male industrial workers in Finl& aged 25 – 64 years during 1971 - 1980 according to population census 1970. Looked at all Central Nervous System tumours	Jobs classified by likelihood to be exposed to EMFs, probable, possible & not exposed	Occupational MF estimated as either probable, possible or none. No measurements taken	Not considered	Probable exposure: 13 observed cases. RR = 1.31 (0.7 - 2.3). Possible exposure: 149 observed cases RR = 1.29 (1.0 – 1.6).	Result quoted by CHD is not quoted on paper
24	Schlehofer *et al.,* 1990	German CC: 1987/88. 226 cases (99 males 127 females), 418 controls. Information gathered by interview questionnaire	Occupational histories obtained. Occupations included in study if total working time ≥ 5 years	Exposure divided into three subdivisions: Low, medium & high		RR for electricians (13 cases vs 14 controls) = 1.87 (0.9 - 4.1). Significant excess found for females who had been employed as an electrician for ≥5 years (RR = 5.2 (1.4 - 20.1). Apparent trend seen in women (RR for females in occupations classified as "high" exposure = 11.8 (1.3 - 104.1), 5 cases, 1 control	CHD correct. Females : Increased risk found in exposed occupations. Also dose - response relation observed in females
25	Floderus *et al.,* 1993	CC: cases: 250, controls: 1121. Cases taken from Cancer Register, controls taken from 1980 Census. Aged 20 - 64 in 1980. All male from mid – Sweden, Astrocytoma I – II & Astrocytoma III - IV	Arithmetic mean, Median, Standard deviation, Time > 0.20 μT	MF exposure at work EMDEX meter carried on waist. Measured 1 day 'snapshot' of job held longest in 10 years	Not considered	Mean ≥ 0.29 μT, 270 controls: All: 1.4 (0.9 - 2.1) n = 74, III - IV: 1.5 (1.0 - 2.4) n = 52; Med ≥ 0.17 μT, 255 controls: All: 1.5 (1.1 - 2.0) n = 77; III – IV: 1.7 (1.2 - 2.4) n = 61; SD ≥ 0.71 μT, 259 controls: All: 1.1 (0.7 - 1.6) n = 64, III – IV: 1.1 (0.7 - 1.7) n = 46. Time ≥ 0.2 μT ≥ 29%, 256 controls, All: 1.5 (1.0 - 2.2) n = 69, III – IV: 1.7 (1.1 - 2.8) n = 51	It is not clear to what the CHD published OR refers to – it is not a figure in the paper

26	Preston - Martin, 1989	Case - control study US males aged 25 - 69 diagnosed 1980 – 1984, 272 cases, 272 controls	Occupations likely to involve high exposure to electric & magnetic fields			OR for gliomas: 1.8 (0.7 - 4.8), for meningiomas: 0.7 (0.1 - 5.8). Risk increased with number of years working in occupation (P for trend = 0.008)	OR quoted in CHD do not appear in paper
27	Demers *et al.,* 1991						Get paper
28	Guénel *et al.,* 1993	Cohort of 2.8 million Danes aged 20 - 64 in 1970 Followed for 17 years (1970 - 87). 339 male cases of brain & nervous system cancer. 198 female cases of brain & nervous system cancer	Industry & occupation information collected in 1970 census	Only ELF EMF considered (50Hz). Threshold for MF assumed to be 0.3 μT	Not considered	Male: Intermittent exposure obs = 339, exp = 360.59 obs/exp = 0.94 (0.85 - 1.05). Continuous exposure obs = 23, exp = 33.33 obs/exp = 0.69 (0.44 - 1.04). Female: Intermittent exposure obs = 198, exp = 184.57 obs/exp = 1.07 (0.93 - 1.23). Continuous exposure obs = 9, exp = 7.30 obs/exp = 1.23 (0.56 - 2.34)	RR in CHD not in paper. No increased risk found for males. Slight increased risk found for females, but not significant
29	McMillan & Pethybridge , 1983	CC: mortality of welders & control groups employed in HM Dockyard Devonport 2,568 men with 656 deaths over a 20 year period 0 Welder deaths, 7 control deaths. Proportional mortality study: 656 deaths in the 3 groups	Occupational: Relative deaths in the 3 groups compared to expected numbers	Comparison of welders to control group 1 (moderate exposure) & shipwrights) & control group 2 (no exposure)	Not considered	Welders: PMR = 0, χ^2 = 0.15, control 1: PMR = 99, χ^2 = 0.12, control 2: PMR = 141, χ^2 = 0.1	CHD quotes PMR of 1.00 (0.3 - 4.0), not found in paper

30	Wrensch *et al.,* 1999	CC: 492 cases, 462 controls. Cases newly diagnosed with glioma between Aug 1 1991 & Mar 31 1994 (N Cal Cancer Center). Controls freq matched for age, gender, ethnicity Selected by r&om digit dialling. Average age 54, 57% male, from San Francisco Bay area counties	EMFs measured WL & KS wire coding. Also, measured using EMDEX within houses. Assessed arithmetic mean, median, SD, 90th percentile, % with measures > 2mG & % with measures > 3mG	Residential exposure measured by wire codes, WL: Very high, ordinary high, ordinary low & very low current configuration. KS: High, medium low. EMDEX measuered inside & out of house, 6 10s spot readings, 40 – 800 Hz	EF not considered	No significant positive results were found from wire coding. Only one positive but insignificant result was found, this was for measurements above 3mG (0.3 μT) Based on 20 cases & 11 controls. OR = 1.7 (0.8 – 3.6)	CHD correct
31	Feychting & Ahlbom, 1994	Nested CC: 223 Cases CNS tumour, 1,091 Controls. Controls matched 2 per case (including 325 Leukaemia cases) matched for age, sex & parish. Population of 382,501 people living near 220 or 400 kV power lines in Sweden. CNS tumours included Astrocytoma I - II & astrocytoma III - IV. All occupations, aged 16 upwards 50% male	Average exposure within house calculated for year of diagnosis, plus 1, 5 & 10 years before date of diagnosis. Also measure cumulative measurements (μT years). Also measured distance from lines	People exposed to residential MFs Field calculated by computer program taking into account position of lines	EF not considered. Corona ions may have been present	Calc field closest to diagnosis, ref ≤ 0.09 μT: Field ≥ 0.2 μT 76 controls: CNS: 0.7 (0.4 - 1.3) n = 18, I - II: 0.6 (0.1 - 1.8) n = 3, III - IV, 1.4 (0.8 - 2.5) n = 15. Cumulative exposure (μT years) 15 years before diagnosis, ≥ 2.0 μT years: CNS: 0.7 (0.3 - 1.3) n = 9 I - II: 0.2 (0.0 - 1.3) n = 1 III - IV: 0.8 (0.4 - 1.7) n = 8	CHD quotes value for exposure ≥ 0.2 μT at time of diagnosis. Many different results – see paper for more details. No significant results found for either type of CNS tumour, number of cases, at this point, was small.

32	Feychting *et al.,* 1994	Nested CC: 223 case of CNS tumours	Residential & occupational exposure	Residual exposure with distance from powerline & MF calculated Occupation from census data & measurements from previous study applied		Close to unity: CNS tumour 1.0 (0.6 - 1.7). Astrocytoma I +II: 0.8 (0.4 - 1.9). Astrocytoma III +IV: 1.1 (0.6 - 2.2)	CHD report 1.3 (0.0 - 4.8) - not sure where this figure comes from – have they averaged it?
33	Li *et al.,* 1997	CC: 577 cases, 552 controls, chosen from cancer registries for diseases not thought to be affected by EMFs Matched for age, sex, & date of diagnosis. Both sexes, all occupations aged 15 & over Living in northern Taiwan. Cases taken from National Cancer registry of Taiwan between 1987 & 1992	Relative Risk & 95% confidence intervals calculated. Distance from power line & magnetic field strength calculated & measured	Cases classed as exposed if living within 100m of a power line. MF strengths measured as 0.1 – 0.2 & > 0.2 μT	Electric fields present (as near power lines) but not considered	0 - 49m from line: BTs = 1.3 (0.8 - 2.1) 45:32. 50 – 99m from line: BTs = 0.8 (0.5 - 1.2) 40:51. Exposure > 0.2 μT: BTs = 1.1 (0.8 - 1.6) 71:63	Good number of case / controls Good EMF measurements. CHD result quotes female breast cancer odds ratios
34	Wertheimer & Leeper, 1987	Case - control study. 1179 cancer cases, death addresses matched with non - cancer deaths in Colorado. Occupational cases - male only. Residential cases – both sexes. Nervous system cancers as a whole	Powerline configurations used as index of residential 60 Hz MF exposure. Occupational exposure also looked at	Occupations classified as "exposed" or "unexposed	Not included in paper	Occupational exposure: Obs/exp = 135 (196 cases males) (X^2 test ≤ 0.001). Residential powerline exposure: C - ratio = 227 (36 cases, both sexes) (X^2 test ≤ 0.05). Association found for both occupational & residential MF exposures	CHD correct.

35	Miller *et al.,* 1996	Nested case – control. 1484 cancer cases, 2179 matched controls taken from a cohort of 31, 543 Ontario Hydro male employees. Employees & pensioners followed from 1970 – 1988. 24 malignant (MT), 11 benign (BT)	Job exposure matrix created from direct measurements on current workforce with the same job title as subjects	Job title compared against JEM Interaction between electric & magnetic fields also looked at	Job title compared against JEM	OR for Electric fields: 172 - 344 V/m - years MT = 0.57 (0.10 - 3.17) BT = 0.73 (0.10 - 19.5) ≥ 345 V/m - years MT = 0.99 (0.16 - 6.24) BT = 0.53 (0.03 - 8.10) OR for Magnetic fields: 3.2 - 7 µT - years MT = 1.27 (0.32 - 5.41) BT = 5.38 (0.42 - 69.3) ≥ 7.1 µT - years MT = 2.36 (0.52 - 10.8) BT = 5.64 (0.30 - 105)	CHD correct
36	Tynes *et al.,* 1994a	Nested case - control ratio 1:3 to 5 Cohort size 13,030 male railway workers at 1958, follow up 1958 - 1990 39 cases, 184 controls	Job description, cumulative exposure, time spent at railway line, both EF & MF	16.67 Hz MF measured 1m above tracks, & estimated from tonnage on railway lines. Max 88 µT, min 0.88 µT, yearly average 19.7 µT. Grouped: low (<310 µT - yr), high (310 - 3600 µT - yr), 50/50 split. also v. high (1900 - 3600 µT - yr), 10/90 split	Max spot measurements 0.8 kV/m, min 0.02 kV/m, yearly average 0.34 kV/m Grouped low (< 5k V/m - yr) High (5 – 30 kV/m - yr) V. high (21 – 30 kV/m - yr)	Ever exposed v never exposed OR 0.82 (0.38 - 1.78) 39 cases, 184 controls. Groupings: MF - no significant results e.g. OR high exposure 0.94 (0.39 - 2.25) 14 cases, 68 controls. EF - trend with increasing exposure but not sig & data 'least reliable': Low 0.69 (0.28 - 1.67) 12 cases 80 controls High 1.17 (0.49 - 2.79) 16 cases 64 controls V. high 1.24 (0.33 - 4.52) 4 cases 15 controls	CHD ORs agree. CHD quotes 194 controls, this is incorrect. CHD quotes 13,300 workers, incorrect. CHD states 'electric & non - Norwegian electric train workers' should read 'Norwegian electric & non - electric train workers'

37	Floderus *et al.,* 1994	Cohort study		Drivers had daily average mean 4.03 μT, average median 0.58 μT, conductors daily average mean 0.6 μT, average median 0.36 μT		1.2 (0.8 - 1.9) 8 +16 cases Drivers & conductors 1.1 (0.6 - 2.2) drivers 1.3 (0.8 - 3.6) conductors	
38	Alfredsson *et al.,* 1996	Cohort study of male engine drivers & conductors employed by Swedish State railways 1976 - 90. Cancer incidence rates in 7,466 drivers & 2,272 conductors compared against general Swedish population. 12 cases of astrocytoma	Working on electrical trains	No measurements taken	No measurements taken	Drivers: 10 cases RR = 1.0 (0.5 - 1.8) Conductors: 2 cases RR = 0.8 (0.1 - 2.9) All: 12 cases RR = 1.0 (0.5 - 1.7)	95% CI in CHD wrong. No increased risk observed.
39	Guénel *et al.,* 1996	Nested case - control study within cohort of 170,000 male employees of EDF (France) between 1978 - 89. 69 cases of brain tumours. Each case matched with 4 controls	50 Hz EF. Measurements of EF were taken to calculate JEM, at different workplaces times of year to take account for regional/seasonal variations	Not looked at in this paper (published previously)	Both arithmetic (TWA) & geometric mean values used to summarise EF exposure of workers	(V/m - years arithmetic mean): < 238 = 1.00 238 - 318 = 2.47 (0.99 - 6.16). 319 - 386 = 1.43 (0.46 - 4.45). ≥ 387 = 3.08 (1.08 - 8.74)	CHD correct. OR = 3.08 (1.08 - 8.74) observed for exposure above 90th percentile

6.3.2 Other relevant epidemiological evidence

Author	**Type of study (No of cases + controls)**	**Metrics**	**Level of MF exposure**	**EFs?**	**Or, RR etc**	**Notes**
Baris *et al.*, 1996	CC: mortality of 21744 electrical utility workers in Quebec 1970 - 1988, exposed to 60Hz MFs, EFs & pulsed EMFs 1582 deaths.	Exposure classified using JEMs & measurements on 466 workers. SMRs calculated relative to Quebec men, RRs in exposed groups relative to background groups estimated using Poisson regression.	Grouped into below & greater than background (0.16 μT for MFs, 5.76 V/m for EFs & 23.70 ppm for pulsed EMFs).	Investigated in study.	All generation (power plant workers), SMR = 3.90 (1.26 - 9.10), (significant at p<0.5 two - sided); linemen, SMR = 0.58 (0.01 - 3.23); No cases among substation workers. Electricians, SMR = 4.55 (95% CI 0.55 - 16.45). MFs: SMR = 0.62 (0.13 - 1.83) for ≤BG; SMR = 1.50 (0.60 - 3.09)>BG; RR = 2.48 (0.64 - 9.62); EFs: SMR = 0.86 (0.24 - 2.21) for ≤BG; SMR = 1.24 (0.46 - 2.71) for >BG; RR = 1.47 (0.41 - 5.21); Pulsed EMFs: SMR = 1.34 (0.61 - 2.54) for ≤BG; SMR = 0.36 (0.01 - 2.04) for >BG; RR = 0.29 (0.04 - 2.21)	
Kleinerman *et al.,* 2005	CC	Use of 14 different electrical appliances	Appliance use	Appliance use	1.7 (CI 1.1 - 2.5) risk of Glioma & ever use of hair dryer no dose response 10.9 (CI 2.3 - 50) for meningioma & electric shaver use – increased with cumulative minutes used – only 2 non - exposed	Conclusion no effect - but mind already made up before paper written!

Tynes *et al.,* 1994	Cohort study of 5088 13 cases leukaemia Employed for at least 1 year betweenm 1 Jan 1920 & 31 Dec 1985, all male. All work in hydroelectric power stations in Norway	Standard incidence ratio found. TWA & cumulative exposure to both electric & magnetic fields	Cumulative exposure to MFs (μT years) electric fields (max voltage by years employed). Workers between minimum 0.1 μT & 200 μT, typical values between 1 & 10 μT	Electric fields catagorised in four levels Also estimated cumulative exposure (V years)	Incidence brain tumours amongst all workers. SIR = 88 (47 - 150). Cumulative exposure < 5 μT years (6 observed) SIR = 182. 5 - 35 μT years (5 observed) SIR = 71. > 35 μT years (2 observed) SIR = 44	In CHD for Leukaemia. No supporting evidence for health effects. Decreasing trend of risk with cumulative exposure
Villeneuve *et al.,* 2002.	543 cases, 543 controls, all male, controls individually matched for age	TWA magnetic flux density calculated from occupational measurements. Cumulative index also found. OR found & 95% CI calculated	Catagories of average exposure were: < 0,3, 0.3 - 0.6 & ≥ 0.6 μT. OR compared to < 0.3 μT	EFs may be present in some occupation, but not charactrised	All brain cancers: ≥ 0.3 = 1.11 (0.84 - 1.48) 133:123, ≥ 0.6 = 1.38 (0.79 - 2.42) 42:29. Atrocytomas: ≥ 0.3 = 0.93 (0.60 - 1.44) 51:54, ≥ 0.6 = 0.61 (0.29 - 1.49) 12:16. Glioblastoma multiforme: ≥ 0.3 = 1.50 (0.91 - 2.46) 55:42, ≥ 0.6 = 5.50 (1.22 - 24.8) 18:6	Not included in CHD. High exposure jobs include: sheet metal workers, telephone cable splicers, projectionists, welders, electricians, electronic assemblers & electric utility workers. OR adjusted for exp to ionising radiation & vinyl chloride were similar

Floderus *et al.,* 1999	Cohort: 1596959 males, 806278 females. All Swedish aged 20-64 years between 1971-1984	Occupations classed as High, medium or low dependent on job description. Job types analysed for MFs by personnel dosimetry in a few cases, extended data to cover all cases	MF levels (μT): High ≥ 0.116; Med 0.084-0.115; Low < 0.084	Possible, but neither measured or estimated	Males: Nervous system: Med = 1.1 (1.0 - 1.2) n = 1058, High = 1.1(1.0 - 1.2) n = 1100. Astrocytoma I-II: Med = 1.0 (0.8 - 1.3) n = 111, High = 0.9 (0.7 - 1.2) n = 110. Astrocytoma III-IV: Med = 1.2 (1.1 - 1.4) n = 111, High = 1.3 (1.2 - 1.5) n = 542. Females: Nervous system: Med = 1.0 (0.9 - 1.1) n = 470, High = 0.9 (0.8 - 1.1) n = 598. Astrocytoma I-II: Med 1.3(0.8 - 2.0) n = 42, High = 0.8(0.5 - 1.3) n = 35. Astrocytoma III-IV: Med = 1.1 (0.9 - 1.3) n = 162, High = 1.0 (0.8 - 1.2) n = 212	Not in CHD for brain tumours (only in for breast cancers)
Howe, 1983	Mortality study of 10% sample of Canadian Labour Force. 415 201 males, 128 Brain cancer deaths, entered cohort between 1965 & 1969	Standard mortality rate & 95% CIs found. Occupation codes form census. EMFs not measured or estimated	Job titles given but no indication of MF exposure	Job titles given but no indication of EF exposure	Occupation division with significantly increased risk, n = number deaths. Professional & technical, n = 10, SMR = 1.95, $0.01 \geq p \geq 0.05$. Occupations with significantly increased risk: Highway & bridge maintenance, n = 5, SMR = 2.94, $0.01 \geq p \geq 0.05$, household furniture, n = 5, SMR = 4.61, $0.01 \geq p \geq 0.05$	Included in CHD for leukaemia Does not mention EMFs. Case numbers small

6.4 Miscarriage

6.4.1 Direct epidemiological evidence from the California Report

NB: In this section, the CHD appears to have 2 report number 3s and no number 16.

No	Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
1	Lee *et al.,*2002	CC: 177 cases, 500 controls Cohort to compare 12 & 30 week exposure	MF measurements, wirecode, personal exposure	TWA: < 0.072, 0.072 – 0.093, 0.093 –0.128, >0.128 μT; RCM: < 0.043, 0.043 – 0.062, 0.062 – 0.094, > 0.094 μT; Max: < 1.431, 1.431 – 2.343, 2.343 – 3.505, > 3.505 μT	Probably, but not explicitly defined	Adjusted ORs for quartiles of MF exposure related to RCM (highest - lowest) = 3.1 (1.6 - 6.0); 2.3 (1.2 - 4.4); 1.5 (0.8 - 3.1); For max MF value = 2.3 (1.2 - 4.4); 1.4 (0.7 - 2.8); 1.9 (1.0 - 3.5); For all categories of TWA = 1.7 (0.9 - 3.3) OR front door spot > 0.2 μT = 3.1 (1.0 - 9.7); OR total home TWA > 0.2 μT = 3.0 (1.1 - 8.4); OR other TWA > 0.2 μT = 4.2 (1.5 - 11.4)	Large number of other ORs, some quoted by CHD some not
2	Li *et al.,* 2002	Cohort: 969 subjects	Average & maximum field level by time of miscarriage	Personal exposure meter 40 - 800 Hz broadb& & 100 - 800 Hz harmonic), MF , 5 μT, diary	Probably, but not explicitly defined	RR for women with normal daily pattern during measurements, for MF > 1.6 μT = 2.9 (1.6 - 5.3); RR same at 10 wks = 5.7 (2.1 - 15.7); RR same for susceptible women (previous fetal losses etc) = 4.0 (1.4 - 11.5)	Lots of other RRs included in CHD report

3	Savitz & Ananth, 1994a	Cohort	Wirecode	Measurements < or > 0.2 μT	Probably, but not explicitly defined	No association found, but lack of data on confounders & small numbers of cases	CHD correct
4	Belanger *et al.,* 1998	Cohort N 2967	Use of electric blankets & heated water beds	Questionnaire	Probably, but not explicitly defined	Adjusted OR for electric blanket use at conception = 1.74 (0.96 - 3.15)	No effect wirecode. CHD correct
5	Lee *et al.,* 2000	Cohort of electric blanket (N = 524) & waterbed (N = 796) use	Intensity of setting; TWA: Off, Low = 0.1 μT, Medium = 0.1 – 1.5 μT, High = 0.2 – 2.0 μT; RCM MF; Interviews	Emdex meters (as in Li *et al.,* 2002)	Probably, but not explicitly defined	OR bed heater highest setting = 1.6 (0.6 - 3.3); OR _ 1 hour of use = 1.4 (0.7 - 3.1); OR electric blanket _ 1 hour of use medium setting = 1.7 (0.5 - 5.7 ; OR electric blanket 2 - 5 hours use medium setting = 1.6 (0.4 - 7.2; OR electric blanket, 1 hour of use high setting = 2.9 (1.1 - 9.0)	CHD some different ORs
6	Lindbolm *et al.,* 1992	CC: 191 cases, 394 controls	VDU use by workers' reports & company information	MF measurements for 2 types of VDU	Probably, but not explicitly defined	OR > 0.9 μT = 3.4 (1.4 - 8.6); Model 1, 2.8 (1.1 - 6.8); Model 2; OR > 20 hrs on VDU/week = 2.0 (0.8 - 3.7); OR quantity of work too high = 2.1 (0.8 - 5.2)	CHD gives MF level OR for model 1 only

7	Schnor *et al.,* 1991	Cohort, users & non users of VDTs	Hours of VDT use per week from company records	Measured at VDT & non - VDT workstations	Probably, but not explicitly defined	No elevated OR for VDT use or by hours of use.	CHD correct. Study found same power frequency field exposure for VDT & non - VDU workstations
8	Ericson & Kallen, 1986a	3 cohorts of women	Occupational code from census	By video screen work - high, medium or low	Probably, but not explicitly defined	Weak trend for more spontaneous abortions in high exposure group	CHD correct
9	Ericson & Kallen, 1986b	CC: 3 groups women - 522 cases miscarriage, malformations or low birth weight; 1032 controls	Occupational code from census.	By questionnaire on work with video screen equipment	Probably, but not explicitly defined	Crude ORs significantly elevated + dose dependent effect; Adjusted ORs no effect	CHD correct, adjusted for various factors
10	McDonald *et al.,* 1986a	Cohort: 56012 current & 48608 previous pregnancies from Montreal hospitals; 17632 VDU users	VDU usage	By interview, occupations ranked by % use of VDU	Probably, but not explicitly defined	Excess of abortions in users	Excess due to recall bias?
11	Goldhaber *et al.,* 1988	CC: 1583 pregnant women, clinics in California	Hours of VDT use, trimester	By hours of VDT use	Probably, but not explicitly defined	OR > 20 hrs use compared to none = 1.8 (1.2 - 2.8)	CHD correct. Suggests studying factors such as ergonomics & stress

12	McDonald *et al.,* 1988	Cohort: VDU users 4712 current & 2164 previous pregnancies	VDU use; Occupational title	By VDU use	Probably, but not explicitly defined	OR current pregnancies relative to all working women = 1.19 (90% CI = 1.09 - 1.30); OR highest exposed occupational category = 1.06 (90% CI = 0.8 - 1.4) for current pregnancies & 1.01 (90% CI = 0.7 - 1.3) for previous pregnancies	CHD OR (> 15 hrs use) = 1.23 (1.1 - 2.4)
13	Bryant & Love, 1989	CC: 334 cases, 1 pregnant & 1 postpartum control per case	VDU usage 3 months pre LMP - 4 mths post LMP	By VDU use	Probably, but not explicitly defined	OR = 1.14 (p = 0.47) for postnatal controls	CHD OR (> 20 hrs use) = 1.1 (0.6 - 2.0)
14	Windham *et al.,* 1990	CC:	VDT use	By VDT use	Probably, but not explicitly defined	OR < 20 hrs use per week = 1.2 0.88 - 1.6); OR > 20 hrs = 1.2 (CI = 0.87 - 1.5)	CHD OR = (20 hrs use) = 1.3 (0.9 - 1.8)
15	Nielsen & Brandt, 1990	CC: 2248 spontaneous abortions & 2252 pregnancies from 24352 registered pregnancy outcomes from 214108 commercial & clerical VDT users in Denmark	Job - based VDT use	By VDT use	Probably, but not explicitly defined	RR & degree of VDT use = 0.94 (0.77 - 1.14)	CHD OR (21 - 30 hrs use/week) = 1.12 (0.76 - 1.65)
17	Roman *et al.,* 1992	CC: 150 miscarriages & 297 controls	VDU work	VDU use by interview	Probably, but not explicitly defined	No relation between use, passive use, or time spent using VDUs	CHD correct

6.4.2 Other relevant epidemiological evidence

Author	**Type of study (No of cases + controls)**	**Metrics**	**Level of MF exposure**	**EFs?**	**Or, RR etc**	**Notes**
Hemminki *et al.,* 1980	Cohort 35000 women 'metal workers'	Occupational	By occupation	Probably, but not explicitly defined	7.8 miscarriages per pregnancy and 13.8 miscarriages per birth, significantly higher than population ($p < 0.05$); Electrical workers had 8 miscarriages per 100 pregnancies as opposed to 5.5 in general population; Radio workers had 12 miscarriages per 100 as opposed to 4.8	
Nordstrom *et al.,* 1983	Reproductive hazards among workers at high voltage substations	Electrical occupations	Probably, but not explicitly defined	By electrical exposure	No elevated risk of miscarriage amongst 80 pregnancies from 372 male workers' spouses	
McDonald *et al.,* 1986b	Cohort: 56012 current and 48608 previous pregnancies from Montreal hospitals	Occupation by interview	By occupation	Probably, but not explicitly defined	RR nursing assistants and attendants = 1.24 in current and 1.13 in previous pregnancies; RR food and beverage servers = 1.31 in current and 1.11 in previous pregnancies; RR sales persons = 1.18 in current and 1.12 in previous pregnancies ($p < 0.05$)	
Shaw & Croen, 1993	Review	Various	Human adverse reproductive outcomes and electromagnetic field exposures	Various	Further research needed	Review

Delpizzo, 1994	Review	Various	Epidemiological studies of work with video display terminals and adverse pregnancy outcomes	Various	More research studies of subjects exposed to higher than average ELF fields are needed	Review
Ahlbom *et al.,* 2001	Review	Various	Review of literature on EMF and health	Various	Some evidence, but more research needed	Review
Shaw 2001	Review	Various	Adverse human reproductive outcomes and electromagnetic fields	Various	Lack of epidemiologic data in this area raises the importance of researching this area further	Review

6.4.3 Direct experimental evidence

Author	Description	Results	Notes
Wertheimer & Leeper, 1986	Possible effects of electric blankets and heated waterbeds on fetal development	Seasonal patterns were seen in fetal growth and in abortion rate for families using electrically heated beds	Effect could be due to excessive heat or to electromagnetic field exposure
Wertheimer & Leeper, 1989	Fetal loss associated with two seasonal sources of electromagnetic field exposure	User group reported fetal loss disproportionately often during the season when electromagnetic field exposure was increasing	Many potential confounders not addressed
Chernoff *et al.,* 1992	A review of the literature on potential reproductive and developmental toxicity of electric and magnetic fields	Experimental and epidemiological results to date have not yielded conclusive data to support the contention that such fields induce adverse reproductive effects	More studies needed
Goddijn & Leschot, 2000	Genetic aspects of miscarriage	Chromosome abnormalities involved in 50% first trimester miscarriages	Lots of evidence to show that cytogenetic damage may be caused by MF (Vijayalaxmi & Obe 2005)

6.4.4 Other relevant theoretical evidence

Author	Description	Results	Notes
Reiter, 1980	Importance of photoperiod in reproductive rhythms	Photoperiod mediates reproduction in mammals	
Arendt *et al.,* 1986	Role of the pineal gland and melatonin in seasonal reproductive function in mammals	Pineal involved in reproductive function	
Arendt *et al.,* 1988	How does melatonin control seasonal reproductive cycles?	Pineal involved in reproductive function	
Savitz, 2001	Magnetic fields and miscarriage	Concludes that there is some evidence in support of hypothesis that MF cause miscarriage	Commentary

6.5 ALS/motor neurone disease

6.5.1 Direct epidemiological evidence from the California Report

No	Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
1	Deapen & Hendersen, 1986	CC: 518 cases (19 electrical occupations) 1977 - 1979, 518 controls (5 electrical occupations)	Occupations at risk of electrical exposure	Unknown	Probably, but not explicitly defined	OR = 3.8 (1.4 - 13.0)	CHD states 678 cases but quotes correct OR
2	Gunnarsson *et al.,* 1991	CC: 1067 cases of ALS in Sweden during the period 1970 - 1983 (from census), 32 exposed, compared to random sample of 1005 controls	By census job title: 'electricity worker'	By job title	Probably, but not explicitly defined	OR = 1.5 (0.9 - 2.6) Significantly more male cases than expected among office workers (OR = 1.8; 34 cases) and farm workers (OR = 1.7; 56 cases) Cluster of male cases in agricultural work in one south - western county (OR = 3.4; 25 cases)	CHD OR 1.5 (0.9 - 2.6)
3	Gunnarsson *et al.,* 1992	CC: 92 cases motor neurone disease, 40 ALS, 372 controls	Questionnaire regarding electricity work and exposure to MF	MF levels	Probably, but not explicitly defined	Men: MHOR for electricity work (n = 4) = 6.7 (1.0 - 32.1; MHOR for welding (n = 8) = 3.7 (1.1 - 13.0)	CHD only quotes OR specific MF exposure of 0.6 (0.2 - 2.0)

4	Davanipour *et al.* 1997	CC: 28 patients, 32 controls	Total and average occupational exposure	Occupation classified blindly as high, medium/high, medium, medium/low, or low EMF exposure; classifications based on data from an earlier study designed to obtain occupational EMF exposure	Probably, but not explicitly defined	OR for _ 20 years work (OR) exposed at the 75th percentile of the total EMF exposure data = 7.5 (P < 0.02, 95% CI = 1.4 - 38.1) OR in 75th percentile for average exposure = 5.5 (P < 0.02, 95% CI = 1.3 - 22.5) OR all cases = 2.5 (P < 0.1, 95% CI = 0.9 - 8.1) for total and 2.3 (P = 0.12, 95% CI = 0.8 - 6.6) for average exposure	CHD quotes OR = 2.3 (0.8 - 6.6)
5	Savitz *et al.,* 1998b	CC: 114 cases ALS, x3 controls per case (deaths from other causes)	Occupational, by job title on death certificate, 1985 - 1991	By occupation	Probably, but not explicitly defined	OR TI (n = 9) = 2.2 (1.0 - 4.6); EER (n = 7) = 3.9 (1.6 - 9.2); PIR (n = 5) = 2.9 (1.1 - 7.7); PPO (n = 6) = 4.8 (1.9 - 12.4); EE (n = 25) = 1.0 (0.6 - 1.5); ET (n = 9) = 0.9 (0.4 - 1.9); E (n = 7) = 1.2 (0.8 - 1.7)	CHD OR = 1.3 (1.1 - 1.6)

6	Savitz *et al.,* 1998a	Cohort: electrical workers at 5 utility companies, total of 28 cases	Duration work exposed jobs, index cumulative exposure	MF levels based on measurements. Career exposure: low 0.000 - 0.589 μT years, mid 0.589 - 1.140 μT years, high 1.140 - 15.452 μT years	Probably, but not explicitly defined	Rate ratio for 5 - 20 yrs exposure = 2.0 (0.7 - 6.0); Rate ratio for > 20 years = 3.1 (1.0 - 9.8) Rate ratio for mid - band of cumulative MF exposure (< 20 years) = 2.3 (0.8 - 6.6); Rate ratio for upper - band = 3.0 (1.0 - 9.2)	CHD OR = 2.4 (0.8 - 6.7)
7	Johansen and Olsen, 1998	Cohort: 21236 males employed in utility companies, 14 cases ALS, 9 exposed EMF	Employment records and JEM to estimate average exposure level	MF levels: 1 : < 0.09 μT, 2 : 0.1 – 0.29 μT, 3 : 0.3 – 0.99 μT, 4 :> 1.0 μT	Probably, but not explicitly defined	SMR 1 = 0.9 (95% CI = 0.02 - 5.01), 2 = 1.9 (95% CI = 0.5 - 4.9), 3 = 2.3 (95% CI = 0.7 - 5.4), 4 = 2.8 (95% CI = 0.8 - 7.2)	CHD OR = 2.5 (1.1 - 4.8)

6.5.2 Other relevant epidemiological evidence

Author	**Type of study (No of cases + controls)**	**Metrics**	**Level of MF exposure**	**EFs?**	**Or, RR etc**	**Notes**
Schulte *et al.,* 1996	Cohort: death certificates for white males, 27 states, 1982 - 1991	Occupation	Communication equipment operator (CEO), power plant operators (PPO), electrical equipment repairers (EER)	Probably, but not explicitly defined	PMR for CEO = 284 (114 - 586); for PPO = 274 (118 - 540); for EER = 270 (108 - 555)	OR as CHD
Strickland *et al.,* 1996	CC: 25 cases, 50 controls	Job history	Exposure by questionnaire	Probably, but not explicitly defined	OR for exposure to welding or soldering materials (n = 8) = 5.3 (1.4 - 20.1); OR for jobs in the welding industry (n = 5) = 5.0 (1.0 - 26.0); OR for electric plating (n = 4) = 8 (0.9 - 72.0, P < 0.07)	Very high ORs, but low sample size
McGuire *et al.,* 1997	CC: 174 cases, 348 controls	Occupational: Interview for lifetime work history	Interview for work exposure levels	Probably, but not explicitly defined	OR (exposed to welding dust or fumes) = 1.2 (0.7 - 2.0)	OR as CHD
Ahlbom, 2001	Review	Occupational exposure to ELF EMF	Various, by occupation	Probably, but not explicitly defined	OR all studies = 1.5 (1.2 - 1.7); OR clinical and society studies = 3.3 (1.7 - 6.7); OR mortality registry and census studies = 1.3 (1.1 - 1.6); OR utility cohorts studies = 2.7 (1.4 - 5.0)	Review of papers 1 – 6

Noonan *et al.,* 2002	Separate case referent sets from recorded deaths of Colorado males, 1987 - 1996	Occupational, based on three exposure assessment methods	Electrical versus nonelectrical occupations, 3 - tiered grouping of potential magnetic - field exposure based on a combination of job title and industry, and categories of exposure based on the means of the magnetic fields estimated from JEM	Probably, but not explicitly defined	OR electrical occupations = 2.30 (1.29 - 4.09)	Could only get abstract
Hakansson *et al.,* 2003	Cohort: Swedish engineering industry workers, 537692 men and 180529 women	Occupational exposure	MF levels by JEM and census	Probably, but not explicitly defined	OR = 2.2 (1.0 - 4.7) for the highest exposure group with the suggestion of an exposure - response relationship	OR as CHD
Li and Sung, 2003	Review	Occupational exposure	Various	Probably, but not explicitly defined	Concludes that the there is some consistency in the literature for an association between ALS and occupational exposure to EMF	Review
Johansen, 2004	Review	Occupational exposure to ELF EMF	Various, by occupation	Probably, but not explicitly defined	Association between ELF EMF and ALS; Increasing trend with duration of employment and EMF exposure	Review

6.6 Childhood brain cancer

To be included in a later version of the report.

6.7 Female breast cancer

6.7.1 Direct epidemiological evidence from the CHDA: Residential and electrical devices

No	Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
1	Wertheimer and Leeper, 1987	CC: 27 cases (< 55 yrs), matched controls	Residential and Occupational exposure to EMF	By Wirecode	Possible exposure	6 exposed out of 27 residential cases; total 87 cases had higher potential MF exposure compared to 53 cases (P< 0.01)	CHD: OR = 1.64 (1.16 - 2.33)
2	Fechting *et al.,* 1998	CC: 699 female cases, 699 matched controls	Residential proximity to 220 or 400 kV powerlines	MF calculated, EF and MF exposure	EF measured	RR (MF> 0.2 μT) = 1.0 (0.7 - 1.5); RR (< 50 yrs) = 1.8 (0.7 - 4.3); RR (estrogen receptor - positive breast cancer, MF < 0.1μT) = 1.6 (0.6 - 4.1); RR (estrogen receptorpositive breast cancer, < 50 yrs) = 7.4 (1.0 - 178.1)	CHD Mean OR (< 50 yrs) = 1.80 (0.70 - 4.30)
3	Verkasalo *et al.,* 1996	Cohort: n = 1229 BC cases	Average annual MF within 500 m of powerlines, calculated to be ≤ 0.01 μT	Exposure categories: < 0.20; 0.20 – 0.39; 0.40 – 0.99; 1.00–1.99; > 2.00 μT years	Possible exposure	SIR (numbers of cases for each exposure catagory) = 945, 1.05 (0.98 - 1.12); 130,1.06 (0.88 - 1.25); 87,0.89 (0.71 - 1.10); 44,1.22 (0.89 - 1.64); 23,0.75 (0.48 - 1.13). RR per 1μT year increase in exposure = 0.95 (0.88 - 1.02)	CHD: OR = 1.00 (0.90 - 1.00)

4	Li *et al.,* 1997	CC: 1980 female breast cancers, 1980 matched controls	Residential exposure to 60 Hz MF	Estimated from powerlines	Possible exposure	OR living <50 m from powerlines = 1.0 (0.9 - 1.0); OR living 50 - 99 m = 1.2 (0.9 - 1.5); OR 0.1 - 0.2 μT = 1.1 (0.8 - 1.5); OR > 0.2 μT = 1.2 (0.9 - 1.3)	CHD: OR = 1.10 (0.90 - 1.30); Controls had other cancers not suspected of being caused by EMF
5	McDowall, 1986	Cohort 7631 women living near powerlines	Residential exposure	By distance from lines	Possible exposure	SMR all (n = 22) = 106 (95% CI = 66 - 160); SMR 0 - 14 m (n = 1) = 37 (95% CI = 1 - 26); SMR 15 - 34 m (n = 11) = 122 (95% CI = 61 - 219); SMR 35 - 50 m (n = 10) = 110 (95% CI = 53 - 202)	CHD: OR = 1.06 (0.66 - 1.60)
6	Schreiber *et al.,* 1993	Cohort: 14 female cases	MF exposure	Residential proximity to powerlines or substation transformers, verified by measurement. High group (<100 m): 0.1 – 1.1 μT; Low group (>100 m): 0.02 – 0.15 μT	Possible exposure	SMR by cause of death = 115 (63 - 193, p< 0.05); SMR by distance from source = 96 (n = 5, 31 - 223) for < 100 μT; 128 (n = 9, 58 - 243)	CHD: OR = 1.00 (0.30 - 2.20)

7	Vena *et al.,* 1991	CC: 382 cases and 439 randomly selected community controls, postmenopausal women	Season and mode of electric blanket use	By blanket setting	Possible exposure	OR (10 years of use) = 0.89 (0.66 - 1.19); OR (use vs non - use) = 0.97 (0.70 - 1.35); OR (sometimes use) = 0.64 (0.40 - 1.05); OR (continuous use) = 1.31 (0.88 - 1.95); OR (daily seasonal use) = 1.25 (0.73 - 2.16)	CHD: OR (continuous use) = 1.25 (0.73 - 2.16)
8	Vena *et al.,* 1994	CC: 290 premenopausal breast cancer cases and 289 randomly selected matched community controls	Season and mode of electric blanket use	By blanket setting	Possible exposure	OR (10 years use) = 1.18 (0.83 1.68); OR (daily seasonal use) = 1.27 (0.86 1.88); OR (use throughout night) = 1.43 (0.94 - 2.17); OR (10 years seasonal use) = 1.10 (0.59 2.05)	CHD: OR (continuous use) = 1.43 (0.94 - 2.17)
9	Gammon *et al.,* 1998	CC: 2199 cases < 55 yrs, 2009 matched controls	Use of electric blankets, mattress pads or heated water beds	By appliance use	Possible exposure	OR (< 45 yrs) = 1.01 (0.86 - 1.18); OR (> 45 yrs) = 1.12 (0.87 - 1.43); No variation with duration or type of usage	CHD: OR (bed heater always on) = 1.24 (0.94 - 1.63)

6.7.2 Direct epidemiological evidence from the California Health Report B: Occupational exposures

No	Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
1	Cantor *et al.,* 1995b	CC: 33509 cases and 117794 controls	Occupational by industry	By JEM	Probable	No association	CHD: OR = 1.14 (1.10 - 1.20). Could only get abstract.
2	Cantor *et al.,* 1995a	CC: 29397 white and 4112 black cases; 102955 white and 14839 black controls	Occupational	By occupation, probable level of exposure, probable exposure to VDUs	Probable	OR medium exposure, white = 1.1 1.03 - 1.20), black = 1.29 (1.1 - 1.5); OR by probability of medium exposure, white = 1.14 (1.05 - 1.3), black = 1.29 (1.06 - 1.60)	CHD: OR = 0.97 (0.80 - 1.20)
3	Loomis *et al.,* 1994	CC: 68 cases and 199 controls in electrical occupations; 27814 cases and 110750 controls other occupations	Occupational	By occupation	Probable	OR electrical workers = 1.38 (1.04 - 1.82); Adjusted OR for electrical engineers = 1.73 (0.92 - 3.25), for electrical technicians = 1.28 (0.79 - 2.07), for telephone installers, repairers and line workers = 2.17 (1.17 - 4.02)	CHD: OR = 1.38 (1.04 - 1.82).

4	Coogan *et al.,* 1996	CC: 6888 cases, 9529 randomly selected controls	Occupational	By occupation: Low, Medium or High exposure	Probable	OR high exposure = 1.43 (0.99 - 2.09); OR medium exposure = 1.09 (0.83 - 1.42); OR low exposure = 1.02 (0.91 - 1.15); OR premenopausal women, high exposure = 1.98 (1.04 - 3.78); OR postmenopausal women, high exposure = 1.33 (0.82 - 2.17); other ORs by job	CHD: OR = 1.09 (0.18 - 1.42)
5	Coogan and Aschengrau, 1998	CC:	Occupation, use of electric heating, use of electric blanket, residential proximity to powerlines or substations	By metrics	Probable	OR job high exposure = 1.2 (0.4 - 3.4); OR job medium exposure = 0.9 (0.5 - 1.7); OR exposure to magnetic fields; OR electric heating = 1.0 (0.7 - 1.4); OR electric blanket = 1.0 (0.7 - 1.4); OR < 152m powerline or substation = 1.5 (0.6 - 3.3)	CHD: OR = 1.20 (0.40 - 3.40). Could only get abstract
6	Forssen *et al.,* 2000	CC: 1767 cases, 1 matched control per case	Residential and occupational exposure, age at diagnosis, type of BC	Occupational MF > 0.25 μT, Residential < 300 m powerlines	Probable	Occupational RR (> 0.25 μT) = 1.0 (96% CI = 0.6 - 1.7); RR (< 50yrs at diagnosis) = 1.5 (0.6 - 3.5); RR (< 50 yrs at diagnosis, estrogen receptor - positive BC) = 3.2 (0.5 - 18.9); RR all BC, < 50yrs at diagnosis = 1.50 (0.60 - 3.50)	CHD: OR = 1.50 (0.60 - 3.50)

7	Kelsh and Sahl 1997	Cohort: 40335 workers, 9788 females, 34 BC deaths	Occupational by job type and period of work	By occupation	Probable	SMR = 0.80 (0.52 - 1.17); SMRs lower by specific job type	CHD: OR = 0.80 (0.52 - 1.17)
8	Vagero *et al.,* 1985	Cohort: 2981 telecommunications workers, 867 women, 7 BC	Occupational	By occupational exposure	Probable	SMR = 0.6 (0.3 - 1.3)	CHD OR same
9	Tynes *et al.,* 1996	Cohort: 2619 female radio and telegraph operators, 50 cases, 4 - 7 controls per case	Occupational	RF (410 - 535 kHz, 1.6 – 25 MHz) and ELF MF	Probable	SIR BC = 1.5 (1.10 - 2.00); Adjusted RR (< 50 yrs, n = 20) = 1.3 (0.8 - 2.0); Adjusted RR (> 50 yrs, n = 7) = 2.6 (1.3 - 5.5); Follow up study SIR for specific occupations = 2.5 (n = 13, 1.3 - 4.2); SIR for women working at sea = 5.2 (1.9 - 1.3); various other SIRs	CHD: OR = 1.50 (1.10 - 2.00)
10	Fear *et al.,* 1996	Cohort: 119227 cancers, 450 electrical workers, 83 female BC	Occupational	By occupation and census information	Probable	PRR = 89 (72 - 112)	CHD: OR = 0.89 (0.72 - 1.12)
11	Guenel *et al.,* 1993	Nested CC: EDF workers, 4 randomly selected controls per case	Occupational	By JEM, verified by measurement	Probable	Was unable to find the separate data for Breast cancer, might be in all cancers?? Need to contact authors for this	CHD: OR = 0.96 (0.91 - 1.01)
12	Johansen and Olsen, 1998	Cohort: 96 cases BC in 5871 female utility workers	Occupational	JEM: background (< 0.09 μT), low (0.1 – 0.29 μT), medium (0.3 – 0.99 μT), high (> 1.0 μT)	Probable	SIR = 1.08 (0.90 - 1.30)	CHD: OR = 1.08 (0.90 - 1.30)

13	Petralia *et al.,* 1998	Cohort	Occupational: specific job and occupation category	By occupation	Probable	Elevated exposure categories: scientific research worker SIR = 3.3 (1.4 - 6.5); medical and public health workers SIR = 1.5 (1.3 - 1.8); economists and financial planners SIR = 1.4 (1.2 - 1.7); teachers SIR = 2.0 (1.8 - 2.2); administrative clerks SIR = 1.6 (1.3 - 1.9); political and security personnel SIR = 2.1 (1.6 - 2.6); rubber and plastics products makers SIR = 1.8 (1.4 - 2.3)	CHD: OR = 1.00 (0.80 - 1.20)
14	Kliukiene *et al.,* 1999	Cohort: 1.1 million women with potential ELF MF exposure, 22543 cases	Cumulative work hours exposure > background; Cumulative exposure in μT years	By occupation/industry, 'expert assessment' and previous measurements	Probable	RR > 2000hrs = 1.14 (1.10 - 1.19); RR > 3.0μT years = 1.08 (1.01 - 1.16); Similar RRs in follow up study	CHD: OR = 1.14 (1.10 - 1.19)
15	Floderus *et al.,* 1999	Cohort: 806278 women, 20 - 64 yrs old	Occupational from census	By occupation: Low 0 – 0.067 μT; Medium 0.067 – 0.129 μT; High > 0.138 μT	Probable	RR (1971 - 1977, medium, n = 1754) = 1.2 (1.1 - 1.3); RR (1971 - 1977, high, n = 2194) = 1.1 (1.0 - 1.1); RR (1971 - 1984, medium, n = 4234) = 1.2 (1.2 - 1.3); RR (1971 - 1984, high, n = 4866) = 1.1 (1.0 - 1.1)	CHD: OR = 1.1 (1.0 - 1.1)

6.8 Male breast cancer

6.8.1 Direct epidemiological evidence from the California Report

No	Author	Type of study (No. of cases + controls)	Metrics	Level of MF exposure	EFs?	OR, RR etc.	Notes
1	Demers *et al.*, 1991	CC study of newly diagnosed epithelial breast cancer in men, identified from 10 population-based cancer registries in the US, 1983-1987. 227 cases, 300 controls. Of which there were 33 exposed cases and 26 exposed controls	Exposed occupation; duration of exposed employment; period of exposure; age at first exposure combined with period of exposure; and exposed at age < 30 yrs and ≥ 30 yrs prior to diagnosis for each job category	Grouped into 5 categories by type of likely EMF exposure and the probability of exposure, and not exposed	EMF exposure in general considered	All jobs with EMF exposure (33 cases, 26 controls): OR = 1.8 (1.0 - 3.7). Individuals first employed in exposed job prior to age 30 yrs have excess risk (OR = 2.5, 1.3 - 5.0). Increased risk in persons exposed 30 or more years prior to diagnosis, 25 cases, 15 controls (OR = 3.1, 1.2 -7.9). Excess risk for first exposed before age 30 who had worked in an exposed job 30 or more years prior to diagnosis, 22 cases, 10 controls (OR = 3.3, 1.5 - 7.3), not for all other exposed	CR OR = 1.85
2	Loomis, 1992	CC study of 923000 men over 19 from death registration data from 24 USA states, 1985-1988. 250 cases of breast cancer, 2500 controls. 4 cases had electrical occupations	Occupational data from death certificate. Ratios of observed to expected cases were estimated by OR	Electrical occupation	Electrical occupation considered only.	3 deaths under age 65 yrs in electrical occupations, more than twice as many as expected, OR = 2.2 (0.6 - 7.8). Numbers of cases so low that statistics no reliable	CR correct but does not quote CI

3	Rosenbaum *et al.*, 1994	CC study of male primary breast cancer, identified from the New York State Tumour Registry, 1979-1988, 71 cases, 256 controls	Positive or negative exposure to EMFs based on occupational history	Exposure to EMFs classified as positive if at least one of the jobs held was considered to involve exposure	EMFs as a whole considered.	No increased in risk observed for males believed to have occupational exposure to EMFs. 6 cases, 33 controls, OR = 0.6 (0.2 - 1.6)	CR correct but does not quote CI
4	Theriault *et al.,* 1994	CC: 3 cohorts of electric utility workers, cases among 223492 men. Male breast cancer not mentioned	Occupational exposure to MFs of 50-60Hz. Cumulative exposure calculated using job exposure matrices (JEM) and measurements of MF exposure levels of occupation. Estimates also made of past exposure based on knowledge of current loading, work practises, and usage	Exposure groups < median (3.1μT-years), ≥ median and ≥ 90^{th} percentile (15.7 μT-years)	EF and corona ion exposure depending on occupation (i.e. definite for transmission and distribution workers)	Male breast cancer not reported	Value stated in CR not found in paper

5	Cocco *et al.,* 1998	CC study of 178 male breast cancer cases and 1041 controls, aged 25 - 74, taken from the US national mortality follow-back survey, 1986	Occupational exposure to EMFs assessed by JEM based on 1980 US census occupation and industry codes	Estimated intensity level (none, low, medium and high) based on literature, exposure databases and industrial hygiene reports. Probability of exposure estimated based on proportion of exposed subjects within given job title	EMFs considered as a whole	Exposure to EMFs was not associated with risk of male breast cancer. High probability of exposure, 19 cases, 116 controls, OR = 1.1 (0.6 - 1.9). High intensity of exposure, 9 cases, 55 controls OR = 1.0 (0.5 - 2.1)	CR correct but does not quote CI
6	Stendlund & Floderus, 1997	CC study of occupational exposure to extremely low-frequency MFs in Swedish men aged 20 to 64, 1985 - 1991 56 cases of male breast cancer (adenocarcinoma) selected from cancer registry, compared to 1121 controls	Occupational exposure from job linked to a JEM based on MF measurements	Quartile determination of average daily exposure: Q1: ≤0.15 µT Q2: 0.16-0.19 µT Q3: 0.20-0.28µT Q4: ≥0.29 µT P90: ≥0.41 µT Q1 and Q2 used as reference	Not considered	All breast cancer: P90, 4 cases, 106 controls: OR = 0.7 (0.2 - 2.3) Age ≤60 years: P90, 3 cases, 68 controls: OR = 1.5 (0.3 - 8.3)	CR has quoted the OR for age ≤ 60 years, with estimated average daily exposure of ≥ 0.41 µT

7	Matanowski *et al.,* 1991	Cohort study of 50582 male workers in one state-wide telephone company, 1976 - 80 2 cases under 65 yrs, both central office technicians	Telephone workers, subdivided into job exposure catagories	Jobs divided into exposure categories with measurements of mean magnetic field exposure for each category made. Central office technician mean exposure of 0.25 μT	EMF exposure considered	SIR = 6.5 (0.79 - 23.5)	CR correct but does not quote CI
8	Savitz & Loomis, 1995	Cohort mortality study No. workers 138,905, No. deaths 20,733. All male, from US electric company employees, 1950-1986	Cause of death		Presumably present in some job areas but not studied	6 observed deaths, 7.5 expected, SMR = 0.80 (0.29-1.74)	CR correct but does not quote CI
9	Feychting *et al.,* 1998a	Nested CC study: 9 cases, 72 controls. All cases male, over 16, from Sweden. Controls matched for age, living in same parish, population of 382,501 people living near 220 or 400 kV power lines in Sweden	Average exposure within house calculated for year of diagnosis, plus 1, 5 and 10 years before date of diagnosis. Also measured distance from lines	People exposed to residential MFs. Field calculated by computer program taking into account position of lines	E-fields not considered. Corona ions may have been present	RR for $\geq$ 0.2 μT = 2.1(0.3 - 14.1), 2 cases, 9 controls	CHD correct. All men were $\geq$ 50 years. Sample size very small

10	Tynes *et al.,* 1992	Cohort: Cohort size 37945 including 3806 cancers (12 cases breast cancer), Norwegian workers aged 20-70. 1960 census, follow up 1960-1985. Cancers found from Cancer Registry	Occupational, 5 categories: Weak MF, Intermediate MF, Weak MF + EF, Heavy MF + EF, Radiofrequency Specified for train drivers (16.67 Hz, 11 kV) and tram drivers (600 Vdc)	Not quantified, grouped as left	Included as part of exposure categories, not measured directly	SIR = 2.07(1.07-3.61)	CHD correct. No testing for confounders. Breast cancers not discussed
11	Fear *et al.,* 1996	Analysis of 371890 cancers registered in England, 1981 - 1987. 7981 were among electrical workers, 14 of which were male breast cancer	Occupational information from cancer registry	12 job categories identified as electrical occupations	Probable but not considered	PRR for electrical workers = 129 (71-217)	CHD correct but does not quote CI
12	Guénel *et al.*, 1993						Get paper
13	Floderus *et al.*, 1994	Cohort: All Swedish men. 94 cases Breast cancer, aged 20 to 64 years, employed in 1960. Railway workers	Average daily mean and median (μT) assessed by personal dosimetry	Mean & median by job (μT), 16.66 Hz field, engine drivers 4.03, 0.58 conductors 0.61, 0.36 station workers 0.3, 0.25 rail linemen 0.59, 0.37	EFs present but not mentioned or recorded	Engine drivers: RR = 8.3 (2.0-34.3) n = 2. Conductors: RR = 2.7 (0.4-20.0) n = 1. Engine Drivers & Conductors: RR = 4.9 (1.6-15.7) n = 3. Railway workers: RR = 4.3 (1.6-11.8) n = 4. Railway industry: RR = 2.1 (0.8-5.8) n = 4.	RR for railway workers quoted in CHD, and agrees

14	Tynes *et al.*, 1994b						Get paper
15	Johansen & Olsen, 1998	Cohort: 21236 males employed in Danish utility companies. 2 cases male breast cancer	Employment records and JEM to estimate average exposure level	MF levels: 1 : < 0.09 μT, 2: 0.1 – 0.29 μT, 3 : 0.3 – 0.99 μT, 4 :> 1.0 μT	Probably, but not explicitly defined	SIR = 0.50 (0.1-1.8)	CHD correct. Small number of cases (2)
16	Floderus *et al.*, 1999	Cohort: 1596959 males All Swedish males aged 20-64 years between 1971 – 1984. 84 cases of breast cancer	Occupations: high, medium or low exposure by job description. Job types analysed by personnel dosimetry for some cases	MF levels (μT): High ≥ 0.116, Med 0.084-0.115, Low < 0.084	Possible, but neither measured or estimated	Med: RR = 1.5 (1.0-2.4) n = 47, High: RR = 1.2(0.7-1.9) n = 37	CHD correct

6.9 Alzheimer's Disease

6.9.1 Direct epidemiological evidence from the California Report

No	Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
1	Sobel *et al.,* 1995	CC: Three sets of patients from three separate locations, total of 386 cases (36 exposed), 475 controls (16 exposed)	Primary lifetime occupational exposure	MF > 1 μT = High, 0.2 – 1 μT = Medium, < 0.2 μT = Low		OR for the three series: 2.9, 3 and 3.1; OR combined = 3.0 (1.6 - 5.4, p = 0.001); OR women = 3.8 (1.7 - 8.6, p = 0.001)	CHD OR = 3.0 (1.6 - 5.4)
2	Sobel *et al.,* 1996a	CC: 86 male and 240 female cases over the age of 65; 76 male, 76 female controls – controls had other cognitive impairment	Estimate of EMF exposure levels from occupation	MF > 1 μT = High, 0.2 – 1 μT = Medium, < 0.2 μT = Low		For medium and high exposures combined: OR (adjusted) both sexes = 3.93 (95% CI = 1.5 - 10.6, p = 0.006); OR males = 4.9 (1.3 - 7.9, p = 0.01); OR females = 3.4 (0.8 - 16.0, p = 0.10)	CHD OR = 3.93 (1.5 - 10.6)
3	Feychting *et al.,* 1998	CC: Twins; 55 cases; 2 reference groups of 228 and 238 controls	Occupational exposure from job exposure matrix (JEM): Primary occupation, last occupation, and occupation with the highest MF exposure. JEM validated by measurements	Various exposure levels, highest = > 0.2 μT		For last occupation, for MF > 0.2 μT, RR for Alzheimer's = 2.4 (0.8 - 6.9) and 2.7 (0.9 - 7.8) respectively. For primary occupation RR = 0.9 (0.3 - 2.8)	CHD gave primary occupation only: OR = 0.9 (0.3 - 2.8)

4	Savitz *et al.,* 1998a	Cohort study of electric utility workers 1950 - 1988	Duration of work in exposed jobs, 16 cases > 20 years exposed	Index of cumulative exposure based on magnetic field measurements		OR > 20 yrs = 1.4 (0.7 - 3.0)	CHD OR = 1.4 (0.7 - 3.0)
5	Savitz *et al.,* 1998b	CC: Alzheimer's 24 cases for underlying cause of death, 56 cases for mentioned cause of death, x3 controls matched by age from US death certificates	Occupational - estimated person years of exposure within job categories	Exposure measured as duration of work in exposed jobs and through cumulative exposure index based on measurements		Alzheimer's Standard Mortality Ratio (SMR) = 1.0 (0.6 - 1.5). Career exposure RR for Alzheimer's as underlying cause of death, per μT year exposure = 1.06 (0.93 - 1.21)	CHD OR = 1.2 (1.0 - 1.4), not found in paper
6	Graves *et al.,* 1999	89 cases and controls from a large health maintenance organization in Seattle, matched by age, sex, and proxy type	Occupational: work history obtained by interview	Exposures to EMF were rated as background, intermittent or prolonged high fields by 2 industrial hygienists (IH)		IH1: OR 0.74 (0.29 - 1.92); IH2: 0.95 (0.27 - 2.43) $p < 0.0001$	CHD OR = 0.74 (0.29 - 1.92), 1 reviewer only

6.9.2 Other relevant epidemiological evidence

Author	**Type of study (No of cases + controls)**	**Metrics**	**Level of MF exposure**	**EFs?**	**Or, RR etc**	**Notes**
Schulte *et al.,* 1996	Cohort: death certificates for 27 states, 1982 - 1991	Occupational	Unknown		Cluster of ALS for EMF exposure	Could only get abstract
Noonan *et al.,* 2002	Separate case - referent sets from recorded deaths of Colorado males, 1987 - 1996	Occupational, based on three exposure assessment methods	No consistent association for Alzheimer's		Could not get hold of paper	Could only get abstract
Feychting *et al.,* 2003	Cohort study of economically active individuals in the Swedish 1980 census	Occupational exposure from job - based exposure matrix	MF in μT Calculated by GM of AM of workday measurements. Data analysed by 4 MF levels: 0.11 μT; 0.19 μT; 0.29 μT and > 0.5 μT		Increased risk of Alzheimer's mortality in men (RR = 2.3 (1.6 - 3.3) for exposure > 5 μT	Some evidence that RR higher for higher MF exposure level (by job)
Hakansson *et al.,* 2003	Cohort of 537692 men and 180529 women from Swedish census and mortality data	Occupational - engineering industry workers, job based exposure matrix	Low, medium, high and very high (> 0.530 μT)		Men and women combined RR = 4.0 (1.4 - 11.7) in highest exposure group (65630 subjects). Exposure response analysis RR = 3.2 for an increase in MF of 1μT (1.4 - 7.3)	

Harmanci *et al.,* 2003	Occupational EMF exposure assessed by interview, exposure levels as classified as 'High' or 'Other' by International Standard Classification of Occupations ISCO - 88	Study of all risk factors for Alzheimer's: Screening for cognitive impairment	Population based case control, 6 probable cases and 4 controls had high EMF exposure		Multivariate logistic regression OR 4.02 (1.02 - 15.78, p = 0.006), OR for use of electric heating 2.77 (1.12 - 6.85, p = 0.148)	Small numbers of cases and controls
Qui *et al.,* 2004	Cohort of 931 with 202 cases, all > 75 years old	Occupational - combination of job exposure matrix and direct measurements	MF levels > 0.2 μT		Male RR with MF > 0.2 μT in principle job = 2.3 (1.0 - 5.1); Male RR with average exposure = 2.4 (0.8 - 6.8) for the upper tertile category	
Ahlbom, 2001	Review of CHD Nos 1,2,5,6 and Feychting *et al.,* 2003	Occupational with various methods of determining exposure	Various		ORs: All 5 studies = 2.2 (95% CI = 1.5 - 3.2); 2 clinical studies = 3.2 (95% CI = 1.9 - 5.4); 3 populations based studies = 1.2 (95% CI = 0.7 - 2.3)	Association depends on study type

6.9.3 Direct experimental evidence and other relevant experimental/theoretical evidence

Author	Description	Results	Notes
Skene *et al.,* 1990	Melatonin levels were measured in human pineals and compared with time of death	Daily variations in melatonin levels disappeared in Alzheimer patients (55 - 89 years old)	
Jacobson, 1994	Neurological diseases treated with very low frequency (2 - 7 Hz) very low MF (0.02 nT)	Improvements seen in patients in all cases	Direct correlation between magnetic field stimulation and melatonin production
Sobel, 1996b	Hypothesis associating EMF and Alzheimer's onset, through increased production of amyloid beta, which it is thought may lead to Alzheimer's	There is evidence for EMF leading to an increase in amyloid beta , through interference with the cells' Ca2+ levels (Querfurth and Selkoe, 1994; Baureus Koch *et al*., 2003); and evidence showing amyloid beta crosses the blood brain barrier, leading to Alzheimer's disease (Mackic *et al*., 2002; Zlokovic *et al*., 2005)	
Pappolla *et al.,* 1997	Alzheimer's amyloid peptide (Aβ), a neuropathological marker of Alzheimer's disease, has neurotoxic properties which are mediated by free radicals	Melatonin is effective in reducing oxidative damage and cell death caused by Aβ	
Bubenik *et al.,* 1998	Melatonin might be used in future to treat Alzheimer's	Evidence showing oxidative damage involved in Alzheimer's (Pratico *et al.,* 1998) and melatonin's powerful antioxidant actions	Review
Reiter *et al.,* 1999	Melatonin might be used to treat Alzheimer's	As above	Review

Bartzokis *et al.,* 2000	Alzheimer's may involve disturbances in brain iron metabolism	Iron concentrations are involved in radical action, radicals can lead to oxidative damage, which might lead to Alzheimer's (Pratico *et al.,* 1998)	Review recommends melatonin treatment for Alzheimer's
Pappolla *et al.,* 2000	Review of the role of Aβ in Alzheimer's	Brains with Alzheimer's subject to large levels of oxidative stress. Aβ generates oxygen radicals which cause damage to the CNS leading to neuronal disfunction and loss, which has been linked to Alzheimer's; melatonin protects the CNS from this	Review
Reiter *et al.,* 2004	Review of melatonin's protective role in dementias	Large amount of evidence that melatonin offers significant neural protection against morphophysiological damage and the biobehavioral consequences of Alzheimer's	Review

6.10 Suicide

6.9.1 Direct epidemiological evidence from the California Report

No	Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
1	Reichmanis *et al.,* 1979	598 cases & controls, UK study with data from 1969 - 1976. Control addresses chosen such that they equalled the number of suicide addresses in each geographical area	For each address, computed total E & M field attributable to OH - HV lines. Study split into 3 E field threshold sub categories in which there are ten MF & EF divisions	The respective MF ranges in each E field division were (nT): 0.87 - > 106.2; 0.45 - > 72.4; 0.16 - >27.9	3 E field threshold divisions: 1.0 (V/M); 0.5 (V/M); 0.1 (V/M). Max E field >45.1 (V/M)	No OR/RR. Results inconclusive, $p<0.05$ in distribution of control & suicide addresses for each division Author believes overall picture is indicative of a correlation between OH - HV lines & suicide	CHD states OR (not calculated) higher estimated & measured fields in cases' homes The paper does not back up this assertion There are a greater number of cases than controls at different exposure levels
2	Perry *et al.,* 1981	Adults in UK 1969 - 1976 590 Cases (+ residences) & 594 controls	MF's measured 0.5m from front door, 1m above ground	Ranged from 1 nT - 15 µT mean = 0.08 µT median = 0.04 µT	N/A	MF strength at suicide addresses greater than controls ($p < 0.02$ - extended median test) Significant differences at "high" & "very high" field levels ($p < 0.01$ & $p < 0.05$ respectively)	Ambiguous remark about 'higher measured fields' Different statistical tests showing significant differences in the distribution of case & control addresses within exposure levels

3	McDowall, 1986	Adults resident in close proximity to an electrical installation in UK (based on 1971 census) 8 cases, but three are uncertain size of study = 7631 houses	Homes within 50 m of substation & 30 m powerlines		N/A	For persons resident less than 15m from an installation - SMR of 1.43 (2 cases) Non - significant SMR of 0.75 on 8 cases	Report does not mention the doubts over 3 of the cases & the total size of the study
4	Baris & Armstrong, 1990	Correspondence Used mortality data in UK for 1970 - 1972 & 1979 - 83, observed & expected by occupations likely to have resulted in exposure to electric & magnetic fields	Job titles on death certificates Used official classifications of diseases & occupations	No exposures recorded Surrogate via occupation	No exposures recorded Surrogate via occupation	In Table 1 (15 - 64 yrs; 1970 - 2), observed cases < expected for all occupations except: Radio + radar Mechanics: (obs/exp = 19/12.4 - PMR = 1.53 (95%C.I. = 0.92 - 2.39)); Telegraph radio operators: (obs/exp = 10/3.9 – PMR = 2.46 (95%C.I. = 1.23 - 4.71)); Electronic engineers: (obs/exp = 16/10.2 – PMR = 1.56 (95%C.I. = 0.89 - 2.53). Table 2 – no significant results (1979 - 1983)	Used PMRs to 'avoid the numerator/ denominator bias in SMRs'
5	Johansen & Olsen, 1998a	Danish study 21236 men employed in utility companies 1900 - 1993 Causes of death found from 01/01/1974 - 31/12/1993/	Analyzed by latency & estimated levels of 50Hz MF exposure JEM (475 average levels of exposure during working day)	5 categories of exposure: background (≤0.09 μT); Low (0.1 - 0.29 μT); Medium (0.3 - 0.99 μT); High (≥1.0 μT); Unknown (~)	N/A	Table 2: 133 observed SMR = 0.9 divided by time since first employment SMR of 1.0 for 10 - 29yrs. Table3 Suicides by exposure Background (n = 19):SMR = 1.0; Low (n = 37):SMR = 0.8; Medium (n = 41):SMR = 0.9; High (n = 36); SMR = 1.4	Concludes study does not support the hypothesis of a link between occupational exposure to 50 Hz EMF & excess suicide mortality. Missed SMR's from length of time since first employment

6	Baris *et al.,* 1996a	n = 21744 in cohort Hydro Quebec male utility workers employed between 1970 - 1988	JEM from 2066 workweek EMF measurements (50/60Hz MFs & EFs & pulsed EMF) compared to blue - collar & white - collar workers	(1)<0.16 μT vs >0.16 μT (11vs.20) (3)<23.7 ppm vs.>23.7ppm (19vs.12) All pulsed measurements	(2)<5.76 (V/M) vs.>5.76 (V/M) (11vs.20)	RR: (1) = 1.7 (0.8 - 3.6). (2) = 1.6 (0.8 - 3.4) (3) = 1.3 (0.6 - 2.8). SMR: < 0.16 μT = 0.5 (0.30 - 1.02); > 0.16 μT = 0.77 (0.47 - 1.19); < 5.76 (V/M) = 0.5 (0.25 - 0.89); >5.76 (V/M) = 0.77 (0.47 - 1.19); < 23.7 ppm = 0.6 (0.36 - 0.93); > 23.7 ppm = 0.74 (0.38 - 1.29)	Report quotes figures as ORs but they are RR & they neglect to mention the SMRs given for these exposures
7	Baris *et al.,* 1996b	n = 21744 Quebec male utility workers 49 deaths from suicide between 1970 - 1988 subcohort (215) was selected comprising a 1% random sample as a basis for risk estimates, deaths identified by company records or by retirement system	Cumulative & current exposures to electric, magnetic & pulsed EM fields were estimated for the subcohort & cases through a JEM	AM MF (< 4.53, 4.53 - 10.36, >10.36 all μT). GM MF (<1.25, ≥1.25 - <2.08, ≥2.08 all μT). AM Pulsed	EMF (<1.10, ≥1.10 - 6.40, ≥6.40). E AM (<136.10 V/M - yr – 308.6 V/M - yr) GM E (<23, ≥23 - <40.30, ≥40.30 all V/M - yr)	Table 6 Only significant results are for the cumulative exposure, geometric mean of the E field (V/M - year) all RR. < 23 (RR = 1.0) is background (16vs.106). ≥23 - <40.30: unadjust. = 2.76 (1.15 - 6.62); Adj.SES = 2.59 (1.08 - 6.22); Adj.SES,M, Alc. = 3.10 (1.18 - 9.21); Adj.all = 2.75 (0.93 - 8.11). ≥ 40.30: no significant results	Report claims results to be OR, when in fact it is relative risk (relative to background) & they only quote one type of adjusted result It does however show the non - significant results for cumulative geometric mean MF results
8	Kelsh, 1997	Cohort mortality study 1960 - 1991 n = 40335 Utility workers in the US Total deaths = 3,753 M = 75% F = 25% of study	Collapsed 20 occupational categories into seven general groups Split cohort into ≤ 15 years & > 15 years	Length of service in different occupations within the utility company	N/A	104 suicides in study (SMR - 0.61 (95%C.I. = 0.50 - 0.74) M = 95 (SMR = 0.62 (0.5 - 0.75)), F = 9 (SMR = 0.53 (0.24 - 1.01). By occupational category, using mRR. Positive results: linemen = 2.03 (1.09 - 3.76), plant operators = 2.65 (1.26 - 5.54), trade/craft = 1.98 (1.03 - 3.82)	

9	Van Wijngaarden *et al.,* 2000	Nested case - control study cohort of 138905 male electric utility workers 536 deaths from suicide & 5348 eligible controls. Workers must have been employed for 6 months continuously between 01/01/1980 - 31/12/1980	Estimated exposure was classified based on work in the most common jobs with increased exposure MFs based on measurement survey. Randomly selected workers wore personal exposure meters TWA	2842 MF measurements obtained 5 average TWA exposure groups: 0.12, 0.21, 0.39, 0.62, and 1.27 μT (converted to μT - years for occupational exposure)	N/A	For recent exposure (μT - years): 0: 294 cases, OR = 1.0 >0 - 0.029:58, 1.19 (0.75 - 1.89), 0.03 - 0.049:62, 1.41 (0.85 - 2.34), 0.05 - 0.11:62, 1.63 (0.97 - 2.71), ≥ 0.12:60, 1.70 (1.0 - 2.90). Men < 50 years: OR range = 2.12 - 3.62. Suicide mortality increased relative to work in exposed jobs & with indices of exposure to MFs. Years of employment as electrician: OR = 2.18 (1.25 - 3.80); linemen: OR = 1.59 (1.18 - 2.14). Dose response gradient with exposure to MFs was found for exposure in previous year with a mortality OR = 1.70 (1.0 - 2.9)	Many results missing from CHD. exposure category

6.9.2 Other relevant epidemiological evidence

Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
Stoupel *et al.,* 1995	All suicides (n = 2359) registered in the State of Israel from 1981 to 1989 (108 months) were analysed & compared with the total number of deaths (n = 15601) & deaths from MI (myocardial infarction, n = 1573) in a large university hospital over 180 months (1974 - 1989)	Monthly correlation with parameters; space proton flux; radiowave propagation (max & min.); geomagnetic activity (K index); hours of –'ve ionization; hours of +'ve ionization of the atmosphere; sudden magnetic disturbances of the ionosphere (Sd); smoothed sunspot number (R); sunspot number (W); solar radio flux at 2.8 GHz Assumed that underlying mechanism is serotonergic			Table 2 shows significant negative correlations between total number of suicides & between suicides in men & (a) GMA (K - index):Total r = - 0.2188, p = 0.03; Male r = - 0.277, p = 0.006) (b) sudden magnetic disturbances of the ionosphere (Sd): Total r = - 0.23, p = 0.02; Male r = - 0.278, p = 0.006. Also correlated strongly with space proton flux.	

Gordon & Berk, 2003	A retrospective study over a 13 year period				The effect was shown to be stronger in females ($p<0.005$) than males ($p<0.025$)	The authors found a correlation between suicides & average storm activity in South Africa between January 1980 & December 1992
Partonen *et al.,* 2004	Finnish study, 1979 – 1999, cases = 27469 The daily data on the number of suicides & the mean & maximum levels of GM activity were compiled & modelled with Poisson regression using the number of inhabitants in a province as the denominator	Time series analysis of monthly numbers of suicides was carried out using seasonal - trend decomposition procedure	*Ak* values: < 9.5; 9.5 - 11.8; 11.8 - 17.0 > 17.0	Wolf number (solar) < 50 50 - 100 > 100	Strong seasonal effect on suicide occurrence ($p < 0.00001$), risk being greatest in spring (May – RR = 1.25 (1.18 - 1.32); June – RR = 1.20 (1.13 - 1.27)). High levels of solar activity were associated with the increased risk of suicide ($p < 0.00001$). For GM, > 17 vs < 9.5, RR = 1.08 (1.05 - 1.12)	
Berk *et al.,* 2006	Relationship between *Ap* indices of geomagnetic storm activity & national suicide statistics for Australia from 1968 - 2002 51485 males & 16327 females	Whether suicide occurred on a day defined as a geomagnetic storm.	*Ap* index ≥ 100nT Vs. *Ap* index < 100nT		The average number of suicides was greatest in spring for males & females, & lowest in autumn for males & summer for females Suicide amongst females increased significantly in autumn during concurrent periods of geomagnetic storm activity ($p = .01$) this pattern was not observed in males ($p = .16$)	

6.11 Heart disease

6.11.1 Direct epidemiological evidence from the California Report

No	Author	Type of study (No. of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc.	Notes
1	Baris *et al.*, 1996	CC: mortality of 21744 male electrical utility workers in Quebec 1970 - 1988, exposed to 60Hz MFs, EFs & pulsed EMFs 1582 deaths	Exposure classified using JEMs & measurements on 466 workers. SMRs calculated relative to Quebec men, RRs in exposed groups relative to background groups estimated using Poisson regression	Grouped into below & greater than background (0.16 μT for MFs, 5.76V/m for EFs & 23.70ppm for pulsed EMFs)	Included	Number cases above:below: MF > 0.16 μT, 137:180, RR = 0.91(0.73-1.14); EF > 5.76 V/m, 130:187, RR = 0.76(0.61-0.95). PEMF > 23.7 ppm, 68:249, RR = 0.87(0.66-1.14)	CHD correct. No separation of different heart diseases.
2	Savitz *et al.,* 1999	Cohort mortality study of 138,902 workers. All male, worked 6 months or more between 1950 and 1986	Standardized mortality ratios found. Many MF metrics, primary metric was duration of employment in job with greater than background MF exposure	Total exposure (μT years): 0 - 0.6, 0.6 - 1.2, 1.2 - 2.0, 2.0 - 4.3 and ≥ 4.3	EFs present but not measured. Possibilities of electric shocks	For Acute myocardinal infarction (heart attack): 0.6 - 1.2 μT, n = 852: RR = 1.14 (1.04 - 1.26); 1.2 - 2.0 μT, n = 899: RR = 1.19 (1.08 - 1.31); 2.0 - 4.3 μT, n = 946: RR = 1.35 (1.22 - 1.48); ≥ 4.3 μT, n = 510: RR = 1.62 (1.45 - 1.82); Slope (RR/μT-yr) = 1.04 (1.03-1.06) For Arrythmia related): 0.6 - 1.2 μT, n = 49: RR = 1.57 (1.04 - 2.37); 1.2 - 2.0 μT, n=42: RR = 1.26 (0.81 - 1.97); 2.0 - 4.3 μT, n = 40: RR = 1.24 (0.79 - 1.95); ≥ 4.3 μT, n = 34: RR = 2.40 (1.48 - 3.89); Slope RR/μT-yr: = 1.08 (1.03 - 1.12)	CHD correct. Many more metrics. No significant risk of Atherosclerosis and Chronic coronary heart disease. Increasing slope with exposure over time

3	Kelsh *et al.,* 1997	Cohort mortality study. 40335 workers among an electric utility workforce worked at least 1 year between 1960 and 1991. Male and female, 3753 deaths	Standardised mortality rates found. No EMFs. Workers classified by occupation category. Mantel Haenszel summary rate ratios compared sub-cohorts	MFs not measured or estimated. Electrical utility jobs may experience MFs	EFs not measured or estimated. Electrical utility jobs may experience EFs	Electrical utility workers: all workers, n=1,277: SMR = 0.62(0.59-0.65); Occupation groups wrt reference group (admin/technical): Management/pro: mRR = 1.19 (0.94 - 1.50); Service/labour: mRR = 1.48 (1.15 - 1.91); Linemen: mRR = 1.42 (1.18 - 1.71); Meter reader/ field service: mRR = 1.71 (1.13 - 2.58); Plant operations: mRR = 1.56 (1.26 - 1.94); Trade/craft: mRR = 1.44 (1.19 - 1.73)	CHD quotes risks for individual occupational categories. No increased risk for electrical works. No separation of different heart diseases. MF exposures not defined

6.11.2 Other relevant epidemiological evidence

No	Author	Type of study (No. of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc.	Notes
	Srivastava *et al.,* 1980	Daily admissions of myocardial infarction (heart attack) cases to the Intensive Coronary Care Units of the three main hospitals in Hyderabad and Secunderabad for 1978 (high sunspot year) are studied against the corresponding daily sums of the three-hourly planetary geomagnetic activity indices K_p and the local indices *K* Similar computations are made with the freshly abstracted medical data and the geomagnetic data for 1972, which was a low sunspot year, for control	Three-hourly planetary geomagnetic activity indices K_p, and the local indices *K*. Sunspot number (yearly)	No direct exposure	No direct exposure	For the monthly mean data for 1972 there was a correlation coefficient of r=+0.59 ±0.20 which is statistically significant. A 50% increase in hospital admissions for myocardial infarction was observed during 1978 compared with 1972, suggesting a relationship with years which have a high sunspot number	

6.12 Depression

6.12.1 Direct epidemiological evidence from the California Report

No	Author	Type of study (No of cases + controls)	Metrics	Level of MF exposure	EFs?	Or, RR etc	Notes
1	Ahlbom, 2001	Literature review meta - analysis technique. Notes on the individual papers reviewed will be inserted in the table as individual papers	See individual papers			"For suicide an overall assessment yields the conclusion that the support for an association is weak For depressive symptoms the assessment is more complex, but the overall conclusion is nevertheless that the evidence is relatively weak." Dowson & Perry have methodological limitations related to the procedures for selection of study subjects & also because they did not use validated scales for identification of depressive symptoms. Perry also reports high EMF levels (average) (0.23 μT cases & 0.21 μT controls). Poole *et al.,* shows a clear association between proximity to power line & depression RR = 2.8 (1.6 - 5.1). McMahon is a similar study but RR = 0.9 CI = 0.5 - 1.9. Savitz - some indications for specific jobs. In Verkasalo *et al.,* - clear excess risk for severe depression among those living < 100 m of transmission lines	

2	Dowson *et al.,* 1998	England: Persons near 132kV power lines & people > 3miles	Distance between home & lines. Questionnaire on depression			132 people near to lines, 9 with depression 94 > 3mils, only 1 with depression	
3	Perry *et al.,* 1989	England: Persons discharged with depression from hospital. Controls from electoral roll	Measurements at front doors Average for cases & control groups compared	Means = 0.21 μT & 0.23 μT		359 patients Cases had average exposure of 0.23 μT & controls had an average exposure of 0.21 μT	
4	Poole *et al.,* 1993	US: 8 towns along a transmission line in 1987. Cut off for depression was median of score from interview	Distance to power line: near or far			382 interviewed: RR = 2.8 (1.6 - 5.1)	
5	Savitz *et al.,* 1994	US Male veterans from the US army (19665 - 1971) with lifetime depression	Present job identified in interview. Duration as electrical worker			183 electrical workers (13 with lifetime depression) & 3861 non - electrical workers RR = 1.0 95%C.I. = 0.5 - 1.7	
6	McMahan *et al.,* 1994.	US Sample of homes near a powerline & one block away. Depressive symptoms identified by questionnaire & scale	EMDEX measurements at front door	Average homes close to power line = 0.486 μT. Average one block away = 0.068 μT		152 women. RR = 0.9 (0.5 – 1.9)	

7	Verkasalo *et al.,* 1997	Finnish twins who had answered the Beck Depression Inventory in 1990 n = 12063	Residential MF estimated from power lines near homes			BDI scores not related to exposure Clear association within 100m of home	
8	Beale *et al.,* 1997	540 adults/ 374 households near transmission lines completed neuropsychological tests. Initially chose properties found whose gate reading was > 0.5 μT For each such house, another was selected with gate reading < 0.3 μT people must have resided ≥ 6 months	MF measurements taken in each room occupied for at least one hour per day to provide an estimate of total - time - integrated exposure	3 measurements were taken on different parts of the subject's bed MF ranges (μT) (Mean, min, max) Individual reading: 0.692, 0.001, 19.43. Room:0.692, 0.001, 14.12. Average exposure: 0.674, 0.001, 7.580. Time - integrates (μT - hour): 10.014, 0.003, 97.403		Significant linear does - response relationships were found between exposure & some psychological & mental health variables.	Little information in report.

6.11.2 Other relevant epidemiological evidence

Author	**Type of study (No of cases + controls)**	**Metrics**	**Level of MF exposure**	**EFs?**	**Or, RR etc**	**Notes**
Friedman *et al.,* 1963	A four year study (1957 - 1961) in the US Looking at possible correlation between *ak* & *ap* sums of geomagnetic K indices from Fredericksburg & incidence of geomagnetic storms & admissions to seven psychiatric hospitals & one psychiatric unit in a general hospital in New York.	Examined 7, 14, 21, 28 & 35 day periods for correlation To obtain the values, the number of admissions for every possible consecutive 7, 14, 21, 28 & 35 day period was summed & correlated with the geomagnetic parameter sums for the corresponding periods	*ak* & *ap* sums were summed from local & global 3h k indices A listing of principal storms between 1957 - 1961 was compiled to compare admissions to the greater intensities of geomagnetic disturbance		Correlation coefficients, r, derived from comparison of total geomagnetic activity parameters, *ak* & *ap*, with hospital admissions are negligible in magnitude regardless of the time - period used. Geomagnetic storms: 14 coefficients obtained by using the 14 day periods range from + 0.077 to 0.221 (this figure is significant): median r = 0.117. 21 day period coefficients: range 0.116 - 0.305 (5 are stat sig.), median r = 0.182. 28 day correlations range: 0.167 - 0.332 (13 are significant): median r = 0.261. 35 day correlations range: 0.222 - 0.345 (11 significant): median r = 0.279	Not in CHD report. Results in this study suggest that statistically significant low to marked linear relationships exist between geomagnetic parameters & a gross measure of human disturbance These relationships are evident when the measure of the geomagnetic parameter is restricted to those periods of higher disturbance which can be categorized as magnetic storms

Kay, 1994	UK Association with Incidence of Depression as Measured by Hospital (Lothian Psychiatric Case Register) admission: Jan 1976 - Dec 1986. Period of 4018 days: 192 geomagnetic storms. Psychotic depression: M = 1042; F = 2407 female admissions. Non - Psychotic depression: M = 582; F = 1472	AA index (mean daily disturbance) obtained from two antipodal observatories for all storms during solar cycle 21 Converted from K index Admissions by sex & diagnosis were summed for three consecutive 7 - day periods after each storm date to account for possible lag times Controls summed for 7 - day quite period in preceding 21 days			Control group: post - storm periods in male psychotic depression: significant increase in the 8 - 14 day period (after storm), of 36.2% for same group smaller, but not significant, increases "The results support the hypothesis that a geomagnetic disturbance is associated with a subsequent increase in the incidence of psychotic depressive illness in males, but no significantly in females or non - psychotic depressions	
Zyss *et al.,* 1997	Epidemiological pilot study in Poland Study conducted in low SE suburb adjacent to an easement containing two 400kV power lines (distance up to 50m from line) Study size = 70 (35M:35F) Control group (not exposed to EMF) = 37	EMF intensity measured Depression & other disorders measured using established tests such as Beck's		Measurements of the EF taken at the front walls of buildings, averaged much higher than normal 'safe' values	The difference between the group exposed to EMF & the control population was statistically significant	Get paper

Wilson, 1988	Review of literature with focus on depressive disorders associated with circadian rhythm days. Chronism for which pineal gland function acts as a convenient marker					
Raps, 1991	Pilot study Israel, examined admission data in period 1977 - 1987 for a ingle psychiatric unit Total admissions = 1829, ages 18 - 97	Calculated correlations of solar & GMA levels with distribution of monthly admissions Main parameters were: (a) Solar radio flux at 2.8 GHz; (b) sudden magnetic disturbances of the ionosphere; (c) monthly index of geomagnetic activity (*K*); (d) hours of positive ionization of the ionosphere			(a) $r = +0.197$, $p<0.05$ (b) $r = +0.274$, $p<0.01$ (c) $r = -0.216$, $p<0.05$ (d) $r = -0.262$, $p<0.01$ Also Solar radio flux was correlated with sudden magnetic disturbances of the ionosphere: $r = 0.969$, $p<0.001$	