# Evaluation of the literature on high-voltage power lines and health part I

Cancer in children

No. 2018/08Ae, The Hague, April 18, 2018

Backgrounddocument to:

Power lines and health part I: cancer in children

Nr. 2018/08e, The Hague 18 April 2018

Health Council of the Netherlands

# contents

# 01 introduction

This is the backgrounddocument to the advisory report *High-voltage power lines and health part I: childhood cancer*, drafted by the Electromagnetic Fields Committee of the Health Council of the Netherlands. In Chapter 2 the Commiittee describes the search strategies used for the various topics and the selection process of the relevant papers.

In Chapter 3 the Commission reports on the methods and criteria used in the assessment of the scientific quality of the relevant papers.

In Chapter 4 core data of all relevant papers are presented in tables arranged by subject.

In Chapter 5 the Committee describes the meta-analyses it performed and presents the results. The most important conclusions are given in the main report.

Chapter 6 contains the framework for assessing causality that is used in the report.

# 02 search strategy

Searches have been performed in PubMed for epidemiological studies on the association between leukaemia and other types of cancer in children, and distance to power lines and exposure to magnetic fields. In the following paragraphs, details of the search strategies are provided per topic: the search terms, the date the search was performed and the number of papers retrieved. Some of the original searches were performed in 2016. No search updates have been performed, but new papers have been retrieved by an ongoing daily search update in PubMed. This has yielded one additional relevant paper as indicated below. In addition, several papers have been retrieved from other sources: reviews, reference lists and personal literature collections. The papers retrieved have been selected for further analysis on the basis of title. In some cases, subsequent full-text analysis showed them to be not relevant. Relevant data of the remaining papers have been extracted and transferred to a database. The number of papers included in the main report is indicated. The relevant data of these papers are presented in the tables in Chapter 4.

The Committee confined itself to epidemiological studies, since these are the most important source of information for this topic. For an overview of experimental animal and in vitro studies, the Committee refers to two important reviews.[1,2]

## 2.1 Leukaemia: distance to power lines

Search terms: (“extremely low frequency” OR “magnetic fields” OR “power line” OR “power lines” OR ELF) NOT (epithelial lining fluid OR ELF-phosphatase) AND (leukaemia OR leukemia) AND (distance OR near) AND epidemiol*.

Search performed on 20-01-2016. Result: 75 papers (children and adults).
Selected for further analysis: 21 papers on children.
Other sources: 2 papers on children.
In main report: 23 papers on children.

### 2.2 Leukaemia: magnetic fields

*Meta- or pooled analyses children*
Search terms: (meta-analysis OR pooled analysis) AND (leukemia OR leukaemia) AND (magnetic field* OR electromagnetic field* OR power line* OR low frequency).
Search performed on 16-06-2016. Result: 107 papers (children and adults). Selected for further analysis (2000-2016): 5 papers on children.
In main report: 3 papers with pooled analyses and 16 papers included in these analyses.

*Recent papers children*
Searched for papers published after the closing date of the most recent pooled analysis: (leukemia OR leukaemia) AND (magnetic field* OR electromagnetic field* OR power line* OR low frequency) AND (“2006”[Date - Entrez] : “3000”[Date - Entrez]) AND epidemiol*) NOT review.
Search performed on 16-06-2016. Result: 751 papers (children and adults). Selected for further analysis: 15 papers on children.
Paper published after search was performed: 1.
Not relevant: 5 papers.
In main report: 11 papers on children published after 2006.
In the main report the older and more recent papers have been analysed together.

### 2.3 Other types of cancer

Search terms: (“extremely low frequency” OR “magnetic fields” OR “electromagnetic fields” OR “power line” OR “power lines” OR ELF) NOT (epithelial lining fluid OR ELF-phosphatase) AND cancer AND epidemiol* AND child*.
Search performed on 24-10-2017. Result: 459 papers. Selected for further analysis: 54 papers.
Not relevant: 36 papers.
In main report: 12 papers on brain tumours, 6 papers on lymphomas.

# 03 assessment of the quality of available studies

The quality of the relevant papers has been judged independently by three Committee members (two epidemiologists and one statistician). They evaluated whether there was a high risk of bias. In that case the study was qualified as of insufficient quality. This was the case when (for all studies):

- no specific cancer types were reported, but only cancer in general;
- the study could not be properly evaluated because of missing essential data;
- the exposure was not adequately assessed (exposure was not determined for each individual case and control, but only at a higher level, e.g. for a certain area);
- there was a considerable risk of selection bias (for instance because cases and controls came from different populations, as is the case with hospital controls).

In addiation for studies on distance:

- there was a considerable risk for recall bias (by selective memory, by parental reporting of the distance to the nearest power line, instead of an objective measurement);
- only broad distance categories were used, for instance more or less than 500 m.

And for studies on magnetic field strength:

- assessment of exposure was performed by determining the ‘wire codes’ or by measurements outside the residence.

Next, the judgements of the experts were compared. If they differed, consensus was sought. The quality of the studies was either marked as *sufficient* or as *insufficient*. The studies of insufficient quality were excluded from the meta-analyses. In the tables in the next chapter the reason for the qualification *insufficient* is indicated for each of these studies.

For some studies, a larger update was available, that included all cases from the earlier study (for instance an update of a study based on a large cancer registry). In that case only the update has been included in the analyses and the earlier study has been indicated in the tables as *Not relevant due to a later update in (..)*.

# 04 summary of availabe data and quality assessments by the Committee

The following tables summarize the avaliable studies on the associations between

- childhood leukaemia and distance to power lines (Table A1);
- childhood leukaemia and magnetic field strength  (Table A2);

- brain tumours in children and distance to power lines (Table A3);
- brain tumours in children and magnetic field strength (Table A4);
- lymphomas in children and magnetic field strength  (Table A5).

For each topic, the studies are listed on the basis of quality (sufficient or insufficient) and next on year of publication. For the studies of insufficient quality, the most important reasons for that qualification are indicated.

**Table A1.** Studies into the association between the distance of the residence to high-voltage power lines and the risk of childhood leukaemia

| Reference | Country | Type of study, data source | Criterion, assessement | Exposure source | Risk estimate (odds ratio)<br>Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| Feychting & Ahlbom (1993)[3] | Sweden | Case-control<br>Population: cancer registry | Distance: 0-50 m, 51-100 m, >100 m (reference) | High-voltage power lines, 220, 400 kV | **0-50 m: 2.9 (1.0-2.7)**<br>**51-100 m: 1.1 (0.4-2.7)**<br><br>**0-100 m: 1.75 (0.88-3.49)** (calculated by Committee) | Sufficient |
| Petridou et al. (1997)[52] | Greece | Case-control<br>Hospital | Distance: <50 m; reference: <50 m 400 V line | High/middle voltage power lines, 15-400 kV | 150/400 kV: 1.56 (0.26-9.39)<br>66 kV: 4.26 (0.94-19.44)<br>**66-400 kV: 2.80 (0.88-8.92)** (calculated by Committee)<br>15/22 kV: 1.84 (0.26-12.81)<br>66 kV: 0.99 (0.54-1.84) | Sufficient |
| Tynes & Haldorsen (1997)[4] | Norway | Case-control<br>Population: cancer registry | Distance: 0-50 m, 51-100 m, >100 m (reference) | High-voltage power lines, >45 kV | **0-50 m: 0.6 (0.3-1.3)**<br>**50-100 m: 1.4 (0.8-2.6)**<br><br>**0-100 m: 1.00 (0.63-1.59)** (calculated by Committee) | Sufficient |
| Li et al. (1998)[5] | Taiwan | Case-control<br>Population: cancer registry<br>Seems more cohort study; estimation of total number of children in area | Distance: <100 m, ≥100 m (reference) | High-voltage power lines, ≥69 kV | SIR<br>*Controls entire Taiwan:*<br>0-4 y: 2.48 (0.20-5.97)<br>5-9 y: 5.06 (1.38-13.0)<br>10-14 y: 1.67 (0.05-9.28)<br><br>**0-14 y: 3.68 (1.53-8.88)** (calculated by Committee) | Sufficient<br>Not in meta-analysis because of deviating distance categories |
| McBride et al. (1999)[6] | Canada | Case-control<br>Population: cancer registry | Distance: <50 m, <100 m, >100 m (reference) | High-voltage power lines, ≥50 kV | **<50 m (ALL): 1.99 (0.74-5.32)**<br>**<100 m (all leukaemia): 1.81 (0.70-4.70)** | Sufficient |

| Reference | Country | Type of study, data source | Criterion, assessement | Exposure source | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| Bianchi et al. (2000)[7] | Italy | Case-control<br>Population: cancer registry | Distance: <150 m, >150 m (reference) | High-voltage power line | *Calculated from Table 1:*<br>**≤50 m: 4.36 (0.57-32.93)**<br>**50-100 m: 3.27 (0.47-19.12)**<br><br>**≤100 m: 4.36 (0.79-23.76)** | Sufficient |
| Kleinerman et al. (2000)[8] | USA | Case-control<br>Cases: leukaemia diagnosed in participating hospitals, controls: random dailing | Distance: 0-14 m, 15-23 m, 24-40 m, >40 m (reference) | High/middle voltage power lines, ≥7.2 kV | <14 m: 0.79 (0.46-1.34)<br>15-23 m: 1.01 (0.60-1.71)<br>24-40 m: 1.23 (0.75-2.03)<br><br>**0-40 m: 1.00 (0.75-1.35)** (calculated by Committee) | Sufficient |
| UK Childhood Cancer Study (2000)[9] | UK | Case-control<br>Population: cancer registry | Distance: continuous (for 100/distance, so OR>1 gives positive association); separately for different line types | High/middle voltage power lines, 11-400 kV | *100/distance:*<br>11, 20 kV: 0.98 (0.88-1.08)<br>33 kV: 0.59 (0.25-1.40)<br>66 kV: 3.15 (1.02-9.68)<br>132 kV: 0.97 (0.72-1.32)<br>275 kV: 1.06 (0.46-2.48)<br>400 kV: 1.34 (0.65-2.76) | Sufficient<br>Endpoint not usable for meta-analysis<br>Not relevant: update in Bunch et al. (2014)[10] |
| Kabuto et al. (2006)[11] | Japan | Case-control<br>Population: cancer registry | Distance: 0-50 m, 50-100 m, >100 m (reference) | High-voltage power lines, 22-500 kV | *ALL:*<br><50 m: 3.06 (1.31-7.13)<br>50-100 m: 1.61 (0.88-2.95)<br><br>*AML:*<br><50 m: 1.25 (0.11-14.9)<br>50-100 m: 3.11 (0.71-13.6)<br><br>*ALL+AML (calculated by Committee):*<br>**<50 m: 2.78 (1.25-6.20)**<br>**50-100 m: 1.96 (1.21-3.18)**<br>**0-100 m: 2.05 (1.30-3.25)** | Sufficient |
| Wünsch-Filho et al. (2011)[12] | Brazil | Case-control<br>Hospital | Distance: <50 m, <100 m, 100-200 m, 200-600 m, >600 m (reference) | High-voltage power lines, ≥88 kV | **<50 m: 3.57 (0.41-31.44)**<br>**50-100 m: 0.28 (0.01-6.14)** (calculated by Committee)<br>**<100 m: 1.54 (0.26-9.12)**<br>100-200 m: 1.67 (0.49-5.75)<br>200-600 m: 0.69 (0.28-1.71) | Sufficient |

| Reference | Country | Type of study, data source | Criterion, assessement | Exposure source | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| Sermage-Faure et al. (2013)[13] | France | Case-control<br>Population: cancer registry | Distance: 0-49 m, 50-99 m, 100-199 m, 200-599 m, ≥600 m (reference) | High-voltage power lines, 63-400 kV | *All lines:*<br>**<50 m: 1.2 ( 0.8-1.9)**<br>**50-99 m: 1.0 (0.7-1.6)**<br>**100-199 m: 0.8 (0.5-1.0)**<br>200-599 m: 1.1 (0.9-1.2)<br>>600 m: 1.1 (0.9-1.2)<br><br>**<100 m: 1.09 (0.81-1.47)** (calculated by Committee)<br><br>*225, 400 kV lines:*<br>**<100 m: 1.32 (0.80-2.17)** (calculated by Committee) | Sufficient |
| Bunch et al. (2014)[10] | England, Wales | Case-control<br>Population: cancer registry 1962-2008 | Distance: 0-49 m, 50-99 m, 100-199 m, 200-299 m, 300-399 m, 400-499 m, 500-599 m, 600-699 m, 700-799 m, 800-899 m, 900-999 m, ≥1,000 m (reference) | High/middle voltage power lines, 2, 275, 400 kV | *All lines:*<br>**0-49 m: 0.80 (0.44-1.44)**<br>**50-99 m: 1.39 (0.90-2.14)**<br>**100-199 m: 1.11 (0.84-1.45)**<br><br>**0-100 m: 1.15 (0.81-1.63)** (calculated by Committee)<br><br>*265, 400 kV lines:*<br>**0-49 m: 0.53 (0.20-1.39)**<br>**50-99 m: 1.12 (0.63-1.98)**<br>**100-199 m: 1.07 (0.74-1.53)**<br><br>**0-100 m: 0.92 (0.56-1.51)** (calculated by Committee) | Sufficient |
| Pedersen et al. (2014)[14] | Denmark | Case-control<br>Population: cancer registry | Distance: 0-199 m, 200-599 m, ≥600 m (reference) | High-voltage power lines, 132-400 kV | <200 m: 0.76 (0.40-1.45)<br>200-600 m: 0.92 (0.67-1.25) | Sufficient<br>Not in meta-analysis: deviating distance categories |

| Reference | Country | Type of study, data source | Criterion, assessement | Exposure source | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| Crespi et al. (2016)[15] | California, USA | Case-control<br>Population: cancer registry | Distance: 0-50 m, 50-100 m, 100-200 m, 200-300 m, 300-400 m, 400-500 m, 500-600 m, ≥600 m (reference) | High-voltage power lines, ≥200 kV | *Only data for distance assessed locally*<br>**0-50 m: 1.6 (0.7-3.7)**<br>**50-100 m: 1.0 (0.5-2.0)**<br>**100-200 m: 0.8 (0.4-1.7)**<br><br>**0-100 m: 1.21 (0.71-2.07)** (calculated by Committee) | Sufficient |
| Coleman et al. (1989)[16] | Southeast England | Case-control<br>Population: cancer registry | Distance: 0-24 m, 25-49 m, 50-99 m, ≥100 m (reference) | High-voltage power line | -- | Insufficient: only 1 patient and 1 control at <100 m; not relevant: update in Bunch et al. (2014)[10] |
| Myers et al. (1990)[17] | England | Case-control, cases are children with cancer (solid/ non-solid)<br>Population: cancer registry | Distance: 0-24 m, 25-49 m, 50-99 m, ≥100 m (reference) | High-voltage power line | *Non-solid tumours:*<br><100 m: 1.02 (0.48-2.17)<br><25 m: 1.32 (0.36-4.76) | Insufficient: no distinction between leukaemia and other types of non-solid tumours |
| Fajardo-Gutiérrez et al. (1993)[18] | Mexico | Case-control<br>Hospital | Distance: <200 m, ≥200 m (reference) | High-voltage power line | 1.57 (0.52-4.81) | Insufficient: distance reported by parents |
| Olsen et al. (1993)[19] | Denmark | Case-control<br>Population: cancer registry | Distance: 50-60 kV <35 m<br>132-15 kV <75 m<br>220-440 kV <150 m | High-voltage power line | -- | Insufficient: no distance data analysed; not relevant: update in Pedersen et al. (2014)[14] |
| Mizoue et al. (2004)[20] | Japan | Case-only<br>Hospital | Distance: ≥50% of district area within 300 m, <50% within 300 m (reference) | High-voltage power line | *IRR*<br>*Address diagnosis*<br>2.2 (0.5-9.0) for >50% vs none<br>1.6 (0.5-5.1) for <50% vs none<br>3.4 (0.9-13.2) >50% vs none<br>1.1 (0.3-4.7) <50% vs none | Insufficient: distance not individually assessed |
| Feizi et al. (2007)[21] | Iran | Case-control<br>Hospital | Distance: <500 m, ≥500 m (reference) | High-voltage power line | 8.76 (1.74-58.4) | Insufficient: origin of controls unclear; only distance more or less than 500 m |

| Reference | Country | Type of study, data source | Criterion, assessement | Exposure source | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| Abdul Rahman et al. (2008)[22] | Malaysia | Case-control<br>Hospital | Distance: ≤200 m, >200 m (reference) | High-voltage power line | 2.30 (1.18-4.49) | Insufficient: geographical origin of cases and controls unclear |
| Sohrabi et al. (2010)[23] | Iran | Case-control<br>Hospital | Distance: <400 m,<500 m, <600 m, ≥400, ≥500 m, ≥600 m (reference) | High-voltage power line | <400 m: 2.75 (1.59-4.76)<br><500 m: 2.67 (1.76-4.24)<br><600 m: 2.61 (1.73-3.94)<br>123 kV: 9.93 (3.47-28.28)<br>230 kV: 10.78 (3.75-31)<br>400 kV:2.98 (0.93-9.54) | Insufficient: geographical origin of cases and controls unclear |
| Tabrizi et al. (2015)[24] | Iran | Case-control<br>Hospital | Distance: <600 m, >600 m (reference) | High-voltage power line | 3.65 (1.69-7.79) | Insufficient: only distance more or less than 600 m |

Abbreviations: AML: acute myeloid leukaemia; ALL: acute lymphatic leukaemia; IRR: incidence rate ratio; kV: kilovolt; OR: odds ratio; SIR: standardized incidence rate.

**Table A2.** Studies into the association between the magnetic field strength and the risk of childhood leukaemia

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| Savitz et al. (1988)[25] | USA | Case-control<br>Population: cancer registry<br><15 y | Original | All; measurement at front door, bedroom child, bedroom parents<br>Low (main switch off) or high (main switch and certain sources on) | *Low:*<br>**≥0.2 μT : 1.93 (0.67-5.56)**<br>**<0.2 μT: 1 (reference)** | Sufficient |
| | | | Greenland | All; measurement at front door, bedroom child, bedroom parents | *Low:*<br>>0.3 μT: 3.87 (0.87-17.3) | |
| London et al. (1991)[26] | USA, Los Angeles County | Case-control<br>Population: cancer registry<br><11 y | Original | All, 24 h in bedroom;<br>Low: equipment off, normal: equipment on | *24 h, normal:*<br>**≥0.268 μT: 1.68 (0.71-4.00)**<br>**0.119-0.267 μT: 0.94 (0.47-1.89)**<br>0.068-0.118 μT: 0.66 (0.36-1.19)<br>**<0.068 μT: 1 (reference)** | Sufficient |
| | | | Original | All, spot measurements on various locations inside and outside<br>Low: equipment off, normal: equipment on | *Spot, low:*<br>≥0.125 μT: 1.22 (0.52-2.82)<br>0.068-0.124 μT: 1.37 (0.65-2.91)<br>0.032-0.067 μT: 1.01 (0.61-1.69)<br><0.032 μT: 1 (reference) | |

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| | | | Greenland | All, 24 h in bedroom, spot measurements on various locations inside and outside | *Normal:*<br>>0.3 µT: 1.53 (0.67-3.50) | |
| Feychting & Ahlbom (1993)[3] | Sweden | Case-control<br>Population: cancer registry<br><16 y | Original | High-voltage power lines, calculated field strength | **≥0.2 µT: 2.7 (1.0-6.3)**<br>**0.1-0.19 µT: 2.1 (0.6-6.1)**<br>**<0.1 µT: 1 (reference)** | Sufficient |
| | | | Original | High-voltage power lines, calculated field strength | **≥0.3 µT: 3.8 (1.4-9.3)**<br>**0.1-0.29** µT: 1.**5 (0.4-4.2)**<br>**<0.1 µT: 1 (reference)** | |
| | | | Original | 4x5 min spot measurement; low: main switch off, mainly external source; high: main switch on, all sources | *Low:*<br>≥0.2 µT: 0.6 (0.2-1.8)<br>0.1-0.19 µT: 0.2 (0.0-0.9)<br><0.1 µT: 1 (reference) | |
| | | | Ahlbom | High-voltage power lines, calculated field strength | ≥0.4 µT: 3.74 (1.23-11.37)<br>continuous per 0.1 µT: 1.31 (0.98-1.73) | |
| | | | Greenland | High-voltage power lines, calculated field strength | >0.3 µT: 4.44 (1.67-11.7) | |
| Olsen et al. (1993)[19] | Denmark | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines, calculated field strength | **≥0.25 µT: 1.5 (0.3-6.7)**<br>**0.10-0.24 µT: 0.5 (0.1-4.3)**<br>**<0.1 µT: 1 (reference)** | Sufficient<br>Not relevant: update in Pedersen et al. (2015)[27] |
| | | | Original | High-voltage power lines, calculated field strength | **≥0.4 µT: 6.0 (0.8-44)**<br>0.10-0.39 µT: 0.3 (0.0-2.0)<br>**0.1-0.4 µT: 0.29 (0.01-2.23)** (recalculated by Committee)<br>**<0.1 µT: 1 (reference)** | |
| | | | Ahlbom | High-voltage power lines, calculated field strength | ≥0.4 µT: --<br>continuous per 0.1 µT: 1.50 (0.85-2.65) | |
| Verkasalo et al. (1993)[28] | Finland | Cohort<br>Population: cancer registry<br><20 y | Original | High-voltage power lines, calculated field strength | *SIR*<br>**≥0.2 µT: 1.60 (0.32-5.40)**<br>**0.01-0.19 µT: 0.89 (0.61-1.30)**<br>**<0.01 µT: 1 (reference**) | Sufficient |
| | | | Ahlbom | High-voltage power lines, calculated field strength | ≥0.4 µT: 6.21 (0.68-56.9)<br>continuous per 0.1 µT: 1.15 (0.79-1.66) | |
| | | | Greenland | High-voltage power lines, calculated field strength | >0.3 µT: 2.00 (0.23-17.7) | |

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| Linet et al. (1997)[29] | USA, participation in Childrens Cancer Group, living in Illinois, Indiana, Iowa, Michigan, Minnesota, New Jersey, Ohio, Pennsylvania, or Wisconsin | Case-control<br>Population: cancer registry<br><15 y | Original: measured | All. Weighted average 24 h measurement bedroom + spot measurements elsewhere | **≥0.2 μT: 1.53 (0.91-2.56)**<br>**0.1-0.199 μT: 1.15 (0.79-1.65)**<br>0.065-0.099 μT: 1.10 (0.81-1.50)<br>**<0.065 μT: 1 (reference)** | Sufficient |
| | | | Original: measured | All. Weighted average 24 h measurement bedroom + spot measurements elsewhere | ≥0.5 μT: 1.41 (0.48-4.09)<br>0.4-0.499 μT: 3.28 (1.15-9.39)<br>0.3-0.399 μT: 1.39 (0.72-2.72)<br>0.2-0.299 μT: 0.92 (0.57-1.48)<br>0.1-0.199 μT: 1.10 (0.83-1.48)<br>0.065-0.099 μT: 1.10 (0.81-1.50)<br><0.065 μT: 1 (reference) | |
| | | | Calculated by Committee | All. Weighted average 24 h measurement bedroom + spot measurements elsewhere | **≥0.4 μT: 2.23 (0.84-6.61)**<br>**0.2-0.4** μT: **1.36 (0.81-2.30)**<br>**<0.2 μT: 1 (reference)** | |
| | | | Ahlbom | All. Weighted average 24 h measurement bedroom + spot measurements elsewhere | ≥0.4 μT: 3.44 (1.24-9.54)<br>continuous per 0.1 μT: 1.30 (1.01-1.67) | |
| | | | Greenland | All. Weighted average 24 h measurement bedroom + spot measurements elsewhere | >0.3 μT: 1.51 (0.92-2.49) | |
| Tynes & Haldorsen (1997)[4] | Norway | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines, calculated year-average field strength | **≥0.14 μT: 0.28 (0.01-1.88)** (calculated by Committee)<br>**0.05-<0.14 μT: 1.48 (0.64-3.46)** (calculated by Committee)<br>**<0.05 μT: 1 (reference)** | Sufficient |
| | | | Ahlbom | High-voltage power lines, calculated year-average field strength | ≥0.4 μT: --<br>continuous per 0.1 μT: 0.78 (0.50-1.23) | |
| | | | Greenland | High-voltage power lines, calculated year-average field strength | >0.3 μT: -- | |
| Dockerty et al. (1998)[30] | New Zealand | Case-control<br>Population<br>No age provided | Original | All. 24 h measurements living and bedroom | **≥0.2 μT: 3.3 (0.5-23.7)**<br>**0.1-<0.2 μT: (1.5 (0.3-7.2)**<br>**<0.1 μT: 1 (reference)** | Sufficient |
| | | | Ahlbom | All. 24 h measurements living and bedroom | ≥0.4 μT: --<br>continuous per 0.1 μT: 1.36 (0.40-4.61) | |
| | | | Greenland | All. 24 h measurements living and bedroom | >0.3 μT: -- | |

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| Michaelis et al. (1998)[31] | Germany | Case-control<br>Population<br><15 y | Original | All. 24 h measurments bedroom child and living room | ≥0.2 μT: 2.3 (0.8-6.7)<br><0.2 μT: 1 (reference) | Sufficient<br>Not relevant: update in Schüz et al. (2001)[32] |
| | | | Ahlbom | All. 24 h measurments bedroom child and living room | ≥0.4 μT: 2.00 (0.26-15.17)<br>continuous per 0.1 μT: 1.31 (0.76-2.26) | |
| | | | Greenland | All. 24 h measurments bedroom child and living room | >0.3 μT: 2.48 (0.79-7.81) | |
| Green et al. (1999)[33] | Canada | Case-control<br>Population: cancer registry<br><15 y | Original | All, spot measurement bedroom child | ≥0.13 μT: 1.13 (0.31-4.06)<br>0.07-0.12 μT: 1.22 (0.32-4.57)<br>0.03-0.06 μT: 0.94 (0.29-3.01)<br><0.03 μT: 1 (reference) | Sufficient |
| | | | Original | All, average spot measurement in house | **≥0.15 μT: 1.47 (0.44-4.85)**<br>0.09-0.14 μT: 0.75 (0.19-3.02)<br>0.04-0.08 μT: 0.47 (0.12-1.89)<br>**<0.04 μT: 1 (reference)** | |
| UKCCS (1999)[34] | UK | Case-control<br>Population: cancer registry<br><15 y | Original | All. Spot and 48 h measurements in house and school | ≥0.2 μT: 0.9 (0.49-1.63)<br>0.1-<0.2 μT: 0.78 (0.55-1.12)<br><0.1 μT: 1 (reference) | Sufficient<br>Not relevant: update in Bunch et al. (2016)[35] |
| | | | Original | All. Spot and 48 h measurements in house and school | ≥0.4 μT: 1.68 (0.40-7.10)<br>0.2-<0.4 μT: 0.78 (0.40-1.52)<br>0.1-<0.2 μT: 0.78 (0.55-1.12)<br><0.1 μT: 1 (reference) | |
| | | | Ahlbom | All. Spot and 48 h measurements in house and school | ≥0.4 μT: 1.00 (0.30-3.37)<br>continuous per 0.1 μT: 0.93 (0.69-1.25) | |
| McBride et al. (1999)[6] | Canada | Case-control<br>Population: cancer registry<br><15 y | Original | All. 48 h personal measurement; 24 h measurement bedroom | ≥0.5 μT: 0.89 (0.24-3.36)<br>0.4-<0.5 μT: 0.44 (0.11-1.80)<br>0.3-<0.4 μT: 1.24 (0.47-3.26)<br>0.2-<0.3 μT: 1.06 (0.57-1.99)<br>0.1-<0.2 μT: 0.70 (0.46-1.06)<br><0.1 μT: 1 (reference) | Sufficient |
| | | | Original | All. 48 h personal measurement; 24 h measurement bedroom | ≥0.2 μT: 1.12 (0.69-1.80)<br><0.2 μT: 1 (reference) | |

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| | | | Calculated by Committee | All. 48 h personal measurement; 24 h measurement bedroom slaapkamer; calculated lifetime exposure | **≥0.2 μT: 1.38 (0.84-2.26)**<br>**<0.2 μT: 1 (reference)**<br>**≥0.27 μT: 1.02 (0.56-1.86)**<br>**0.15-0.27 μT: 1.02 (0.56-1.86)**<br>**<0.15 μT: 1 (reference)** | |
| | | | Ahlbom | All. 48 h personal measurement; 24 h measurement bedroom | ≥0.4 μT: 1.55 (0.65-3.68)<br>continuous per 0.1 μT: 1.21 (0.96-1.52) | |
| | | | Greenland | All. 48 h personal measurement; 24 h measurement bedroom | >0.3 μT: 1.42 (0.63-3.21) | |
| Bianchi et al. (2000)[36] | Italy | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines. Calculation based on distance measurement | **>0.1 μT: 4.51 (0.88-23.17)**<br>0.001-0.1: 3.29 (1.11-9.73)<br>**<0.001: 1 (reference)** | Sufficient |
| | | | Kheifets | High-voltage power lines. Calculated field strength. | ≥0.3 μT: -- | |
| Schüz et al. ( 2001)[32] | Germany | Case-control<br>Population: cancer registry<br><15 y | Original | All. 24 h measurements living and bedroom | **≥0.4 μT: 5.94 (0.80-44.1)**<br>**0.2-<0.4 μT: 1.45 (0.67-3.14)**<br>**0.1-<0.2 μT: 1.34 (0.90-2.01)**<br>**<0.1 μT: 1 (reference)** | Sufficient |
| | | | Original | All. 24 h measurements living and bedroom | **≥0.24 μT: 1.69 (0.83-3.46)**<br>**<0.2 μT: 1 (reference)** | |
| | | | Kheifets | All. 24 h measurements living and bedroom | ≥0.3 μT: 3.05 (0.68-13.8) | |
| Kabuto et al. (2006)[11] | Japan | Case-control<br>Hospital, controls population<br>≤15 y | Original | All. 1 week measurement in bedroom | **>0.4 μT: 2.56 (0.76-8.58)**<br>**0.2-0.4 μT: 1.12 (0.53-2.36)**<br>**0.1-0.2 μT: 0.91 (0.50-1.63)**<br>**<0.1 μT: 1 (reference)** | Sufficient |
| | | | Calculated by Committee | All. 1 week measurement in bedroom | **>0.2 μT: 1.41 (0.75-2.66)**<br>**0.1-0.2 μT: 0.91 (0.50-1.63)**<br>**<0.1 μT: 1 (reference)** | |
| | | | Kheifets | All. 1 week measurement in bedroom | ≥0.3 μT: 1.40 (0.56-3.49) | |
| Meija-Arangure et al. (2007)[37] | Mexico | Case-control<br>Children with Down<br>Hospital, controls specialized centers<br><16 y | Original | All. Spot measurement front door | ≥0.6 μT: 3.70 (1.05-13.00)<br>0.40-0.59 μT: 0.88 (0.15-5.10)<br>**≥0.4 μT: 1.42 (0.51-3.88)** (calculated by Committee)<br>0.101-3.99 μT: 0.94 (0.37-2.40)<br>**≤0.1 μT: 1 (reference)** | Sufficient |

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| | | | Original | All. Spot measurement front door | >0.1 µT: 1.20 (0.52-2.80)<br>≤0.1 µT: 1 (reference) | |
| Kroll et al. (2010)[38] | UK | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines. Calculated with 2D-model and geo-coding | ≥0.4 µT: 2.00 (0.18-22.04) | Sufficient<br>Not relevant: update in Bunch et al. (2016)[35] |
| | | | Kheifets | High-voltage power lines. Calculated with 2D-model and geo-coding | ≥0.3 µT: 0.98 (0.14-6.97) | |
| Malagoli et al. (2010)[39] | Italy | Case-control<br>Population: cancer registry<br><14 y | Original | High-voltage power lines. Calculated with 2D-model and geo-coding | **≥0.4 µT: 2.1 (0.2-26.2)**<br>**0.1-<0.4 µT: 6.7 (0.6-78.3)**<br>**<0.1 µT: 1 (reference)** | Sufficient |
| | | | Kheifets | High-voltage power lines. Calculated with 2D-model and geo-coding | ≥0.3 µT: 2.26 (0.20-25.9) | |
| Does et al. (2011)[40] | USA | Case-control<br>Hospital<br><8 y | Original | All, 30 min measurement in room with median magnetic field strength | >0.3 µT: 0.57 (0.14-2.36) | Sufficient |
| Wünsch-Filho et al. (2011)[12] | Brazil | Case-control<br>Hospital<br>No age limit | Original | All. 24 h measurement bedroom | **≥0.3 µT: 1.09 (0.33-3.61)**<br>**0.1-<0.3 µT: 0.75 (0.36-1.55)**<br>**<0.1 µT: 1 (reference)** | Sufficient |
| Wünsch-Filho et al. unpublished | | | Kheifets | All. 24-h measurement bedroom | ≥0.3 µT: 1.26 (0.61-2.62) | |
| Bunch et al. (2015)[41] | England, Wales | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines. Calculated field strength (geo-coding) | >0.4 µT: 1.15 (0.33-4.03)<br>0.2-0.39 µT: 1.43 (0.20-10.47)<br>0.1-0.19 µT: 0.61 (0.05-6.88)<br><0.1 µT: 1 (reference) | Sufficient |
| | | | Calculated by Committee | High-voltage power cables. Calculated field strength (geo-coding) | **>0.4 µT: 2.00 (0.18-22.06)**<br>**0.2-0.39 µT: 0.92 (0.20-4.17)**<br>**>0.2 µT: 1.15 (0.32-4.15)**<br>**0.1-0.19 µT: 0.80 (0.07-9.10)**<br>**<0.1 µT: 1 (reference)** | |
| | | | Original | Trend, calculated | 1.01 (0.91-1.12) | |
| Pedersen et al. (2015)[27] | Denmark | Case-control<br>Population: cancer registry<br><15 y<br>1968-2003 | Original | High-voltage power lines and cables, calculated (determination of distance not provided) | **≥0.4 µT: 1.67 (0.51-5.46)**<br>**0.1-0.39 µT: 0.77 (0.27-2.16)**<br>**<0.1 µT: 1 (reference)** | Sufficient |

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| | | | Calculated by Committee | High-voltage power lines and cables, calculated (determination of distance not provided) | **≥0.1 µT: 1.08 (0.49-2.36)**<br>**<0.1 µT: 1 (reference)** | |
| Salvan et al. (2015)[42] | Italy | Case-control<br>Population: cancer registry, permission asked<br><11 y | Original | All sources. 24-48 h measurements | **<0.2** µT: **0.79 (0.35-1.79)**<br>**0.1-0.2: 1.87 (1.04-3.34)**<br>**≤0.1: 1 (reference)** | Sufficient |
| | | | Original | Living near high-voltage power lines | 3.65 (1.69-7.88) | |
| Bunch et al. (2016)[35] | UK | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines, calculated | **≥0.4 µT: 0.50 (0.15-1.62)**<br>**0.2-0.39 µT: 0.49 (0.13-1.88)**<br>**≥0.2 µT: 0.50 (0.20-1.21)** (calculated by Committee)<br>**0.1-0.19 µT: 0.74 (0.25-2.24)**<br>**<0.1 µT: 1 (reference)** | Sufficient |
| Kheifets et al. (2017)[43] | California, USA | Case-control<br>Population: cancer registry<br><16 y | Original | High-voltage power lines, calculated | **≥0.4 µT: 1.45 (0.67-3.11)**<br>**0.2-<0.4 µT: 0.95 (0.45-2.00)**<br>**≥0.2 µT: 1.17 (0.68-1.99)** (calculated by Committee)<br>**0.1-<0.2 µT: 0.83 (0.47-1.44)**<br>**<0.1 µT: 1 (reference)** | Sufficient |
| Tomenius (1986)[44] | Sweden | Case-control<br>Population: cancer registry<br><19 y | Original | All; measurement outside at front door | ≥0.3 µT: 0.3<br><0.3: 1 (reference) | Insufficient: only measurement outside residence |
| | | | Greenland | All; measurement outside at front door | >0.3 µT: 1.41 (0.38-5.29) | |
| Coghill (1996)[45] | UK | Case-control<br>Population<br>Ads<br><15 y | Original | All, 12-h measurements bedroom child | No difference magnetic field strength cases and controls | Insufficient: no risk estimates for magnetic field categories |
| | | | Greenland | All, 12-h measurements bedroom child | No OR (1 case >0.3 µT) | |
| Feizi et al. (2007)[21] | Iran | Case-control<br>Hospital | Original | High-voltage power line | <0.45 vs ≥0.45 µT: 3.60 (1.1-12.39) | Insufficient: source of controls unclear; high non-participation rate |

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation | Quality |
|---|---|---|---|---|---|---|
| Jirik et al. (2012)[46] | Czech Republic | Case-control<br>Hospital<br><15 y | Original | All sources, outdoor measurements | >0.2 μT: 0.93 (0.45-1.93)<br><0.2 μT: 1 (reference) | Insufficient: source population cases and controls not identical, outdoor measurements |
| | | | Original | All sources | >0.3 μT: 0.77 (0.34-1.75)<br><0.3 μT: 1 (reference) | |
| | | | Original | All sources | >0.4 μT 0.91 (0.37-2.19)<br><0.4 μT: 1 (reference) | |
| Tabrizi & Bidgoli (2015)[24] | Iran | Case-control<br>Hospital<br><12 y<br>Origin controls unclear | Original | High-voltage power lines; 24-48 h measurements | Continuous per 1 μT: 0.89 (0.19-4.20) | Insufficient: unclear exposure characterization and selection controls |

Abbreviations: μT: microtesla; SIR: standardized incidence rate.

**Table A3.** Studies into the association between the distance of the residence to high-voltage power lines and the risk of brain tumours in children

| Reference | Country | Type of study, data source | Criterion, assessment | Exposure source | Risk estimate (odds ratio) | Quality |
|---|---|---|---|---|---|---|
| Feychting & Ahlbom (1993)[3] | Sweden | Case-control<br>Population: cancer registry | Distance: 0-15 m, 51-100 m, >100 m (reference) | High-voltage power lines, 220, 400 kV | ≤50 m: 0.5 (0.0-2.8)<br>51-100 m: 1.4 (0.5-3.1) | Sufficient |
| Bunch et al. (2014)[10] | England, Wales | Case-control<br>Population: cancer registry 1962-2008 | Distance: 0-49 m, 50-99 m, 100-199 m, 200-299 m, 300-399 m, 400-499 m, 500-599 m, 600-699 m, 700-799 m, 800-899 m, 900-999 m, ≥1000 m (reference) | High/middle-voltage power lines, 2, 275, 400 kV | *Pooled OR over entire period:*<br>0-199 m: 1.06 (0.84-1.35)<br>200-599 m: 1.09 (0.96-1.24)<br>600-999 m: 1.07 (0.97-1.20) | Sufficient |

Abbreviations: kV: kilovolt; OR: odds ratio.

**Table A4.** Studies into the association between magnetic field strength and the risk of brain tumours in children

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation. | Quality |
|---|---|---|---|---|---|---|
| Feychting & Ahlbom (1993)[3] | Sweden | Case-control<br>Population: cancer registry<br><16 y | Original | High-voltage power lines, calculated field strength | ≥0.2 μT: 0.7 (0.1-2.7)<br>0.1-0.19 μT: 1.0 (0.2-3.8)<br>≤0.09 μT: 1.0 (reference) | Sufficient |
| | | | Original | | **≥0.3 μT: 1.0 (0.2-3.9)**<br>**0.1-0.29 μT: 0.7 (0.1-2.6)**<br>**≤0.09 μT: 1.0 (reference)** | |
| Olsen et al. (1993)[19] | Denmark | Case-control<br>Population: cancer registry<br><15 y | Original<br><br><br><br>Original | High-voltage power lines, calculated field strength | ≥0.4 μT: 6.0 (0.7-44)<br>0.10-0.39 μT: 0.4 (0.1-2.8)<br><0.10 μT: 1.0 (reference)<br><br>≥0.25 μT: 1.0 (0.2-5.0)<br>0.10-0.24 μT: 1.0 (0.1-9.6)<br><0.10 μT: 1.0 (reference) | Sufficient<br>Not relevant: update in Pedersen et al. (2015)[27] |
| Verkasalo et al. (1993)[28] | Finland | Cohort<br>Population: cancer registry<br><20 y | Original | High-voltage power lines, calculated field strength | SIR<br>**≥0.2 μT: 2.3 (0.75-5.4)**<br>**0.01-0.19 μT: 0.85 (0.59-1.2)** | Sufficient |
| Preston-Martin et al. (1996)[47] | USA, Los Angeles County | Case-control<br>Population<br><20 y | Original | All, outdoor measurement, 24 h indoor measurement for subset | Bedroom average:<br>**0.249-0.960 μT: 1.6 (0.6-4.5)**<br>**0.059-0.248 μT: 1.37 (0.78-2.38)** (calculated by Committee)<br>0.107-0.248 μT: 1.2 (0.5-2.8)<br>0.059-0.106 μT: 1.5 (0.7-3.0)<br>**0.010-0.058 μT: 1.0 (reference)** | Sufficient |
| Tynes & Haldorsen (1997)[4] | Norway | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines, calculated year-average field strength | ≥0.14 μT: 0.7 (0.2-2.1)<br>0.05-<0.14 μT: 1.9 (0.8-4.6)<br>**>0.05 μT: 1.25 (0.64-2.44)** (calculated by Committee)<br>**<0.05 μT: 1.0 (reference)** | Sufficient |
| Savitz et al. (1988)[25] | USA, Denver | Case-control<br>Population: cancer registry<br><15 y | Original | All; measurement at front door, bedrooms child, parents low (main switch off) or high (main switch and certain sources on) | *Low:*<br>**1.04 (0.22-4.82)**<br>*High:*<br>0.82 (0.23-2.93) | Sufficient |

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessement | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. In some cases the Committee performed a (re)calculation. | Quality |
|---|---|---|---|---|---|---|
| UKCCS (1999)[34] | UK | Case-control<br>Population: cancer registry<br><15 y | Original<br><br><br><br>Original | All; spot and 48 h measurements in house and at school | ≥0.4 μT: --<br>0.2-<0.4: 0.70 (0.16-3.17)<br><0.1 μT: 1.0 (reference)<br><br>≥0.2 μT: 0.46 (0.11-1.86)<br><0.1-0.2 μT: 2.44 (1.17-5.11)<br><0.1 μT: 1.0 (reference) | Sufficient<br>Not relevant: update in Bunch et al. (2015)[41] |
| Schüz et al. (2001)[48] | Germany | Case-control<br>Population: cancer registry<br>0-14 y | Original | All, 24 h measurement | **≥0.2 μT: 1.67 (0.32-8.84)**<br>**<0.2 μT: 1.0 (reference)** | Sufficient |
| Saito et al. (2010)[49] | Japan | Case-control<br>Hospital (cases), Population register (controls)<br>0-14 y | Original | All, (1 week, bedroom) + spot measurements elsewhere | **≥0.4 μT: 10.9 (1.05-113)**<br>**0.2-0.4: 1.58 (0.25-9.83)**<br>**0.1-0.2 μT: 0.74 (0.17-3.18)**<br>**<0.1 μT: 1.0 (reference)** | Sufficient |
| Bunch et al. (2015)[41] | Engeland, Wales | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power cables. Calculated field strength (geo-coding) | **≥4 μT: 4.28 (0.43-42.17)**<br>**0.2-0.39 μT: 0.62 (0.05-6.93)**<br>**0.1-0.19 μT: 1.19 (0.29-4.83)**<br>**<0.1 μT: 1.0 (reference)** | Sufficient |
| Pedersen et al. (2015)[27] | Denemarken | Case-control<br>Population: cancer registry<br><15 y<br>1968-2003 | Original | High-voltage power lines, cables, calculated (assessment of distance not provided) | **≥4 μT: 1.33 (0.41-4.33)**<br>**0.1-0.39 μT: 1.04 (0.46-2.36)**<br>**<0.1 μT: 1.0 (reference)** | Sufficient |
| Bunch et al. (2016)[35] | UK | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines, calculated | **≥0.4 μT: 0.61 (0.18-2.06)**<br>**0.2-0.39 μT: 0.86 (0.14-5.22)**<br>**0.1-0.19 μT: 1.14 (0.30-4.35)**<br>**<0.1 μT: 1 (reference)** | Sufficient |

Abbreviations: μT: microtesla; SIR: standardized incidence rate.

**Table A5.** Studies into the association between magnetic field strength and lymphomas in children

| Reference | Country | Type of study, data source, age | Data source: original publication or pooled analysis | Exposure source, exposure assessment | Risk estimate (odds ratio) Data used in the meta-analysis are indicated in boldface type. | Quality |
|---|---|---|---|---|---|---|
| Savitz et al. (1988)[25] | USA | Case-control<br>Population: cancer registry<br><15 y | Original | All; measurement at front door, bedrooms child, parents<br>low (main switch off) or high (main switch and certain sources on) | **Low: 2.17 (0.46-10.31)**<br>High: 1.81 (0.48-6.88) | Sufficient |
| Feychting & Ahlbom (1993)[3] | Sweden | Case-control<br>Population: cancer registry<br><16 y | Original | High-voltage power lines, calculated field strength | ≥0.3 μT: 0.9 (0.0-5.4)<br>0.1-0.29 μT: 1.3 (0.2-5.0)<br>≤0.09 μT: 1.0 (reference) | Sufficient |
| | | | Original | | **≥0.2 μT: 1.3 (0.2-5.1)**<br>**0.1-0.19 μT: 0.9 (0.0-5.2)**<br>**≤0.09 μT: 1.0 (reference)** | |
| Olsen et al. (1993)[19] | Denmark | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines, calculated field strength | ≥0.4 μT: 5.0 (0.3-82)<br>0.10-0.39 μT: 5.0 (0.7-32)<br><0.10 μT: 1.0 (reference) | Sufficient<br>Not relevant: update in Pedersen et al. (2015)[27] |
| | | | Original | | ≥0.25 μT: 5.0 (0.3-82)<br>0.10-0.24 μT: 5.0 (0.7-36)<br><0.10 μT: 1.0 (reference) | |
| Verkasalo et al. (1993)[28] | Finland | Cohort<br>Population: cancer registry<br><20 y | Original | High-voltage power lines, calculated field strength | SIR<br>≥0.2 μT: --<br>**0.01-0.19 μT: 0.91 (0.51-1.5)** | Sufficient |
| Tynes & Haldorsen (1997)[4] | Norway | Case-control<br>Population: cancer registry<br><15 y | Original | High-voltage power lines, calculated year-average field strength | **≥0.14 μT: 2.5 (0.4-15.5)**<br>0.05-<0.14 μT: 1.0 (0.1-8.7)<br>**<0.05 μT: 1.0 (reference)** | Sufficient |
| Pedersen et al. (2015)[27] | Denmark | Case-control<br>Population: cancer registry<br><15 y<br>1968-2003 | Original | High-voltage power lines, cables, calculated field strength (assessment of distance not provided) | **≥4 μT: 2.50 (0.46-13.65)**<br>**0.1-0.39 μT: 1.25 (0.35-4.43)**<br>**<0.1 μT: 1.00 (reference)** | Sufficient |

Abbreviations: μT: microtesla; SIR: standardized incidence rate.

# 05 meta-analyses performed by the Committee

The Committee used the program Stata, versions 12 and 14, to perform meta-analyses using the data from the studies of sufficient quality. Random effect analyses have been used since the study populations of the different studies may be different. This chapter contains the results of the Committee's meta-analyses of the data on:

- childhood leukaemia and distance (§ 5.1, Figures 1-3);
- childhood leukaemia and magnetic field strength (§ 5.2, Figures 4-7);
- brain tumours in children and magnetic field strength (§ 5.3, Figure 8);
- lymphomas in children and magnetic field strength (§ 5.4, Figure 9).

The Committee also performed meta-regression analyses on these data to investigate whether the risk increases with increasing exposure.

## 5.1 Childhood leukaemia and distance of the residence to high-voltage power lines

In order to be able to compare the current meta-analysis with the pooled analysis of Kheifets, distance categories of 0-50, 50-100 and 100-200 m were used (Figure 1). The reference group in the various studies differed, but was always the group living at the largest distance from the power line. This may have led to slight underestimations of the risk estimates.

In addition, the following sensitivity analyses were performed:

- the categories 0-50 and 50-100 m were combined to one category 0-100 m (Figure 2);
- only data from studies with power lines with voltages of 200 kV and higher were included in the data of the distances 0-50, 50-100 and 100-200 m (Figure 3).

The Committee was unable to include in its meta-analysis two studies that were included in the pooled analysis of Kheifets.[39,50] These publications do not contain data on distance and childhood leukaemia incidence. These data were provided to Kheifets for inclusion in the pooled analysis by the researchers (Kheifets, pers. comm.). These data were not available to the Committee. The Committee's meta-analysis also included an update[10] of an earlier study in the UK[38] that was included in Kheifets' pooled analysis. Moreover, data from a study in Brazil[12] were included for which only preliminary results were available to Kheifets.
An analysis by age category could not be performed due to insufficient variation in age.

| Study ID | Risk estimate childhood leukaemia (95% CI) | % Weight | Lowest included voltage level |
|---|---|---|---|
| 0-50m | | | |
| Feychting, 1993 | 2.90 (1.00, 7.30) | 5.80 | 220 |
| Tynes, 1997 | 0.60 (0.30, 1.30) | 8.91 | 45 |
| Petridou, 1997 | 2.80 (0.88, 8.92) | 4.56 | 66 |
| McBride, 1999 | 1.31 (0.38, 4.52) | 4.08 | 50 |
| Kleinerman, 2000 | 1.00 (0.75, 1.35) | 19.12 | 7.2 |
| Bianchi, 2000 | 4.36 (0.57, 32.93) | 1.69 | 132 |
| Kabuto, 2006 | 2.78 (1.25, 6.20) | 7.93 | |
| Wünsch-Filho, 2011 | 3.57 (0.41, 31.44) | 1.49 | 88 |
| Sermage-Faure, 2013 | 1.20 (0.80, 1.90) | 15.30 | 63 |
| Bunch, 2014 | 0.80 (0.44, 1.44) | 11.45 | 132 |
| Crespi, 2016 | 1.00 (0.80, 1.40) | 19.67 | 60 |
| Subtotal (I-squared = 47.4%, p = 0.040) | 1.22 (0.93, 1.61) | 100.00 | |
| . | | | |
| 50-100m | | | |
| Feychting, 1993 | 1.10 (0.40, 2.70) | 4.91 | 220 |
| Tynes, 1997 | 1.40 (0.80, 2.60) | 11.34 | 45 |
| McBride, 1999 | 2.89 (0.65, 12.82) | 2.12 | 50 |
| Bianchi, 2000 | 3.27 (0.47, 19.12) | 1.39 | 132 |
| Kabuto, 2006 | 1.96 (1.21, 3.18) | 15.43 | |
| Wünsch-Filho, 2011 | 0.28 (0.01, 6.14) | 0.50 | 88 |
| Sermage-Faure, 2013 | 1.00 (0.70, 1.60) | 19.17 | 63 |
| Bunch, 2014 | 1.39 (0.90, 2.14) | 17.99 | 132 |
| Crespi, 2016 | 1.00 (0.70, 1.30) | 27.15 | 60 |
| Subtotal (I-squared = 20.4%, p = 0.262) | 1.27 (1.02, 1.58) | 100.00 | |
| . | | | |
| 100-200m | | | |
| Sermage-Faure, 2013 | 0.80 (0.50, 1.00) | 26.62 | 63 |
| Bunch, 2014 | 1.11 (0.84, 1.45) | 35.41 | 132 |
| Crespi, 2016 | 0.80 (0.60, 1.00) | 37.96 | 60 |
| Subtotal (I-squared = 43.3%, p = 0.171) | 0.90 (0.72, 1.12) | 100.00 | |
| . | | | |

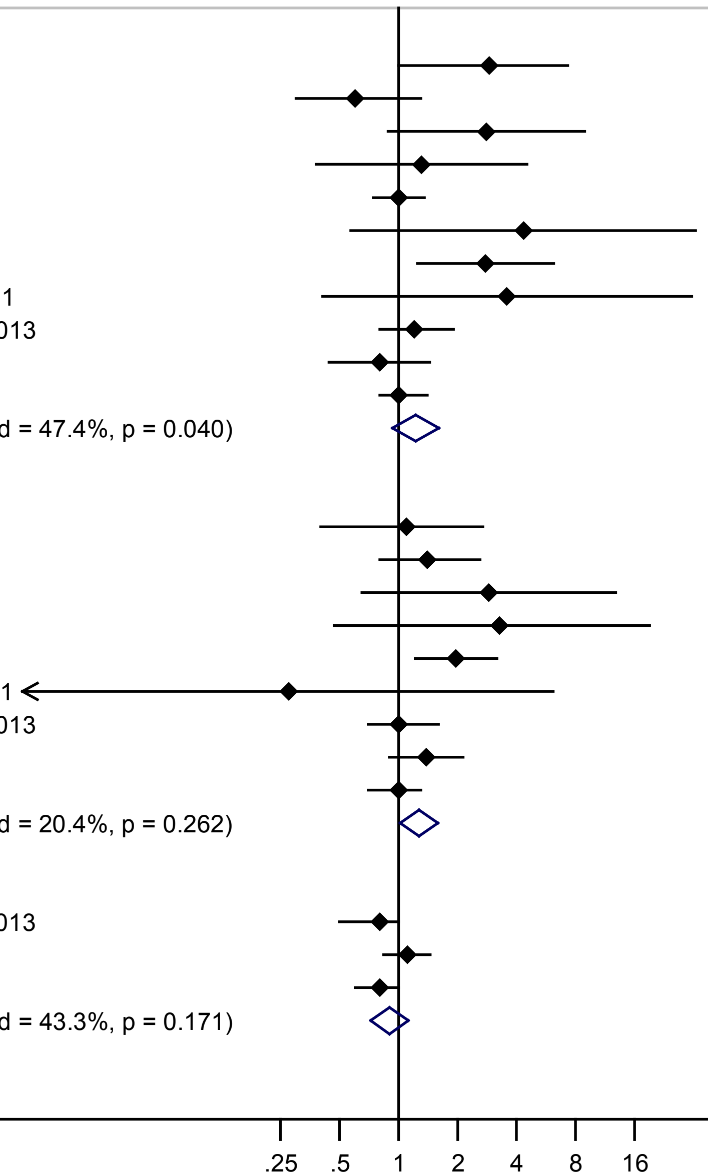


**Figure 1.** Childhood leukaemia: meta-analysis for the distance categories 0-50, 50-100 and 100-200 m. For each study, the risk estimate, the 95% confidence interval and the weight of the study in the analysis are indicated. The ‘subtotal’ is the risk estimate with confidence interval for all studies in that category. The factor ‘I-squared’ gives an indication of the heterogeneity of the data: the higher the percentage, the more variation between the studies.

A metaregression analysis of the data from the individual studies indicates no statistically significant exposure-response relationship between the distance of the residence to high-voltage power lines and the risk of childhood leukaemia. The chance to find the observed (or more extreme) results when there is actually no effect, is 20% (p=0.20).

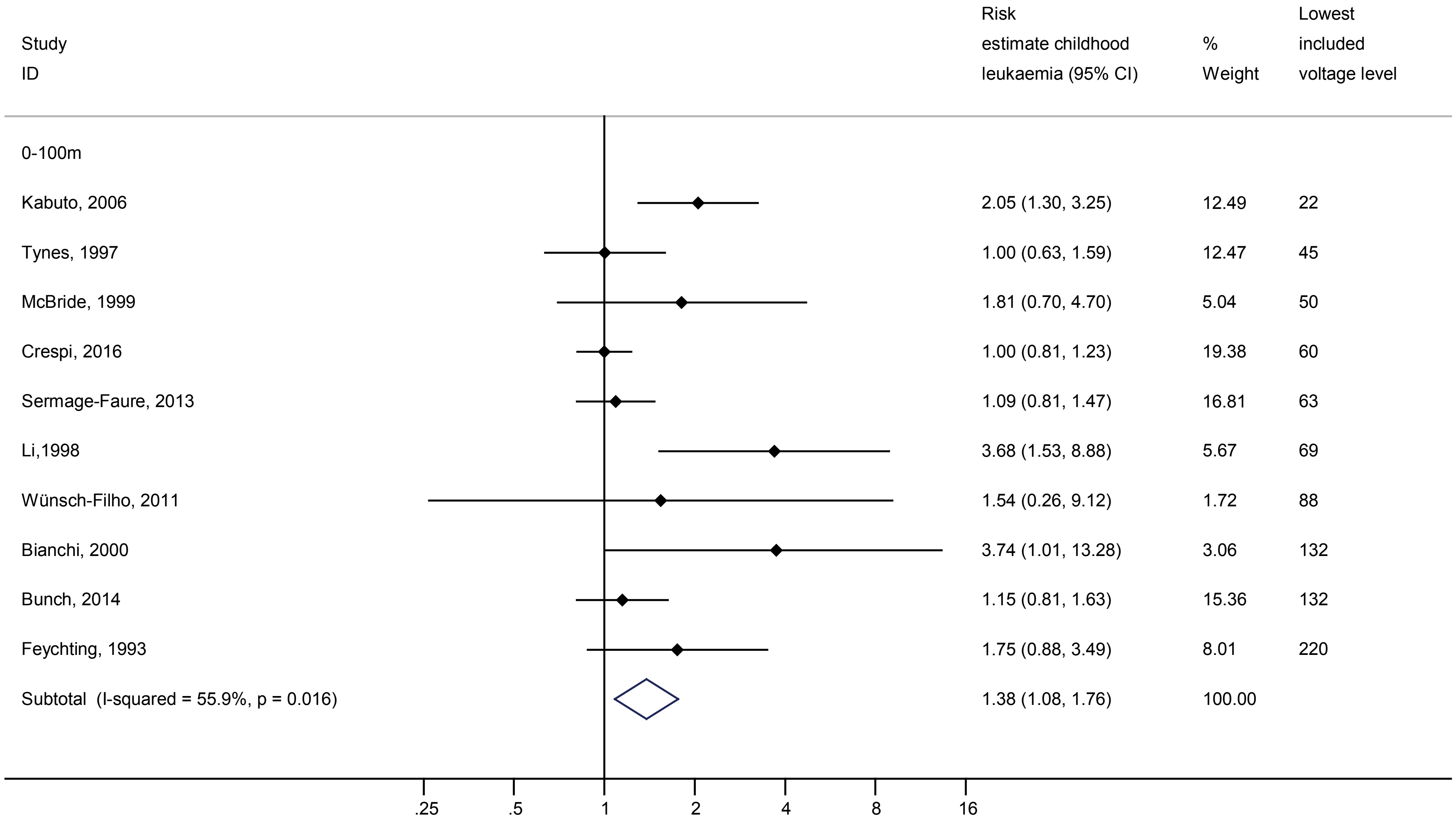


**Figure 2.** Childhood leukaemia, sensitivity analysis: meta-analysis for the distance category 0-100 m. For each study, the risk estimate, the 95% confidence interval and the weight of the study in the analysis are indicated. The ‘subtotal’ is the risk estimate with confidence interval for all studies in that category. The factor ‘I-squared’ gives an indication of the heterogeneity of the data: the higher the percentage, the more variation between the studies.

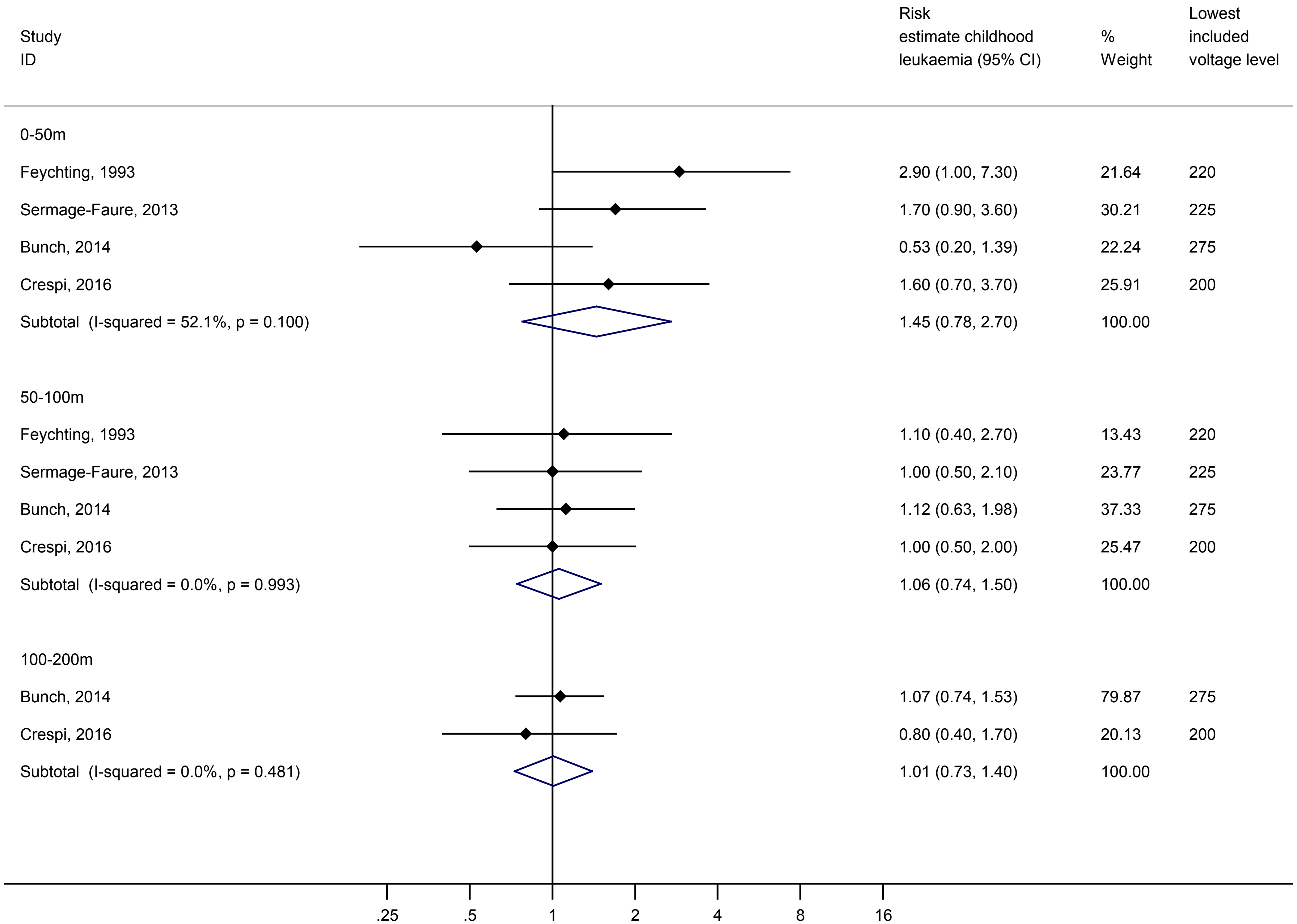


**Figure 3.** Childhood leukaemia, sensitivity analysis: meta-analysis for the distance categories 0-50, 50-100 and 100-200 m, but only for power lines with voltages of 200 kV and higher. For each study, the risk estimate, the 95% confidence interval and the weight of the study in the analysis are indicated. The 'subtotal' is the risk estimate with confidence interval for all studies in that category. The factor 'I-squared' gives an indication of the heterogeneity of the data: the higher the percentage, the more variation between studies. A metaregression analysis of the data from the individual studies indicates no statistically significant exposure-response relationship between the distance of the residence to high-voltage power lines and the risk of childhood leukaemia. The chance to find the observed (or more extreme) results when there is actually no effect, is 30% (p=0.30).

## 5.2 Childhood leukaemia and magnetic field strength

The main analysis was performed with magnetic field strength categories of 0.1-(0.2 or 0.3) , 0.2-0.4 and >0.3 or >0.4 μT (Figure 4). Since the individual studies did not always use the same categories, the Committee used a grouping of data that were as equivalent as possible. The reference categories differed between studies, but they represented always the lowest magnetic field strength exposure. This might have led to a small underestimation of the risk estimates.

Also a stratified meta-analysis was performed to investigate the effect of a more accurate exposure assessement: only at the birth address or the address at diagnosis (low quality) or at all addresses between birth and diagnosis (higher quality):

- same as main analysis, but including only studies with exposure assessment at all addresses between birth and diagnosis (Figure 5);
- same as main analysis, but only studies with exposure assessment at the birth address or the address at diagnosis (Figure 6).

Also the following sensitivity analysis was performed:

- same as main analysis, but only studies with exposure categories reference, 0.1-0,2 and >0,2 or 0,3 μT (Figure 7).

Data were insufficient to perform separate analyses of specific types of leukaemia or of leukaemia in young children (0-5 year).

Finally, metaregression analyses were performed to assess exposure-response relationships.

| Study ID | Risk estimate childhood leukaemia (95% CI) | % Weight | MF lower bound | MF upper bound |
|---|---|---|---|---|
| >0.3 or 0.4 microtesla | | | | |
| Pedersen et al. (2015) | 1.67 (0.51, 5.46) | 8.51 | .4 | |
| Bunch et al. (2016) | 0.50 (0.15, 1.62) | 8.46 | .4 | |
| Kheifets et al. (2017) | 1.45 (0.67, 3.11) | 17.93 | .4 | |
| Meija-Arangure et al. (2007) | 1.42 (0.51, 3.88) | 11.23 | .4 | |
| Kabuto et al. (2006) | 2.56 (0.76, 8.58) | 8.18 | .4 | |
| Bunch et al. (2015) | 2.00 (0.18, 22.06) | 2.23 | .4 | |
| Schüz et al.( 2001) | 5.94 (0.80, 44.10) | 3.17 | .4 | |
| Malagoli et al. (2010) | 2.10 (0.20, 26.20) | 2.17 | .4 | |
| Linet et al. (1997) | 2.23 (0.84, 6.61) | 10.91 | .4 | |
| Feychting & Ahlbom (1993) | 3.80 (1.40, 9.30) | 12.66 | .3 | |
| Does (2011) | 0.57 (0.14, 2.36) | 6.17 | .3 | |
| Wünsch-Filho et al. (2011) | 1.09 (0.33, 3.61) | 8.38 | .3 | |
| Subtotal (I-squared = 9.4%, p = 0.353) | 1.62 (1.13, 2.34) | 100.00 | | |
| . | | | | |
| 0.2-0.4 microtesla | | | | |
| McBride et al. (1999) | 1.02 (0.56, 1.86) | 15.54 | .27 | |
| London et al. (1991) | 1.68 (0.71, 4.00) | 7.49 | .27 | |
| Verkasalo et al. (1993) | 1.60 (0.32, 5.40) | 2.80 | .2 | |
| Salvan et al. (2015) | 0.79 (0.35, 1.79) | 8.40 | .2 | |
| Dockerty et al. (1998) | 3.30 (0.50, 23.70) | 1.50 | .2 | |
| Savitz et al. (1988) | 1.93 (0.67, 5.56) | 5.00 | .2 | |
| Does (2011) | 1.03 (0.30, 3.55) | 3.67 | .2 | .3 |
| Kabuto et al. (2006) | 1.12 (0.53, 2.36) | 10.04 | .2 | .4 |
| Bunch et al. (2016) | 0.49 (0.13, 1.88) | 3.14 | .2 | .4 |
| Linet et al. (1997) | 1.36 (0.81, 2.30) | 20.55 | .2 | .4 |
| Bunch et al. (2015) | 0.92 (0.20, 4.17) | 2.43 | .2 | .4 |
| Kheifets et al. (2017) | 0.95 (0.45, 2.00) | 10.06 | .2 | .4 |
| Schüz et al.( 2001) | 1.45 (0.67, 3.14) | 9.38 | .2 | .4 |
| Subtotal (I-squared = 0.0%, p = 0.882) | 1.18 (0.93, 1.50) | 100.00 | | |
| . | | | | |
| 0.1-0.2 or 0.3 microtesla | | | | |
| Green et al. (1999) | 1.47 (0.44, 4.85) | 1.83 | .15 | |
| Bianchi et al. (2000) | 4.51 (0.88, 23.17) | 0.98 | .1 | |
| Tynes & Haldorsen (1997) | 1.48 (0.64, 3.46) | 3.70 | .05 | |
| McBride et al. (1999) | 1.15 (0.70, 1.88) | 10.79 | .15 | .27 |
| London et al. (1991) | 0.94 (0.47, 1.89) | 5.44 | .12 | .27 |
| Salvan et al. (2015) | 1.87 (1.04, 3.34) | 7.74 | .1 | .2 |
| Kheifets et al. (2017) | 0.83 (0.47, 1.44) | 8.40 | .1 | .2 |
| Bunch et al. (2015) | 0.80 (0.07, 9.10) | 0.44 | .1 | .2 |
| Bunch et al. (2016) | 0.74 (0.25, 2.24) | 2.19 | .1 | .2 |
| Does (2011) | 1.98 (0.94, 4.17) | 4.75 | .1 | .2 |
| Kabuto et al. (2006) | 0.91 (0.50, 1.63) | 7.54 | .1 | .2 |
| Schüz et al.( 2001) | 1.34 (0.90, 2.01) | 16.31 | .1 | .2 |
| Dockerty et al. (1998) | 1.50 (0.30, 7.20) | 1.04 | .1 | .2 |
| Linet et al. (1997) | 1.15 (0.79, 1.65) | 19.42 | .1 | .2 |
| Feychting & Ahlbom (1993) | 1.50 (0.40, 4.20) | 1.91 | .1 | .3 |
| Wünsch-Filho et al. (2011) | 0.75 (0.36, 1.55) | 4.94 | .1 | .3 |
| Malagoli et al. (2010) | 4.11 (0.05, 324.62) | 0.14 | .1 | .4 |
| Pedersen et al. (2015) | 0.77 (0.27, 2.16) | 2.44 | .1 | .4 |
| Subtotal (I-squared = 0.0%, p = 0.681) | 1.18 (1.00, 1.39) | 100.00 | | |
| . | | | | |

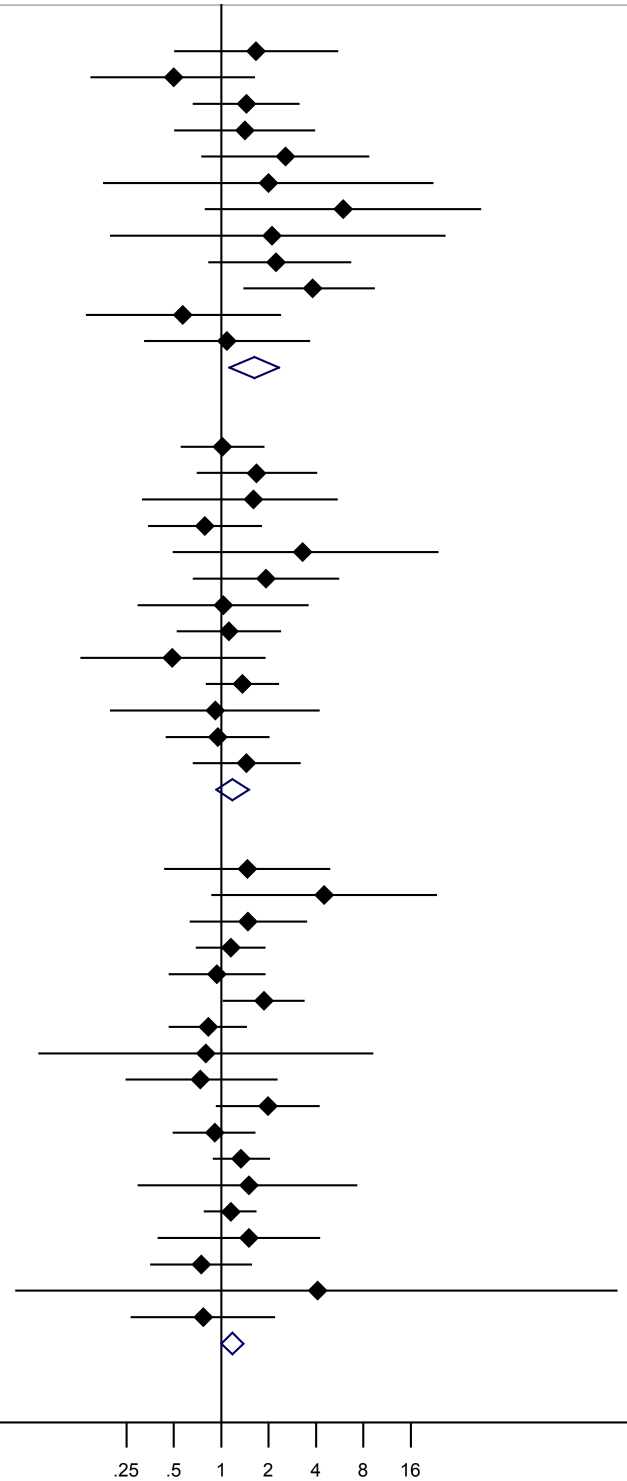


**Figure 4.** Childhood leukaemia: main analysis of magnetic field strength. For each study the risk estimate, the 95% confidence interval and the weight of the study in the analysis are indicated. The 'subtotal' is the risk estimate with confidence interval for all studies in that category. The factor 'I-squared' gives an indication of the heterogeneity of the data: the higher the percentage, the more variation between studies. A metaregression analysis of the data from the individual studies indicates no statistically significant exposure-response relationship between the magnetic field strength and the risk of childhood leukaemia. The chance to find the observed (or more extreme) results when there is actually no effect, is 15% (p=0.15).

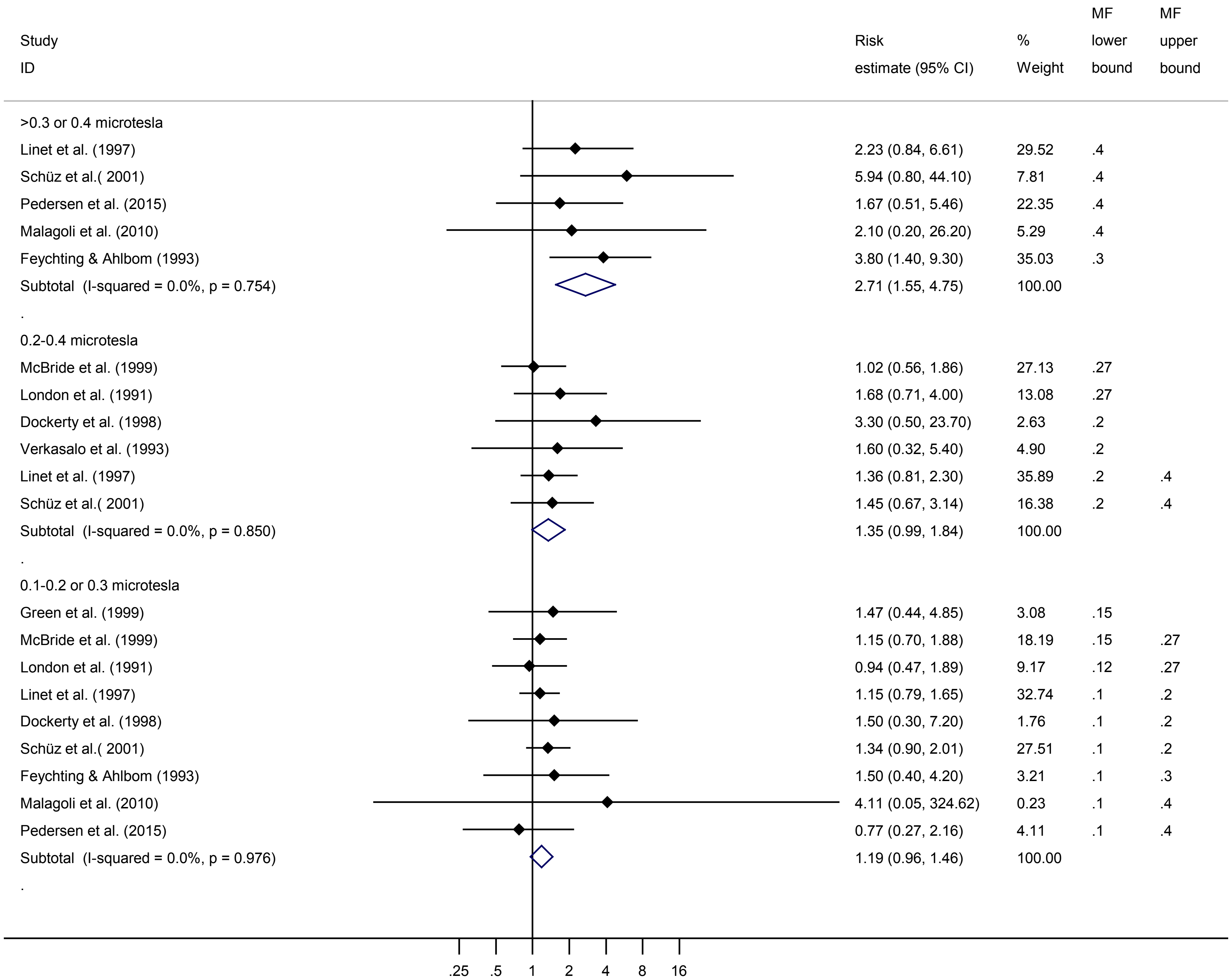


**Figure 5.** Childhood leukaemia, sensitivity analysis: similar to the main analysis, but including only studies with exposure assessment at all addresses between (or before) birth and diagnosis. For each study the risk estimate, the 95% confidence interval and the weight of the study in the analysis are indicated. The 'subtotal' is the risk estimate with confidence interval for all studies in that category. The factor 'I-squared' gives an indication of the heterogeneity of the data: the higher the percentage, the more variation between studies. A metaregression analysis of the data from the individual studies indicates no statistically significant exposure-response relationship between magnetic field strength and the risk of childhood leukaemia. The chance to find the observed (or more extreme) results when there is actually no effect, is 7% (p=0.07).

| Study ID | Risk estimate (95% CI) | % Weight | MF lower bound | MF upper bound |
|---|---|---|---|---|
| >0.3 or 0.4 microtesla | | | | |
| Bunch et al. (2016) | 0.50 (0.15, 1.62) | 13.01 | .4 | |
| Kheifets et al. (2017) | 1.45 (0.67, 3.11) | 31.26 | .4 | |
| Bunch et al. (2015) | 2.00 (0.18, 22.06) | 3.19 | .4 | |
| Kabuto et al. (2006) | 2.56 (0.76, 8.58) | 12.54 | .4 | |
| Meija-Arangure et al. (2007) | 1.42 (0.51, 3.88) | 17.89 | .4 | |
| Wünsch-Filho et al. (2011) | 1.09 (0.33, 3.61) | 12.87 | .3 | |
| Does (2011) | 0.57 (0.14, 2.36) | 9.23 | .3 | |
| Subtotal (I-squared = 0.0%, p = 0.520) | 1.21 (0.79, 1.85) | 100.00 | | |
| . | | | | |
| 0.2-0.4 microtesla | | | | |
| Salvan et al. (2015) | 0.79 (0.35, 1.79) | 19.67 | .2 | |
| Savitz et al. (1988) | 1.93 (0.67, 5.56) | 11.70 | .2 | |
| Does (2011) | 1.03 (0.30, 3.55) | 8.58 | .2 | .3 |
| Bunch et al. (2016) | 0.49 (0.13, 1.88) | 7.34 | .2 | .4 |
| Kabuto et al. (2006) | 1.12 (0.53, 2.36) | 23.49 | .2 | .4 |
| Bunch et al. (2015) | 0.92 (0.20, 4.17) | 5.68 | .2 | .4 |
| Kheifets et al. (2017) | 0.95 (0.45, 2.00) | 23.55 | .2 | .4 |
| Subtotal (I-squared = 0.0%, p = 0.807) | 0.99 (0.69, 1.42) | 100.00 | | |
| . | | | | |
| 0.1-0.2 or 0.3 microtesla | | | | |
| Bianchi et al. (2000) | 4.51 (0.88, 23.17) | 3.56 | .1 | |
| Tynes & Haldorsen (1997) | 1.48 (0.64, 3.46) | 10.61 | .05 | |
| Does (2011) | 1.98 (0.94, 4.17) | 12.61 | .1 | .2 |
| Bunch et al. (2015) | 0.80 (0.07, 9.10) | 1.69 | .1 | .2 |
| Bunch et al. (2016) | 0.74 (0.25, 2.24) | 7.10 | .1 | .2 |
| Salvan et al. (2015) | 1.87 (1.04, 3.34) | 16.98 | .1 | .2 |
| Kabuto et al. (2006) | 0.91 (0.50, 1.63) | 16.74 | .1 | .2 |
| Kheifets et al. (2017) | 0.83 (0.47, 1.44) | 17.75 | .1 | .2 |
| Wünsch-Filho et al. (2011) | 0.75 (0.36, 1.55) | 12.95 | .1 | .3 |
| Subtotal (I-squared = 31.3%, p = 0.168) | 1.19 (0.86, 1.65) | 100.00 | | |
| . | | | | |

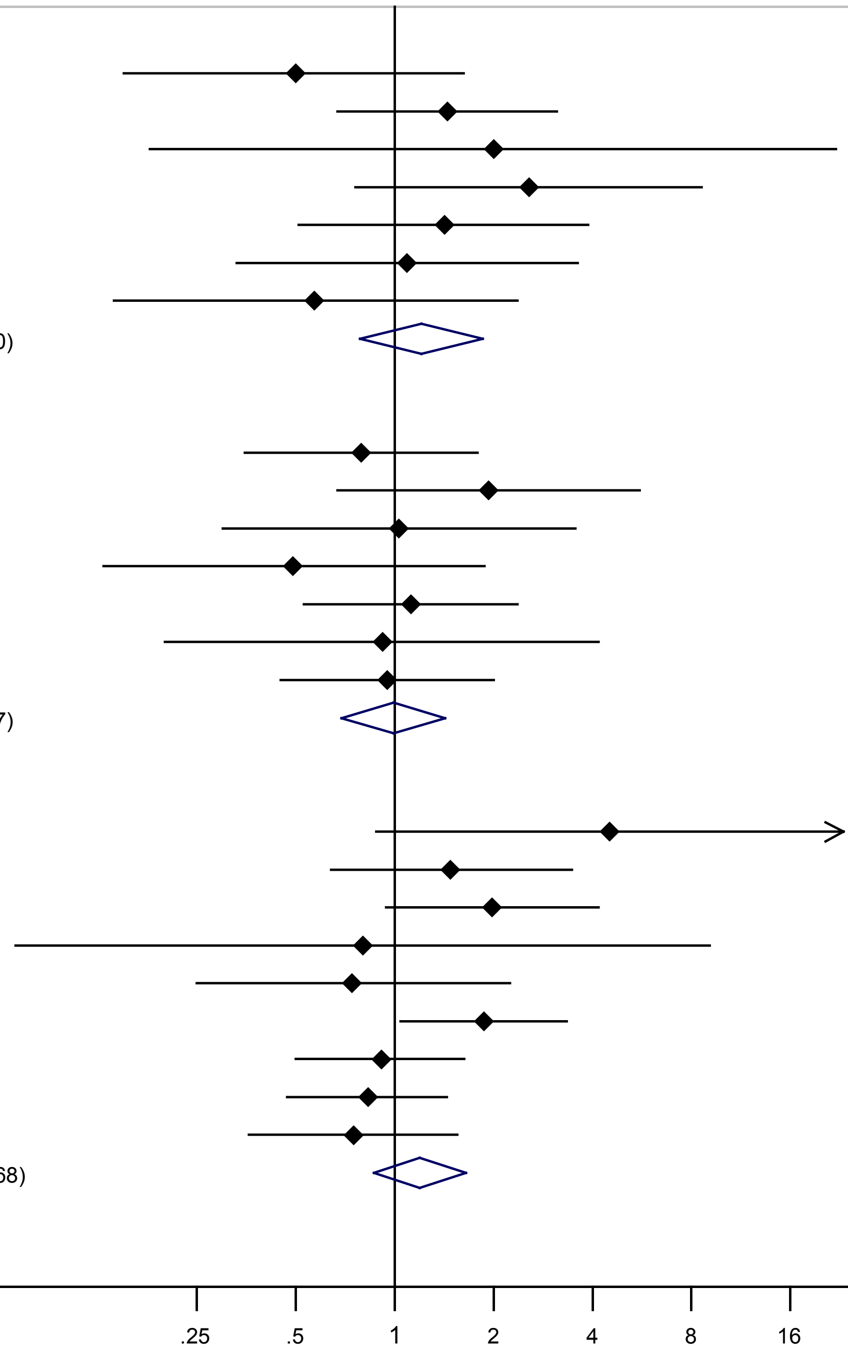


**Figure 6.** Childhood leukaemia, similar to the main analysis, but including only studies with exposure assessment either at the birth address or the address at diagnosis. For each study the risk estimate, the 95% confidence interval and the weight of the study in the analysis are indicated. The ‘subtotal’ is the risk estimate with confidence interval for all studies in that category. The factor ‘I-squared’ gives an indication of the heterogeneity of the data: the higher the percentage, the more variation between studies.

| Study ID | Risk estimate childhood leukaemia (95% CI) | % Weight | MF lower bound | MF upper bound |
|---|---|---|---|---|
| >0.2 or 0.3 microtesla | | | | |
| Wünsch-Filho et al. (2011) | 1.09 (0.33, 3.61) | 2.94 | .3 | |
| London et al. (1991) | 1.68 (0.71, 4.00) | 5.63 | .27 | |
| Verkasalo et al. (1993) | 1.60 (0.32, 5.40) | 2.11 | .2 | |
| Savitz et al. (1988) | 1.93 (0.67, 5.56) | 3.76 | .2 | |
| Olsen et al. (1993) | 1.50 (0.30, 6.70) | 1.74 | .25 | |
| Kabuto et al. (2006) | 1.41 (0.75, 2.66) | 10.50 | .2 | |
| McBride et al. (1999) | 1.38 (0.84, 2.26) | 17.18 | .2 | |
| Bunch et al. (2015) | 1.15 (0.32, 4.15) | 2.56 | .2 | |
| Feychting & Ahlbom (1993) | 2.70 (1.00, 6.30) | 4.97 | .2 | |
| Linet et al. (1997) | 1.53 (0.91, 2.56) | 15.73 | .2 | |
| Schüz et al.( 2001) | 1.69 (0.83, 3.46) | 8.26 | .2 | |
| Kheifets et al. (2017) | 1.17 (0.68, 1.99) | 14.59 | .2 | |
| Bunch et al. (2016) | 0.50 (0.20, 1.21) | 5.19 | .2 | |
| Does (2011) | 0.76 (0.30, 1.93) | 4.86 | .2 | |
| Subtotal (I-squared = 0.0%, p = 0.680) | 1.35 (1.10, 1.66) | 100.00 | | |
| . | | | | |
| 0.1-0.2 microtesla | | | | |
| Green et al. (1999) | 1.47 (0.44, 4.85) | 2.19 | .15 | |
| Bianchi et al. (2000) | 4.51 (0.88, 23.17) | 1.18 | .1 | |
| Tynes & Haldorsen (1997) | 1.48 (0.64, 3.46) | 4.44 | .05 | |
| London et al. (1991) | 0.94 (0.47, 1.89) | 6.52 | .12 | .27 |
| Does (2011) | 1.98 (0.94, 4.17) | 5.69 | .1 | .2 |
| Bunch et al. (2015) | 0.80 (0.07, 9.10) | 0.53 | .1 | .2 |
| Bunch et al. (2016) | 0.74 (0.25, 2.24) | 2.63 | .1 | .2 |
| Schüz et al.( 2001) | 1.34 (0.90, 2.01) | 19.57 | .1 | .2 |
| Kabuto et al. (2006) | 0.91 (0.50, 1.63) | 9.05 | .1 | .2 |
| Kheifets et al. (2017) | 0.83 (0.47, 1.44) | 10.08 | .1 | .2 |
| Linet et al. (1997) | 1.15 (0.79, 1.65) | 23.29 | .1 | .2 |
| Wünsch-Filho et al. (2011) | 0.75 (0.36, 1.55) | 5.93 | .1 | .3 |
| Feychting & Ahlbom (1993) | 2.10 (0.60, 6.10) | 2.35 | .1 | .2 |
| Olsen et al. (1993) | 0.50 (0.10, 4.30) | 0.89 | .1 | .24 |
| Pedersen et al. (2015) | 1.08 (0.49, 2.36) | 5.11 | .1 | |
| Malagoli et al. (2010) | 6.70 (0.60, 78.30) | 0.53 | .1 | |
| Subtotal (I-squared = 0.0%, p = 0.536) | 1.15 (0.96, 1.37) | 100.00 | | |
| . | | | | |

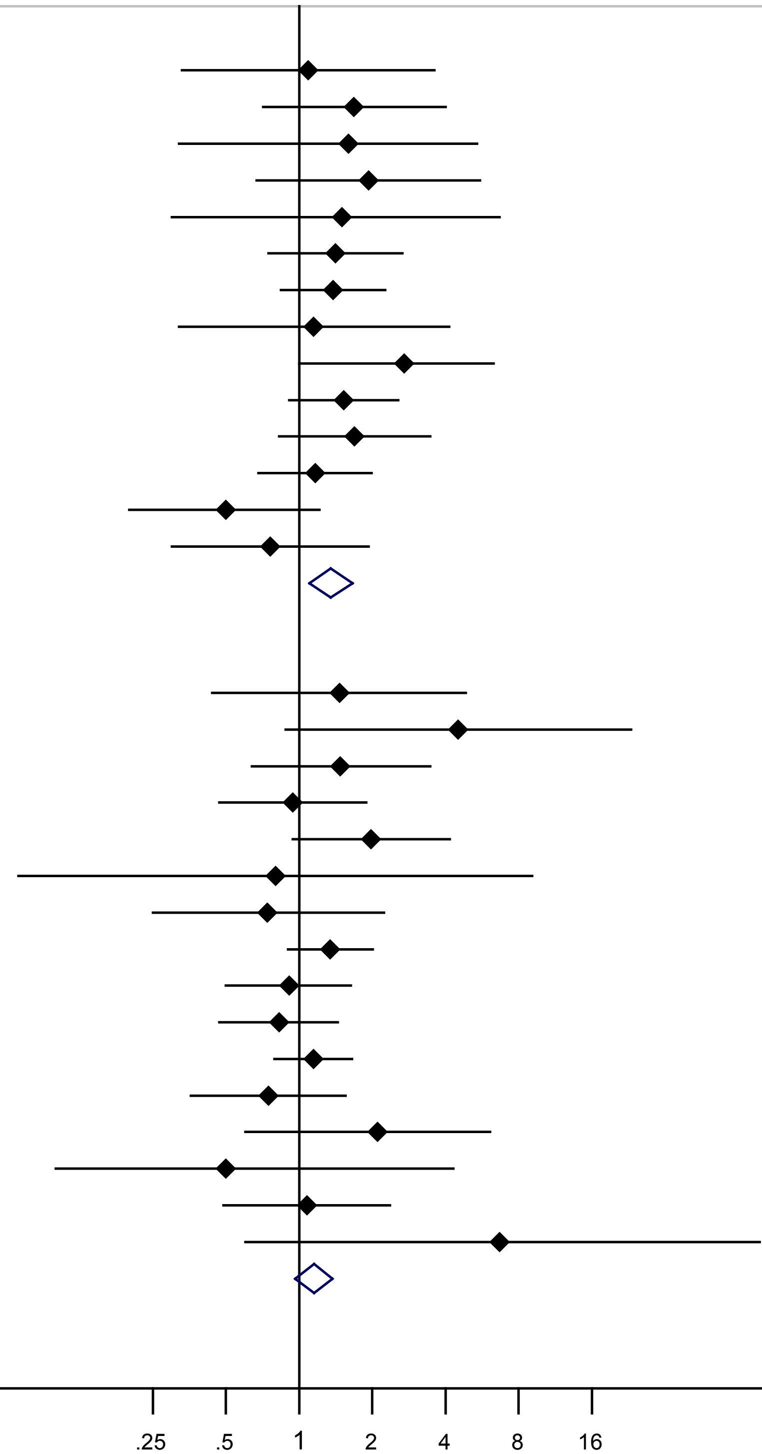


**Figure 7.** Childhood leukaemia, similar to the main analysis, but only for the categories 0.1-0.2 and >0.2 or 0.3 μT. For each study the risk estimate, the 95% confidence interval and the weight of the study in the analysis are indicated. The 'subtotal' is the risk estimate with confidence interval for all studies in that category. The factor 'I-squared' gives an indication of the heterogeneity of the data: the higher the percentage, the more variation between studies.

## 5.3 Brain tumours in children and magnetic field strength

The main analysis was with magnetic field strength categories of 0.1-(0.2 or 0.3), 0.2-0.4 and >0.3 or >0.4 μT (Figure 8). Since the individual studies do not always use the same categories, the Committee used a grouping of data that were as equivalent as possible. The reference categories differed between studies, but they represented always the lowest magnetic field strength exposure. This might have led to a small underestimation of the risk estimates.

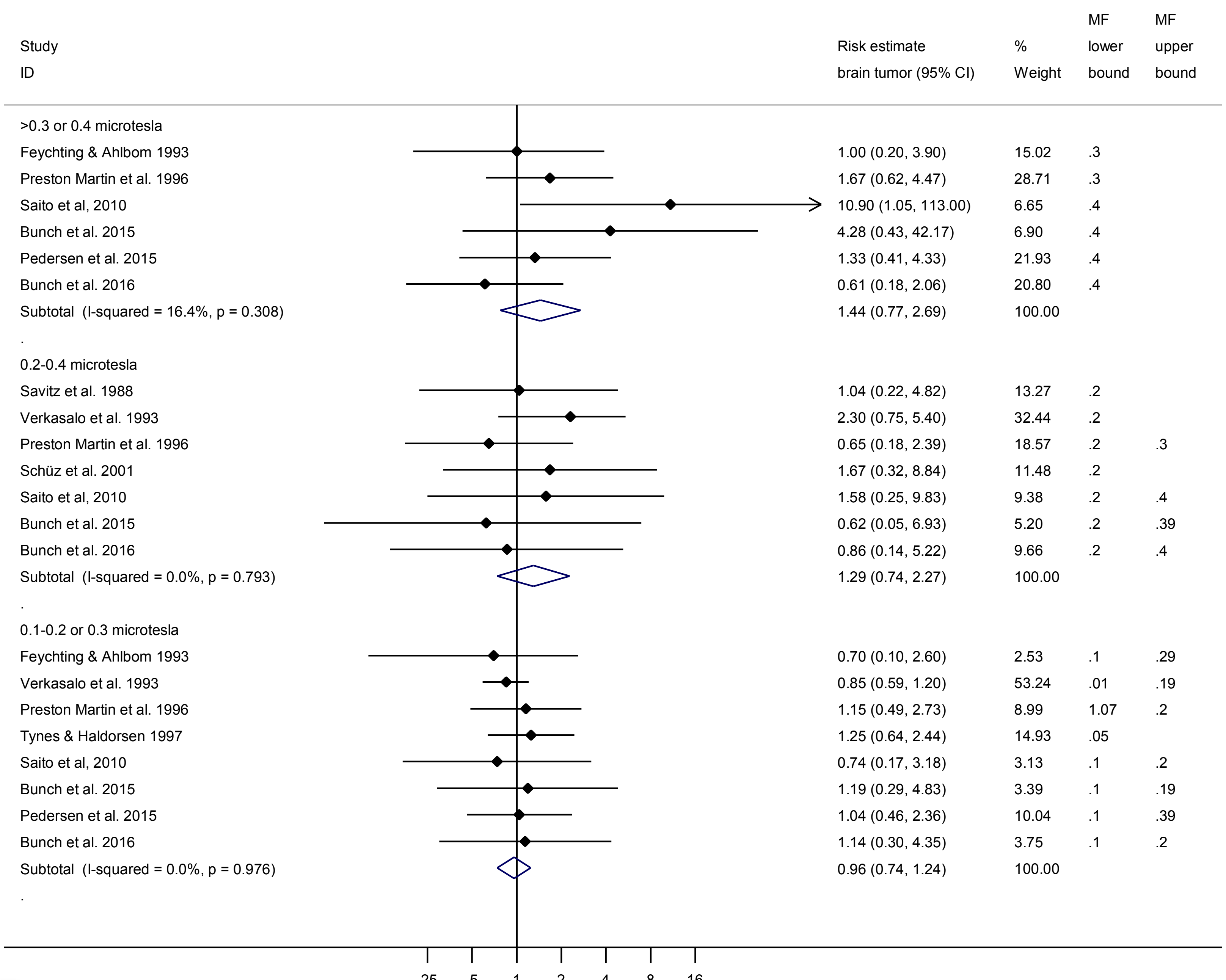


**Figure 8.** Brain tumours in children: main analysis of magnetic field strength. For each study the risk estimate, the 95% confidence interval and the weight of the study in the analysis are indicated. The 'subtotal' is the risk estimate with confidence interval for all studies in that category. The the factor 'I-squared' gives an indication of the heterogeneity of the data: the higher the percentage, the more variation between studies. A metaregression analysis of the data from the individual studies indicates no statistically significant exposure-response relationship between the magnetic field strength and the risk of childhood leukaemia. The chance to find the observed (or more extreme) results when there is actually no effect, is 8% (p=0.08).

## 5.4 Lymphomas in children and magnetic field strength

The main analysis was with magnetic field strength categories of 0.01-0.2, 0.1-0.4 and >0.2 μT (Figure 9). Since the individual studies do not always use the same categories, the Committee used a grouping of data that were as equivalent as possible. The reference categories differed between studies, but they represented always the lowest magnetic field strength exposure. This might have led to a small underestimation of the risk estimates.

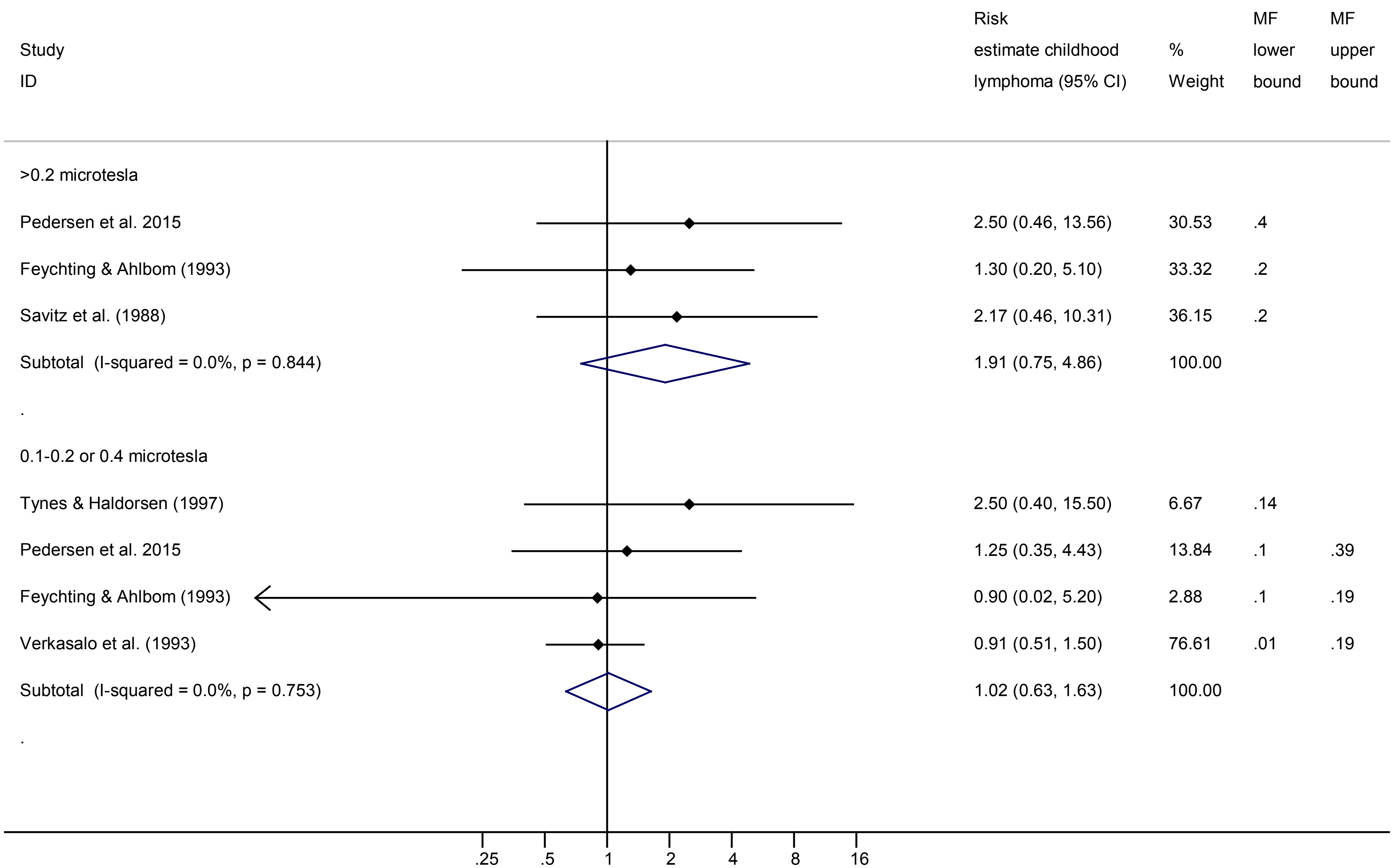


**Figure 9.** Lymphomas in children: main analysis of magnetic field strength. For each study the risk estimate, the 95% confidence interval and the weight of the study in the analysis are indicated. The ‘subtotal’ is the risk estimate with confidence interval for all studies in that category. The factor ‘I-squared’ gives an indication of the heterogeneity of the data: the higher the percentage, the more variation between studies. A metaregression analysis of the data from the individual studies indicates no statistically significant exposure-response relationship between the magnetic field strength and the risk of childhood leukaemia. The chance to find the observed (or more extreme) results when there is actually no effect, is 18% (p=0.18).

# 06 criteria for strength of evidence for a causal relationship

The Committee uses the EPA framework for the assessment of the strength of evidence for causality.[51]

**Table A6.** EPA framework for the assessment of causality[51]

| Strength of evidence for causal relation | Description of the evidence (abbreviated) |
|---|---|
| Causal relationship proven | Evidence is sufficient to conclude that there is a causal relationship with relevant exposures. Multiple high-quality studies conducted by multiple research groups in which chance, confounding, and other biases could be ruled out with reasonable confidence have shown health effects. Such studies include controlled human exposure studies or observational studies that are supported by other lines of evidence (e.g., animal studies or mode of action information). |
| Causal relationship likely | Evidence is sufficient to conclude that a causal relationship is likely to exist. Multiple high-quality studies where results are not explained by chance, confounding, and other biases have shown health effects, but uncertainties remain in the evidence overall. For example: observational studies show an association, but exposures to other agents are difficult to address and/or other lines of evidence (controlled human exposure, animal, or mode of action information) are limited or inconsistent. Or animal toxicological evidence from multiple studies from different laboratories demonstrate effects, but limited or no human data are available. |
| Suggestive of a causal relationship | Evidence is suggestive of a causal relationship but is limited, and chance, confounding, and other biases cannot be ruled out. For example: at least one high-quality epidemiologic study shows an association and/or at least one high-quality animal study shows effects relevant to humans. Or, when the body of evidence is relatively large, evidence from studies of varying quality is generally supportive but not entirely consistent,. |
| Inadequate to infer a causal relationship | Evidence is inadequate to determine that a causal relationship exists. The available studies are of insufficient quantity, quality, consistency, or statistical power to permit a conclusion regarding the presence or absence of an effect. |
| Not likely to be a causal relationship | Several adequate studies, covering the full range of levels of exposure that human beings are known to encounter and considering at-risk populations and lifestages, are mutually consistent in not showing an effect at any level of exposure. |

# literature


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